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An Economic Analysis of Rebates Conditional on Positive Reviews

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Abstract. Strategic sellers on some online selling platforms have recently been using a conditional-rebate strategy to manipulate product reviews under which only purchasing consumers who post positive reviews online are eligible to redeem the rebate. A key concern for the conditional rebate is that it can easily induce fake reviews, which might be harmful to consumers and society. We develop a microbehavioral model capturing consumers' review-sharing benefit, review-posting cost, and moral cost of lying to examine the seller's optimal pricing and rebate decisions. We derive three equilibria: the no-rebate, organic-review equilibrium; the low-rebate, boosted-authentic-review equilibrium; and the high-rebate, partially-fake-review equilibrium. We find that the seller's optimal price and rebate decisions critically depend on both the review-posting and moral costs. The seller adopts the no-rebate strategy when the review-posting cost is low but the moral cost is high, the low-rebate strategy when the review-posting cost is high or when the review-posting cost is intermediate and the moral cost is high, and the high-rebate strategy when the review-posting cost is not too high and the moral cost is low. Our results suggest that it is not always profitable for strategic sellers to adopt the conditional-rebate strategy. Even if the conditional-rebate strategy is adopted, it does not always result in fake reviews. Furthermore, we find that, compared with the benchmark of no rebate, conditional rebates do not always hurt consumer surplus or social welfare. When a low (high) rebate is offered, if the review-posting cost is not too low (not very high), the conditional-rebate strategy can even lead to higher consumer surplus and social welfare. Our findings shed new light on the platform-policy debate about the fake-review phenomenon induced by conditional rebates.

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1. Introduction

Online reviews have been well documented as an important information source for consumers' purchase decisions (Zhu and Zhang 2010, Kats 2018). Sellers often offer various incentives to encourage consumers to post reviews online. For example, after a consumer shops at Home Depot, the consumer is often invited to write reviews with the promise that he/she will have a chance to draw a lottery for some prize (e.g., an iPad), and Best Buy offers 25 reward points ($0.50 monetary value) to consumers who write reviews. In recent years, a new approach to encourage reviews has emerged. On Taobao.com, the leading online trading platform in China, many sellers offer purchasing consumers rebates redeemable only if the consumers post positive reviews online. In Google Play, some developers run campaigns offering discounted prices or in-game currency for five-star reviews.[1] This conditional-rebate strategy is different from the typical unconditional-rebate strategy because in some sense sellers bribe buyers for positive reviews rather than simply expanding the review pool using monetary incentives.

A typical conditional-rebate strategy on Taobao.com works as follows. When a buyer places an online order with a seller, the buyer is unaware of the existence or the amount of the rebate. When shipping the product, the seller might include a mail-in conditional rebate, such as the one in Figure 1. As shown in Figure 1, the key conditions to redeem the rebate include leaving a

Figure 1. (Color online) An Example of Rebates Conditional on Positive Reviews

five-star rating and writing reviews that meet some minimum length requirement. The distinctive feature of this type of rebate is that only those purchasing consumers who post positive reviews are eligible to redeem rebates. Once done, the consumer needs to take a screenshot or photo of the review and send it to the seller for verification. Afterward, the rebate is honored by the seller through Alipay (a widely adopted mobile payment method and e-wallet).

Because the conditional rebates provide monetary incentives to bribe consumers for positive reviews, a key concern is that it can easily induce consumers to post fake reviews that might harm consumers and society. Recently, leading online platforms in the United States have developed various countermeasures and online-review policies to combat fake reviews. For example, Google has deployed a system that combines human intelligence with machine learning to detect fake reviews,[2] and Amazon's review policy clearly disallows "offering compensation or requesting compensation (including free or discounted products) in exchange for creating, modifying, or posting content."[3] However, strategic sellers often do not preannounce the rebate information on their web pages, and they bypass platform monitoring and regulation by secretly packaging the paper rebate cards in the same delivery as the purchased products. It is therefore very difficult for platforms and other consumers to distinguish manipulated from legitimate reviews. Motivated by the prevailing conditional-rebate practice and the incentivized-review phenomenon common on today's e-commerce platforms, as well as the technical challenges of detecting online-review manipulation, this study aims to answer the following research questions: Under what conditions do strategic sellers prefer the conditional-rebate strategy? Under what conditions do fake reviews arise as an equilibrium outcome? How do conditional rebates affect sellers' profits, consumer surplus, and social welfare?

On the one hand, positive reviews offer a clear benefit. For example, prior studies show that one extra star in a Yelp review could increase revenues by 5%–9% (Economist 2015), which explains why restaurants often seek fake acclaim, offering customers discounts in exchange for positive reviews on social networking sites and other online platforms. On the other hand, offering a cash rebate incurs a direct cost for sellers. Therefore, it may not always be profitable to pursue such a strategy. Although poor ratings and reviews affect a seller's reputation and sales, a favorable product price can mitigate these negative effects. The Better Business Bureau's recent Trust Sentiment Index report shows that roughly one in three consumers says they would still purchase from a business that has poor ratings or reviews if the price is right.[4] Therefore, it is not immediately clear whether a strategic seller should provide a monetary incentive to boost its positive reviews to increase consumers' perceived value of its product, and thus charge a price premium, or it should offer a price discount to attract more consumers. This research aims to understand how a strategic seller should trade off the rebate incentive and product pricing to maximize profit.

We develop a two-period model to examine a strategic seller's conditional-rebate and pricing decisions, taking into account consumers' product-purchase and review-posting decisions. The focal product has both digital and nondigital attributes. Digital attributes refer to the attributes that can be easily communicated through the Internet, such as size and color, whereas nondigital attributes are those that are hard to evaluate prior to purchase, such as product fit. Prior to purchase, consumers learn the product's digital-attribute value but only form an expectation on the nondigital-attribute

value. In the first period, the seller announces the product price and privately determines whether to offer purchasing consumers a mail-in conditional rebate and the rebate amount (if any). Consumers make purchase decisions based on the expected product valuation without online reviews. At the end of the first period, purchasing consumers make their review-posting decisions based on the realized product valuation as well as a conditional rebate (if any). In general, consumers incur a cost to post online reviews but derive a benefit by sharing their true opinions. If they post fake reviews, consumers suffer a moral cost. Consumers trade off these benefits and costs to determine whether to post positive reviews, negative reviews, or no reviews. In the second period, the seller announces the price and consumers observe the online reviews, based on which they update their expectations on the product valuation and make purchase decisions.

We derive three equilibrium outcomes: the no-rebate, organic-review equilibrium, the low-rebate, boosted-authentic-review equilibrium, and the high-rebate, partially-fake-review equilibrium. We find that sellers' optimal price and rebate decisions critically depend on review-posting cost, moral cost, and the expected nondigital-attribute value. In the presence of a high expected nondigital-attribute value, when the review-posting cost is low but the moral cost is high, the seller has no incentive to offer the conditional rebate because of a sizable volume of voluntary reviews (due to low review-posting cost) and a high cost to bribe unsatisfied consumers (due to the high moral cost). When the review-posting cost is high or it is intermediate and the moral cost is high, the seller offers a low rebate to elicit more positive reviews from satisfied consumers. Only when the review-posting cost is not too high and the moral cost is low, would the seller offer a high rebate. The high rebate not only motivates more satisfied consumers to share their true experiences, but also induces unsatisfied consumers to post fake reviews. In the presence of a low expected nondigital-attribute value, the seller never offers a high rebate. In this case, when the review-posting cost is high, the seller offers a low rebate to boost positive reviews; otherwise, the seller offers no rebate. Furthermore, we find that when consumers are more willing to post reviews in the presence of larger disparity between their prepurchase belief and post-purchase satisfaction, or when they are sophisticated enough to partially factor into the effect of conditional rebates on review manipulation, the seller is less likely to offer conditional rebates. On the other hand, when the product has a lower probability to deliver a high nondigital-attribute value, the seller is more likely to adopt the conditional-rebate strategy.

Overall, our findings suggest that it is not always profitable for strategic sellers to pursue the conditional-rebate strategy. In addition, the seller's conditional-rebate strategy does not necessarily result in fake reviews. Fake reviews come with a high cost for the seller. Not only must the seller provide enough monetary incentive to bribe unsatisfied consumers to lie, but the monetary incentive will also be taken by satisfied consumers who would otherwise have posted positive reviews without the rebate. Only when the moral cost is low, the review-posting cost is not too high, and the expected value from nondigital attributes is high would the seller prefer a high-rebate strategy, causing fake reviews to appear in equilibrium. Further, numerically, we find that offering a low rebate is more likely to arise as an equilibrium than a high rebate in the entire feasible parameter space we examine. Under the low-rebate equilibrium, the rebate is used to boost positive reviews from satisfied consumers, not to bribe unsatisfied consumers to lie and post fake reviews. The information shared online still reflects the true opinions from purchasing consumers. These findings shed new light on the criticism and concern about the fake-review phenomenon induced by the conditional-rebate strategy.

The conditional rebate motivates additional consumers to post positive product reviews, and the inflated product reviews increase consumers' perceived nondigital-attribute value of the product, leading to increased overall perceived product valuation. Compared with the benchmark case where no rebate is considered, the use of a conditional rebate not only enables the seller to charge a price premium, but also increases the overall product demand and profit, regardless of low or high rebate amount being optimally offered. However, the profit implications of the review-posting and moral costs are different under the low- and high-rebate equilibria. In the equilibrium when a high rebate is offered, the seller's profit (weakly) decreases in both review-posting and moral costs. This is intuitive because, to induce additional positive reviews, the seller must both cover consumers' review-posting cost and compensate unsatisfied consumers' moral cost of posting fake reviews. In sharp contrast, surprisingly, in the equilibrium when a low rebate is offered, the seller's profit increases in review-posting cost because, as the review-posting cost increases, the number of satisfied consumers who would otherwise have posted positive reviews without monetary incentive decreases. Because offering a rebate to this group of consumers incurs a pure cost to the seller, the reduced size in this group significantly benefits the seller and enables the seller to further optimize its price and rebate, resulting in increased rebate offering and profit. In this equilibrium, the seller's profit is independent of moral cost, because no consumers post fake reviews.

The effects of the conditional rebate on consumer surplus and social welfare also depend on the review-posting and moral costs. Conditional rebates engender

both social gain and social loss. The social gain comes from the additional transactions due to boosted product reviews. The social loss comes from distorted consumer review-posting behavior—some consumers posting reviews when their review-sharing benefits are below their review-posting cost and some consumers being induced to post fake reviews, incurring both review-posting and moral costs. Compared with the benchmark case where no rebate is considered, when the review-posting cost is not too low in the low-rebate equilibrium or when the review-posting cost is not very high in the high-rebate equilibrium, the social gain can even outweigh the social loss. Under these cases, the conditional rebate increases social welfare. Meanwhile, the seller may transfer a proportion of its gain to consumers in the form of rebates and lower prices, resulting in increased consumer surplus. Under other conditions, the conditional rebate may increase social welfare but hurt consumer surplus or hurt both social welfare and consumer surplus. Overall, our findings offer new insights into the fake-review phenomenon induced by sellers' conditional-rebate strategy.

The rest of the paper is organized as follows. Section 2 reviews the relevant literature. Section 3 introduces our baseline model. We analyze consumers' review-posting behavior, derive the seller's equilibrium pricing and rebate decisions, and discuss their profit implications in Section 4. Section 5 presents several model extensions and further examines the effects of conditional rebates on consumer surplus and social welfare. Section 6 discusses managerial implications and concludes.

2. Related Literature

Our work examines a new rebate mechanism to encourage online product reviews. Two streams of research are particularly relevant to our study—research on rebates and on product reviews.

Rebates as promotional tools have been widely studied in economics and marketing for decades (e.g., Gerstner and Hess 1991, Chen et al. 2005). One common explanation for rebates is a pricing device to achieve market segmentation (e.g., Chen et al. 2005, Lu and Moorthy 2007)—compared with uniform pricing, the firm raises the price for consumers who do not redeem the rebate but decreases it for those who redeem it, reaping benefits from price discrimination. However, in the presence of the online cash-back mechanism, Ho et al. (2017a) show that offering rebates may not always benefit consumers. Different from this stream of the literature, we focus on a new conditional-rebate mechanism under which only purchasing consumers posting positive reviews are eligible to redeem the rebate.

Our work primarily relates to product reviews. Consumers today are increasingly influenced by online product reviews in a variety of purchase decisions (Lu et al. 2013, Kwark et al. 2014). Prior research finds that online product reviews are an important source of information to reduce consumers' uncertainty about products, especially nondigital attributes such as product fit where consumers have ex ante incomplete knowledge (Godes and Mayzlin 2004, Chen and Xie, 2008). Several analytical papers thus focus on firms offering reviews to facilitate consumer learning of product fit (Sun 2012, Kwark et al. 2014). Similar to Chen and Xie (2008), who model consumer reviews as an imperfect signal of whether the product is a match or mismatch, we focus on the impact of online reviews on consumers' nondigital-attribute evaluation.

A growing body of literature studies the informational role of online reviews and their impact on firms' pricing and marketing strategies (e.g., Chen and Xie 2008, Li and Hitt 2010, Liu et al. 2017, Feng et al. 2019, Zimmermann et al. 2018). Chen and Xie (2008) investigate how consumer reviews influence a monopolistic firm's incentive to provide fit-revealing information. Liu et al. (2017) study how online reviews and past sales-volume information jointly affect consumers' purchasing decisions and firms' pricing strategies when herding consumers are uncertain about product quality. Although interesting, this stream of research takes the online-review-generation mechanisms as given and focuses on firms' marketing responses to indirectly influence online reviews. We add to this line of inquiry by considering how firms can strategically influence online-review-generation mechanisms and directly manipulate online review provisions.

Like many voluntarily provided public goods (Gallus 2017), online reviews may be underprovisioned (Anderson 1998, Avery et al. 1999), limiting their helpfulness to other consumers (Mudambi and Schuff 2010). Prior studies find that financial incentives effectively motivate individuals to write reviews on Airbnb.com (Fradkin et al. 2015) and Best Buy (Khern-am-nuai et al 2018). Li and Xiao (2014) consider a rebate mechanism in which sellers provide a rebate to cover the buyer's feedback-reporting cost, regardless of whether the feedback is positive or negative. They find that, compared with the no-rebate market, the seller's rebate decision has a significant impact on the buyer's purchasing decision and result in more efficient trades. In contrast, Cabral and Li (2015) conduct controlled field experiments on eBay and find evidence that buyers reciprocate with sellers favorably if the sellers provide a feedback rebate. As such, sellers can "buy" feedback, but such feedback is likely to be biased. A distinct feature of these studies is that the rebate is used to compensate buyers' review-posting cost and is independent of whether the feedback is positive or negative. In contrast to these studies, we consider a conditional-rebate strategy in which sellers

selectively reward buyers who post positive online reviews.

Because higher ratings positively impact sales and revenue, strategic sellers may engage in online review manipulation. Dellarocas (2006) examines firms' incentive to manipulate reviews in public forums and the implications to consumer welfare when firms introduce a product to a new market. Different from that work, we consider a conditional-rebate strategy in which sellers only reward buyers who post positive online reviews. We study firms' product pricing and rebate strategies to manipulate consumer reviews in online markets. This focus is also different from prior research studying firms' other strategic behaviors, such as deceptive advertising to fool consumers about a product's true quality (Piccolo et al. 2017) and false advertising to overstate the product's value (Rhodes and Wilson 2018). We complement this stream of literature and enrich our understanding of firms' and consumers' strategic interaction in online markets.

Finally, our research contributes to ongoing research in online platforms' information policies (Gutt et al. 2019, Hao and Tan 2019). Jiang and Guo (2015) consider product valuation and consumer misfit cost, and study their impact on a firm's pricing and review-system design decisions. By focusing on the sellers' strategic decisions in offering a conditional rebate to encourage reviews, we examine how the sellers' conditional-rebate strategy affects the review outcomes and social welfare. We uncover the different conditions under which unbiased (authentic) reviews or biased (fake) reviews may emerge as equilibrium outcomes and conditions that lead to social welfare gains. Our findings provide important implications for platform owners in the design and implementation of online-review guidelines and policies.

3. Model

We consider an online seller selling a product to potential consumers. As in Lal and Sarvary (1999), we distinguish two types of product properties—digital attributes and nondigital attributes. Digital attributes refer to the attributes that can be easily communicated to and assessed by consumers through the Internet before purchase. Nondigital attributes refer to those that are difficult to evaluate online, which can be determined only by trying, inspecting, or even consuming the product. For instance, size and color of a product are examples of digital attributes, and how well the product fits a consumer's specific setting can be an example of a nondigital attribute (e.g., whether a jacket fits a consumer's figure or whether a piece of furniture fits the consumer's room design/style). We denote X as the part of valuation associated with digital attributes and Y as the part of valuation associated with nondigital attributes. A consumer's valuation of the product is $X + Y$, determined by both the digital and nondigital attributes.

We assume that before purchase, each consumer learns her digital-attribute value based on information provided by the seller, such as product description. In the baseline model, we assume consumers derive the same value x from the digital attributes; that is $X = x$. In the extension, we allow for heterogeneity in digital-attribute value. In contrast, before purchase, consumers cannot exactly know their nondigital-attribute value y or its distribution, although they may have some expectation based on the available information such as online reviews. For ease of exposition, we assume that ex post y can be either high or low: Consumers derive a high value if the product fits their needs well; otherwise, they derive a low value. Without loss of generality, we assume the high value to be $2y$ and normalize the low value to 0; that is, $Y = 2y$ and $Y = 0$, respectively. As a result, consumers are either satisfied or unsatisfied after their purchase. We assume that consumers are equally likely to be satisfied or unsatisfied. In other words, they can derive high or low value from the nondigital attributes with equal probability, and the expected value is y.

We consider a two-period model and assume an independent consumer group of size 1 in each period. In the first period, consumers make purchase decisions based on price and expected product valuation without online reviews. At the end of the first period, purchasing consumers make their review-posting decisions. In the second period, consumers observe the online reviews, based on which they update their expectations on the product valuation and make purchase decisions.

In the first period, upon weighing the review-posting benefits and costs, satisfied consumers may post positive reviews about the product, and unsatisfied consumers may post negative reviews. One important reason for consumers to post reviews is that consumers have the desire for sharing.[5] We thus assume that, on the one hand, consumers derive value v from sharing their true opinions, which follows a uniform distribution over $[0,1]$. On the other hand, consumers incur a cost c ($c \geq 0$) for posting reviews due to the time and effort required. Without additional incentive, whether a consumer posts reviews is determined by her review-sharing benefit and the review-posting cost. We assume $c < 1$ to ensure that even in the absence of additional incentive, some consumers still post reviews.

To motivate more consumers to post positive reviews, the seller may offer a monetary incentive. Following the common practice on Taobao.com, we consider that the seller gives a rebate s ($s \geq 0$) to each purchasing consumer who posts positive reviews online. When the rebate is

zero, this setting reduces to the classical pricing problem. Consistent with common practice, we assume that the seller does not preannounce the rebate information (including the existence and amount), and the rebates (if any) are offered privately to buyers. Also note that this rebate is conditional on posting positive reviews. Although the monetary incentive naturally motivates more satisfied consumers to share their true opinions (i.e., provide positive reviews), the effect of this incentive on unsatisfied consumers is more nuanced. Generally an individual has an aversion to viewing oneself as a dishonest person (e.g., Shalvi et al. 2015, Gino and Ariely 2016). Following the literature (Charness et al. 2019, Duch et al. 2020), we assume consumers who lie would incur an intrinsic moral cost of lying m ($m \geq 0$). Therefore, when unsatisfied consumers post positive reviews, although they can enjoy the rebate, they not only fail to derive the value v from sharing their true opinions, but also suffer from the moral cost of cheating. To focus on more general cases, we assume that the maximum value that consumers may derive from nondigital attributes is not too high (i.e., $y \leq 1$); otherwise, the seller would always have incentive to offer a rebate.

In the second period, consumers make their purchase decisions based on their expected product valuation, which can be influenced by online reviews. In our baseline model, we assume that consumers are naïve: They do not factor in the effect of the rebate on reviews in their expectations, because they are unaware of the possible review manipulation at the time of purchase. We denote $\hat{\lambda}$ as the perceived proportion of satisfied consumers among those who purchased the product, and consumers think that with probability $\hat{\lambda}$ they will be satisfied as well (i.e., derive high value from the nondigital attributes). We denote n_g, n_b, and n_o as the numbers of purchasing consumers who post positive, negative, and no reviews, respectively. Those who post no reviews are believed to be either satisfied or unsatisfied with equal probability. Based on these notations, we have $\hat{\lambda} = \frac{n_g + 0.5n_o}{n_g + n_b + n_o}$, and the expected nondigital-attribute value is $2\hat{\lambda}y$.

We denote p_1 and p_2 as the prices charged by the seller in the first and second periods, respectively. We denote D_i, where $i \in \{1,2\}$, as the respective demand. The seller's expected profit across the two periods is as follows:

$$\Pi(p_1, p_2, s) = p_1 D_1(p_1) + p_2 D_2(p_2, p_1, s) - s \cdot n_g(p_1, s), \tag{1}$$

where the first and second terms on the right-hand side are the revenue from the purchasing consumers in the first and second periods, and the third term represents the cost of rebate to those consumers who post positive reviews. The marginal production cost is assumed to be zero. The seller chooses its product prices and rebate to maximize profit.

As illustrated in Figure 2, the timing of the game is as follows. In the first stage, the seller first announces price p_1 in the absence of online reviews, and then consumers make purchases decisions based on price p_1 and expected product valuation $x + y$. Subsequently, the seller sends products to the consumers, possibly with a rebate s attached, and then consumers make their review-posting decisions, based on the realized nondigital-attribute value, review-sharing benefit, review-posting cost, rebate (if any), and moral cost. In the second period, in the presence of online reviews, the seller first announces price p_2, and then consumers make purchases decisions based on price p_2 and expected product valuation $x + 2\hat{\lambda}y$. In each period, if the price is no greater than the expected valuation, consumers make purchases.

Table 1 summarizes the main notations used in the paper.

4. Equilibrium Analysis

In this section, we first analyze consumers' review-posting decisions and then examine the seller's pricing

Figure 2. Timing of the Game

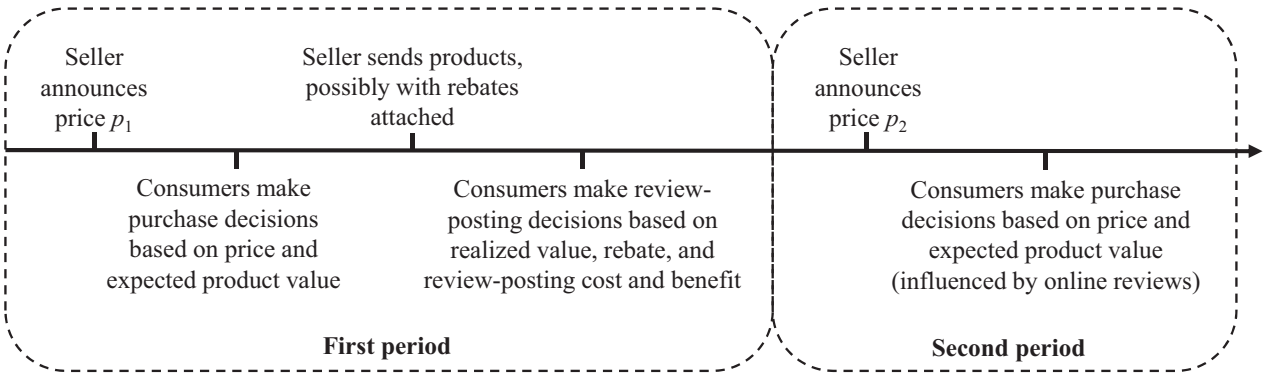


Table 1. Summary of Notations

Notation	Definition
s	Rebate amount
p_i	Product price in period i, $i \in \{1,2\}$
D_i	Demand in period i, $i \in \{1,2\}$
Π	The seller's profit
X	Digital-attribute valuation
Y	Nondigital-attribute valuation
c	Consumers' review-posting cost
m	Consumers' moral cost of lying
v	Consumers' review-sharing benefit
n_g	The number of positive reviews
n_b	The number of negative reviews
n_o	The number of purchasing consumers who post no reviews
$\hat{\lambda}$	Consumers' perceived likelihood of being satisfied

and rebate decisions. Finally, we investigate the effect of conditional rebates on the seller's equilibrium profit.

4.1. Review-Posting Decisions

Once consumers receive the product in the first period, they observe their nondigital-attribute value, which is either high or low. As a result, consumers are either satisfied or unsatisfied. Together with the product, consumers might receive the rebate. Based on rebate s, possibly moral cost m, review-sharing benefit v, and review-posting cost c, both satisfied and unsatisfied consumers make their review-posting decisions.

1. Satisfied consumers: A satisfied consumer chooses to post either positive or no reviews. If she posts a positive review, the consumer derives net value $v + s - c$ by sharing her true opinion and redeeming the rebate. The consumer derives zero value if not posting. A satisfied consumer does not have incentive to post a negative review as she derives negative value in this case.

2. Unsatisfied consumers: An unsatisfied consumer chooses to post negative, positive, or no reviews. The consumer derives net value $v - c$ if she shares her true opinion and posts a negative review, and zero value from not posting. Incentivized by the rebate, the consumer might consider posting a positive (fake) review, but doing so incurs a moral cost m from lying, leading to net value $s - m - c$.

In light of the trade-off in these options, we can derive consumers' review-posing decisions as follows.

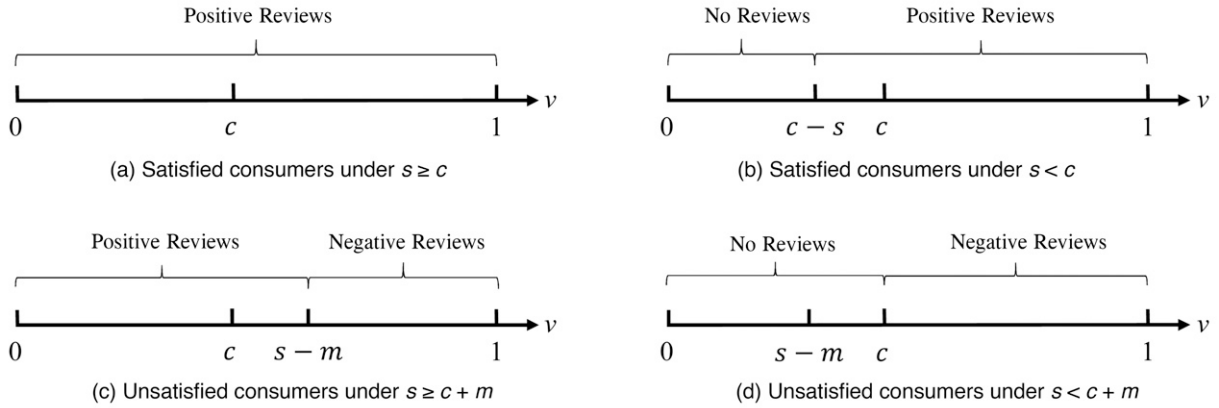
Lemma 1. *In equilibrium, satisfied consumers with v such that $v + s \geq c$ post positive reviews, and the other satisfied consumers post no reviews. Unsatisfied consumers with v such that $v \geq max\{s - m, c\}$ post negative reviews, those with v such that $s - m \geq max\{v, c\}$ post positive (fake) reviews, and the other unsatisfied consumers post no reviews.*

Proof. All proofs are in the online appendix. □

Satisfied consumers post positive reviews if the benefit from review sharing and the rebate is greater than the review-posting cost (i.e., $v + s \geq c$). When the rebate is large enough such that $s \geq c$, all satisfied consumers are motivated to post positive reviews; Otherwise, some satisfied consumers (i.e., $v < c - s$) do not post, as illustrated in Figure 3(a) and (b). Unsatisfied consumers may consider posting positive reviews only if the rebate is high enough to compensate for the moral and review-posting costs (i.e., $s \geq m + c$); Otherwise, no unsatisfied consumers post (fake) positive reviews. In the former case, as shown in Figure 3(c), the unsatisfied consumers who derive high value from sharing their true opinions (i.e., $v \geq s - m$) post negative reviews and the others post (fake) positive reviews. In the latter case, as illustrated in Figure 3(d), the unsatisfied consumers post negative reviews if the review-sharing benefit is greater than the cost (i.e., $v \geq c$) and post no reviews otherwise.

Note that, in the first period, consumers have a homogeneous expected product valuation $x + y$, and the seller will optimally price the product such that all consumers purchase. When these consumers receive the products, the realized value and the rebate s affect their review-posting decisions. Thus, the numbers of

Figure 3. Consumers' Review-Posting Decisions



purchasing consumers who post positive, negative, and no reviews (i.e., $n_g(p_1,s)$, $n_b(p_1,s)$, and $n_o(p_1,s)$) are functions of s. We next distinguish cases by the rebate level and derive the segmentation of the three consumer groups accordingly.

• **High-Rebate Case** ($s \geq c+m$). In this case, the rebate is so high that all satisfied consumers post positive reviews. Meanwhile, the unsatisfied consumers with v less than or equal to $s-m$ post (fake) positive reviews, and those with v greater than $s-m$ post negative reviews. Therefore, we have

$$n_g(p_1,s)=\frac{1}{2}+\frac{1}{2}(s-m),\ n_b(p_1,s)=\frac{1}{2}[1-(s-m)],\ \text{and}\ n_o(p_1,s)=0 \tag{2}$$

• **Intermediate-Rebate Case** ($c \leq s < c+m$). In this case, the rebate is high enough to motivate all satisfied consumers to post positive reviews but not high enough to induce any unsatisfied consumers to post positive reviews. The unsatisfied consumers with v greater than or equal to c post negative reviews, and those with lower v do not post. Therefore, we have

$$n_g(p_1,s)=\frac{1}{2},\ n_b(p_1,s)=\frac{1}{2}(1-c),\ \text{and}\ n_o(p_1,s)=\frac{1}{2}c \tag{3}$$

• **Low-Rebate Case** ($0 \leq s < c$). In this case, the rebate is low such that not all satisfied consumers are incentivized to post positive reviews. The satisfied consumers with v greater than or equal to $c-s$ post positive reviews, and those with lower v do not post. The unsatisfied consumers with v greater than or equal to c post negative reviews, and those with lower v do not post. Therefore, we have

$$n_g(p_1,s)=\frac{1}{2}[1-(c-s)],\ n_b(p_1,s)=\frac{1}{2}(1-c),\ \text{and}\ n_o(p_1,s)=\frac{1}{2}(c-s)+\frac{1}{2}c \tag{4}$$

As expected, the numbers of purchasing consumers who post positive, negative, and no reviews change with the rebate level. Moreover, the composition of each consumer segment differs under different rebate levels, leading to different functional forms for the same consumer segment in the three cases. For example, with a high rebate, both satisfied and unsatisfied consumers post positive reviews, whereas with a low rebate only satisfied consumers post positive reviews.

4.2. Price and Rebate Decisions

Anticipating the consumer segmentation, the seller maximizes its profit in Equation (1) by optimally choosing prices and rebate. The following proposition summarizes the optimal decisions in equilibrium.

Proposition 1. *The seller's optimal first-period price is $p_1^*=x+y$; the optimal second-period price and rebate are*

$$(p_2^*,s^*)=\begin{cases}(x+y,0) & \text{if } m\geq\hat{m}(c) \text{ and } c\leq\hat{c}\\ \left(x+y+\dfrac{(c+y-1)y}{4},\dfrac{c+y-1}{2}\right) & \text{if } m\geq\hat{m}(c) \text{ and } c>\hat{c}\\ \left(x+y+\dfrac{(-m+2y-1)y}{2},\dfrac{m+2y-1}{2}\right) & \text{if } m<\hat{m}(c) \text{ and } m\leq\bar{m}(c)\\ (x+y+cy,c+m) & \text{otherwise,}\end{cases} \tag{5}$$

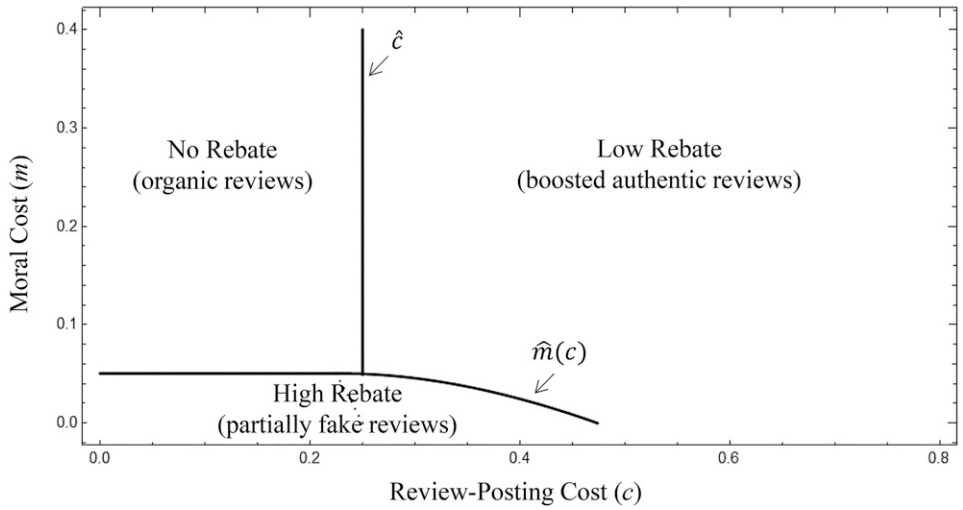
where $\hat{c}=1-y$, $\bar{m}(c)=2y-1-2c$, and

$$\hat{m}(c)=\begin{cases}(\sqrt{2y}-1)^2 & \text{if } c\leq\min\{\hat{c},\sqrt{2y}-1\}\\ \dfrac{(2y-c-1)c}{1+c} & \text{if } \min\{\hat{c},\sqrt{2y}-1\}<c\leq\hat{c}\\ 1+2y-\sqrt{(1-c)^2+2y(3+c)+y^2} & \text{if } \hat{c}<c\leq\max\left\{\hat{c},\dfrac{1}{3}(y-5+2\sqrt{y(y+2)+4})\right\}\\ \dfrac{c(6y-2)-5c^2-(1-y)^2}{4(c+1)} & \text{if } \max\left\{\hat{c},\dfrac{1}{3}(y-5+2\sqrt{y(y+2)+4})\right\}<c.\end{cases} \tag{6}$$

The proposition shows that the seller's optimal second-period price and rebate decisions critically depend on both the moral and review-posting costs. As illustrated in Figure 4, there are three equilibrium rebate strategies (no rebate, low rebate, and high rebate), corresponding to three review outcomes (organic reviews, boosted authentic reviews, and partially fake reviews).[6] Only when the moral cost is low and the review-posting cost is not too high would the seller offer a high rebate to both motivate more satisfied consumers to post positive reviews and induce unsatisfied consumers to post fake positive reviews (the high-rebate, partially-fake-review equilibrium). When the review-posting cost is high or when it is intermediate and the moral cost is high, the seller prefers to offer a low rebate to motivate more satisfied consumers to post positive reviews (the low-rebate, boosted-authentic-review equilibrium). When the review-posting cost is low but the moral cost is high, the seller prefers not to offer a rebate, resulting in organic reviews in the absence of any monetary incentive (the no-rebate, organic-review equilibrium).

The intuition is as follows. A conditional rebate can benefit the seller by boosting consumers' perceived expected

Figure 4. Equilibrium Rebate Decisions and Review Outcomes ($\gamma = \frac{3}{4}$)



valuation, but it comes with a cost. When the moral cost is high, it is very costly to induce unsatisfied consumers to lie and post fake positive reviews. As a result, the seller has no incentive to bribe unsatisfied consumers but only considers motivating satisfied consumers. There are two distinct cases: low review-posting cost and high review-posting cost. If the review-posting cost is low, a sizable proportion of satisfied consumers voluntarily share their true opinions and post positive reviews in the absence of a monetary incentive. If the seller offers a rebate, a large number of satisfied consumers who would otherwise have posted positive reviews without monetary incentive also redeem the rebate, representing a high cost to the seller. As a result, the seller chooses not to offer any rebate, yielding the no-rebate, organic-review equilibrium. On the other hand, if the review-posting cost is high, the number of consumers who voluntarily share their true opinion and post reviews is relatively small. Therefore, the benefit of inducing additional positive reviews using monetary incentives can outweigh the cost of offering the rebate. Consequently, the seller prefers to offer a low rebate to elicit more positive reviews from satisfied consumers, thus the low-rebate, boosted-authentic-review equilibrium.

In contrast, when the moral cost is very low, unsatisfied consumers are easily induced to post fake positive reviews with a monetary incentive. Therefore, offering a high rebate to engage both satisfied and unsatisfied consumers might become a valuable option to the seller. In general, fake positive reviews would lead to upward bias of consumers' perceived valuation of the nondigital attributes of the product, which is beneficial to the seller, especially when the valuation of the nondigital attributes is high. Meanwhile, satisfied consumers who would otherwise have posted positive reviews without monetary incentive also redeem the rebate, a high cost for the seller. In the presence of high valuation of the nondigital attributes, when the moral cost is very low, the total rebate cost can be compensated by the total benefit from the inflated positive reviews and consumers' increased perceived product valuation. Thus, offering a high rebate to induce fake reviews is more profitable than offering no rebate. Notice that an alternative strategy is to offer a low rebate, and its value critically depends on the review-posting cost. As discussed, if the review-posting cost is low, a sizable proportion of satisfied consumers who would otherwise voluntarily post positive reviews in the absence of any monetary incentive redeem the rebate, a high cost to the seller. The total benefit of inducing more positive reviews can be outweighed by the total rebate cost. As a result, offering a low rebate is not profitable. Therefore, if the moral cost is low and review-posting cost is not too high, offering a high rebate to induce fake reviews is optimal, resulting in the high-rebate, partially-fake-review equilibrium.

Nevertheless, when the review-posting cost is high, offering a low rebate becomes profitable because the total number of organic reviews is not large and thus the total benefit of eliciting more reviews can outweigh the total rebate cost. The seller must trade off the high-rebate strategy against the low-rebate strategy. As the review-posting cost increases, the seller needs to increase the rebate to entice consumers to post reviews. The increase in total rebate cost under the high-rebate strategy is more significant than that under the low-rebate strategy because of a larger volume of rebate redemption in the former. As a result, when the review-posting cost increases, the seller becomes less likely to offer a high rebate (i.e., $\hat{m}(c)$ decreases in c). Further, when the review-posting cost is high enough, the seller gives up bribing unsatisfied

consumers and only offers a low rebate to compensate satisfied consumers to post reviews, resulting in the low-rebate, boosted-authentic-review equilibrium. Corollary 1 summarizes the conditions under which offering a high rebate cannot be an equilibrium.

Corollary 1.

(a) *When the review-posting cost increases, the seller becomes less likely to offer a high rebate; that is,* $\hat{m}(c)$ *decreases in* c.

(b) *When the review-posting cost* $c \geq \bar{c}$, *the seller would never offer a high rebate to induce unsatisfied consumers to post fake positive reviews, where*

$$\bar{c} = \begin{cases} 2y - 1 & \text{if } y \leq \frac{2}{3} \\ \frac{1}{5}(3y - 1 + 2\sqrt{y^2 + y - 1}) & \text{if } y > \frac{2}{3}. \end{cases}$$

This corollary and Proposition 1 imply that fake positive reviews can be induced by a high rebate in equilibrium only if the moral cost is low and the review-posting cost is not too high. To induce unsatisfied consumers to post fake positive reviews, the seller needs at least to offer $m + c$ to compensate their moral and review-posting costs. Because this offer increases in review-posting cost, when the review-posting cost is high (even if the moral cost is low), the rebate offer can be high. Further, this high rebate will also be redeemed by satisfied consumers who post reviews. Therefore, when the review-posting cost is high enough (i.e., $c \geq \bar{c}$), the cost to induce fake positive reviews can be too high to be justified by its benefit, and the seller has no incentive to offer a high rebate. Instead, a low rebate to motivate satisfied consumers to post positive reviews can be desirable—the high review-posting cost limits the number of unsatisfied consumers who post negative reviews, and thus the overall effect of additional positive reviews can be significant to offset the monetary incentive offered to the satisfied consumers.

Moreover, whether the seller has an incentive to offer a rebate also depends on consumers' expected valuation of the nondigital attributes y. Analysis of y leads to the following results.

Corollary 2.

(a) *The segmentation curves* $\hat{c}$ *decreases and* $\hat{m}(c)$ *increases in* y *for* $c \in [0, 1]$.

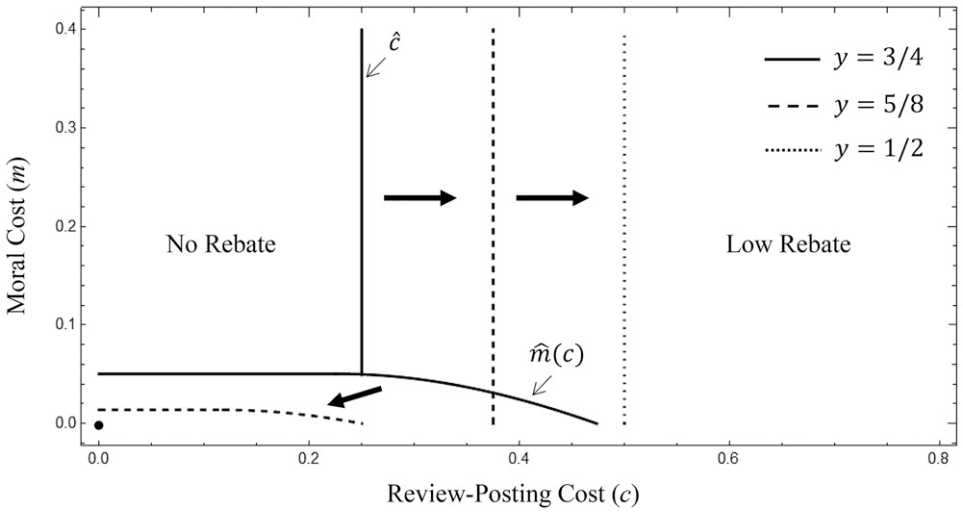
(b) *When* y *decreases, the seller is less likely to offer a rebate (either low or high).*

(c) *When* $y \leq 1/2$, *the seller never offers a high rebate regardless of the moral cost or the review-posting cost.*

The seller benefits from offering a conditional rebate to boost consumers' perceived product valuation, particularly their perceived value from the nondigital attributes. Because y measures the expected value consumers derive from the nondigital attributes, it plays a crucial role in determining the seller's rebate strategy. As illustrated in Figure 5, when y becomes smaller, the expected value from the nondigital attributes decreases, and the seller's incentive to offer either a high or low rebate decreases (the $\hat{m}(c)$ line moves downward and the $\hat{c}$ line moves to the right). In particular, when y is small enough (i.e., $y \leq 1/2$), the seller no longer has an incentive to offer a high rebate (when $y = 1/2$, $\hat{m}(c)$ shrinks to the origin point at the low-bottom corner in Figure 5 and $\bar{c} = 0$ in Corollary 1). In contrast, the seller continues to have an incentive to offer a low rebate in the case where the review-posting cost is high (i.e., $c > \hat{c}$).

In sum, it is worth noting that the seller's conditional-rebate strategy does not necessarily result in fake reviews. Fake reviews come with a high cost for the seller. Not only must the seller provide enough monetary incentive to bribe unsatisfied consumers to lie, that

Figure 5. Effect of y on Equilibrium Rebate Decisions



monetary incentive will also be taken by satisfied consumers who would otherwise have posted positive reviews without the rebate. Only when the moral cost is low, the review-posting cost is not too high, and the expected value from nondigital attributes is high, would the seller prefer a high-rebate strategy and would fake reviews appear in equilibrium. Further, numerically, we find that offering a low rebate is more likely to arise as an equilibrium than a high rebate in the entire feasible parameter space we examine. Under the low-rebate equilibrium, the rebate is used to motivate more satisfied consumers to share their true opinions, rather than to bribe unsatisfied consumers to lie and post fake reviews. This finding sheds new light on the criticism and concern about the fake-review phenomenon induced by the conditional-rebate strategy.

4.3. Effect of Conditional Rebate on the Seller's Profit

We next examine the effect of a conditional rebate on the seller's equilibrium profit. We use the case in which no rebate is considered (i.e., the price-only strategy) as the benchmark to examine how the conditional-rebate strategy affects the equilibrium outcome.

By substituting the equilibrium prices and rebate into the profit function in Equation (1), we can derive the seller's equilibrium profit.

Proposition 2. *The seller's equilibrium profit is*

$$\Pi^* = \begin{cases} 2(x+y) & \text{if } m \geq \hat{m}(c) \text{ and } c \leq \hat{c} \\ 2(x+y) + \dfrac{(c+y-1)^2}{8} & \text{if } m \geq \hat{m}(c) \text{ and } c > \hat{c} \\ 2(x+y) + \dfrac{(m+2y-1)^2 - 8my}{8} & \text{if } m < \hat{m}(c) \text{ and } m \leq \bar{m}(c) \\ 2(x+y) + \dfrac{2cy - (1+c)(c+m)}{2} & \text{otherwise.} \end{cases} \tag{7}$$

where $\hat{c}$, $\bar{m}(c)$, *and* $\hat{m}(c)$ *are defined in Proposition 1.*

To examine the effect of a conditional rebate on the seller's profit, we study a benchmark case in which no rebate is considered. In the benchmark, the seller maximizes its expected profit by optimally choosing prices only, which leads to the same solution as when the seller decides to offer no rebate under the conditional-rebate strategy (i.e., $s^* = 0$). As a result, the equilibrium prices and profit in Propositions 1 and 2 when the seller chooses to offer no rebate are the equilibrium outcome for the benchmark case. That is, the seller offers the same price $p_b^* = x + y$ in the two periods and obtains the equilibrium profit $\Pi_b^* = 2(x+y)$.

Notice that under the conditional-rebate strategy, the seller always has the option to offer zero rebate. The seller chooses to offer a positive conditional rebate only if doing so is more profitable than offering no rebate. Therefore, the option to offer a conditional rebate makes the seller (weakly) better off.

We next examine how the seller may gain from the conditional rebate. The conditional rebate is costly, because consumers who post positive reviews are paid by the seller. The seller can be better off only if the benefit from the rebate offsets the cost, and the benefit essentially stems from the consumers' boosted product valuation. Compared with the price-only strategy under the benchmark case, Proposition 3 shows how the conditional-rebate strategy alters the equilibrium profit, demand, and price.

Proposition 3.

(a) *The equilibrium profit under the conditional-rebate strategy is (weakly) greater than that in the benchmark case (i.e.,* $\Pi^* \geq \Pi_b^*$*).*

(b) *When a positive rebate is offered in the first period, the equilibrium second-period price under the conditional-rebate strategy is higher than that in the benchmark case (i.e.,* $p_2^* > p_b^*$*). However, the price premium is smaller than the rebate amount (i.e.,* $p_2^* - p_b^* < s^*$*).*

When consumers' perceived value of nondigital attributes is boosted by more positive reviews induced by the monetary incentive, their overall valuation and willingness to pay for the product increase. The seller strategically raises its product price to maximize profit. As a result, the second-period price under the conditional-rebate strategy is higher than that under the price-only strategy.

Notice that, compared with the benchmark, the seller charges a price premium from each consumer in the second period because of the enhanced product valuation. However, the seller incurs the rebate cost s^* for each purchasing consumer who redeems the rebate in the first period, and the rebate amount is larger than the price premium. Therefore, even with an increased product price, offering a rebate involves a net cost for the seller.

Next, we examine how the moral cost and review-posting cost affect the seller's equilibrium profit. First, in the equilibrium when no rebate is offered, neither the consumers' nor the seller's decisions involve a moral cost, and thus the seller's profit is independent of moral cost. In addition, because the review-posting cost dictates consumers' review-posting decisions in the same way whether a consumer is satisfied or unsatisfied, it does not affect the proportion of positive reviews among purchasing consumers. Consequently, consumers' perceived expected utilities are independent of review-posting cost, as is the seller's profit. Proposition 4 summarizes the other cases when a low or high rebate is offered.

Proposition 4.

(a) *In the equilibrium when a low rebate is offered, the rebate amount, second-period price, and seller's profit increase in review-posting cost and are independent of moral cost (i.e.,* $\frac{\partial s^*}{\partial c} > 0$, $\frac{\partial p_2^*}{\partial c} > 0$, $\frac{\partial \Pi^*}{\partial c} > 0$, $\frac{\partial s^*}{\partial m} = 0$, $\frac{\partial p_2^*}{\partial m} = 0$, *and* $\frac{\partial \Pi^*}{\partial m} = 0$ *for* $m > \hat{m}(c)$ *and* $c > \hat{c}$*).*

(b) *In the equilibrium when a high rebate is offered, the rebate amount and second-period price (weakly) increases and the seller's profit (weakly) decreases in review-posting cost; the rebate amount increases, the second-period price (weakly) decreases, and the seller's profit decreases in moral cost (i.e.,* $\frac{\partial s^*}{\partial c} \geq 0$, $\frac{\partial p_2^*}{\partial c} \geq 0$, $\frac{\partial \Pi^*}{\partial c} \leq 0$, $\frac{\partial s^*}{\partial m} > 0$, $\frac{\partial p_2^*}{\partial m} \leq 0$, *and* $\frac{\partial \Pi^*}{\partial m} < 0$ *for* $m \leq \hat{m}(c)$*).*

In the equilibrium when a low rebate is offered, first, because the consumers' and seller's decisions do not involve a moral cost, the rebate amount, second-period price, and seller's profit are independent of moral cost. Second, interestingly, we find that the seller's profit increases in review-posting cost. The rationale behind this counterintuitive result is as follows. Notice that only satisfied consumers redeem the rebate in this case. There are two groups: those who are incentivized by the rebate to post positive reviews and those who claim the rebate as a free gift and would have written positive reviews without the rebate. The first group brings a benefit by boosting positive reviews but the second group creates a pure cost to the seller because this group of consumers would have posted positive reviews in the absence of any monetary incentive. When the review-posting cost increases, the number of consumers in the second group decreases, which reduces the seller's pure cost and the marginal cost of the rebate. Therefore, the seller is willing to offer a higher rebate, incentivizing more consumers in the first group to boost reviews, which, in turn, enhances consumers' product valuation, enabling the seller to charge a higher price in the second period. As a result, the seller's total profit increases.

In the equilibrium when a high rebate is offered, both satisfied and unsatisfied consumers redeem the rebate. In sharp contrast, the seller's profit (weakly) decreases in review-posting cost. With the high rebate offering in this case, all satisfied consumers redeem the rebate regardless of the amount. The equilibrium rebate amount is primarily determined by the incentive required to induce unsatisfied consumers to post fake reviews. When the review-posting cost is relatively high (i.e., $c \geq \bar{m}^{-1}(m)$ in Proposition 1), the seller optimally sets the rebate at $(c + m)$, which is the minimum amount required to cover unsatisfied consumers' review-posting and moral costs to induce some of them to post fake reviews. Therefore, the rebate increases in review-posting cost. Meanwhile, the increased rebate leads to a larger proportion of unsatisfied consumers posting fake reviews, resulting in higher perceived product valuation and higher equilibrium price in the second period. However, the second-period's gain cannot outweigh the first-period's total rebate costs, resulting in decreased seller's profit. When the review-posting cost is low, the seller has an incentive to rebate more than the minimum amount required to induce fake reviews. In this case, unsatisfied consumers trade off the options of posting fake reviews (with payoff $s - m$) and posting their true opinions (with payoff v). Subsequently, as also shown in Equation (5) of Proposition 1 (the third case), the review-posting cost becomes irrelevant. As a result, the rebate amount, second-period price, and seller's profit are independent of review-posting cost.

In addition, in the high-rebate equilibrium, unsatisfied consumers are paid to lie and post fake reviews, which involves moral cost. The rebate needs to be high enough to cover the moral cost. In this case, the amount of rebate increases in moral cost. Consequently, the equilibrium profit decreases in moral cost. The equilibrium second-period price also decreases because, in the presence of a higher moral cost, fewer unsatisfied consumers lie and post fake reviews in equilibrium.

5. Extensions

In the previous sections, we have developed a stylized model to study the seller's optimal conditional-rebate strategies and consumers' equilibrium review-posting decisions. In this section, we extend our baseline model in five directions by considering (1) consumers' heterogeneous digital-attribute valuation, (2) the effect of review manipulation on consumer satisfaction, (3) sophisticated consumers, (4) the unequal likelihood of being satisfied and unsatisfied, and (5) consumers' alternative belief updating rule. We demonstrate that the main insights gained from our baseline model are robust under these various model extensions.

5.1. Heterogeneous Digital-Attribute Valuation

To focus on the influence of review manipulation on nondigital-attribute valuation, in the baseline model we assume that consumers derive the same valuation from the digital attributes. In this extension, we allow consumers to have heterogeneous digital-attribute valuation. Similar to the nondigital-attribute valuation, we assume that the digital-attribute valuation can take either a high value $2x$ or a low value 0 with equal likelihood; that is, $X = 2x$ and $X = 0$, respectively. Everything else stays the same as in the baseline model.

In general, when x is small, the heterogeneity of consumer valuation is relatively small, and all consumers purchase the product in equilibrium, leading to similar results as in the baseline model. To focus on

more interesting cases, we consider that x is relatively large such that in the first period, significant heterogeneity in consumer product valuation exists and only the consumers with high digital-attribute value purchase the product in equilibrium. In the second period, whether only consumers with high digital-attribute value or consumers with both high and low digital-attribute value purchase the product depends on the equilibrium price in this period, which is affected by the rebate offered in the first period. We focus on the cases in which consumers with both high and low digital-attribute value purchase the product under a high-rebate equilibrium, whereas under a low-rebate equilibrium either only consumers with high digital-attribute value or consumers with both high and low digital-attribute value purchase. For ease of exposition, we consider that y is not too large such that, in equilibrium, the seller has no incentive to induce all purchasing consumers to post positive reviews. The other cases lead to similar results and insights.

Following the same approach as in the baseline model, we can derive the equilibrium outcome. Consumers' review-posting decisions remain the same as in Lemma 1. Similar to Proposition 1, the following proposition summarizes the seller's optimal decisions in equilibrium.

Proposition 5. *When* $x \geq \max\left\{\frac{8y+y^2}{16}, \frac{8y+13y^2+8y\sqrt{1+y+y^2}}{48}\right\}$, *the seller's optimal first-period price is* $p_1^* = 2x + y$; *the optimal second-period price and rebate are*

$$(p_2^*, s^*) = \begin{cases} (2x+y, 0) & \text{if } m \geq \hat{m}(c) \text{ and } c \leq \hat{c} \\ \left(2x+y+\frac{(c+y-1)y}{4}, \frac{c+y-1}{2}\right) & \text{if } m \geq \hat{m}(c) \text{ and } \hat{c} < c \leq \tilde{c} \\ \left(y+\frac{(c+2y-1)y}{4}, \frac{c+2y-1}{2}\right) & \text{if } m \geq \hat{m}(c) \text{ and } c > \tilde{c} \\ \left(y+\frac{(-m+4y-1)y}{2}, \frac{m+4y-1}{2}\right) & \text{if } m < \hat{m}(c) \text{ and } m \leq \bar{m}(c) \\ (y+cy, c+m) & \text{otherwise} \end{cases} \tag{8}$$

where $\hat{c} = 1-y$, $\tilde{c} = \frac{16x-3y(2+y)}{2y}$, $\bar{m}(c) = 4y-1-2c$, *and* $\hat{m}(c)$ *is defined in Equation* (34) *in the online appendix*.

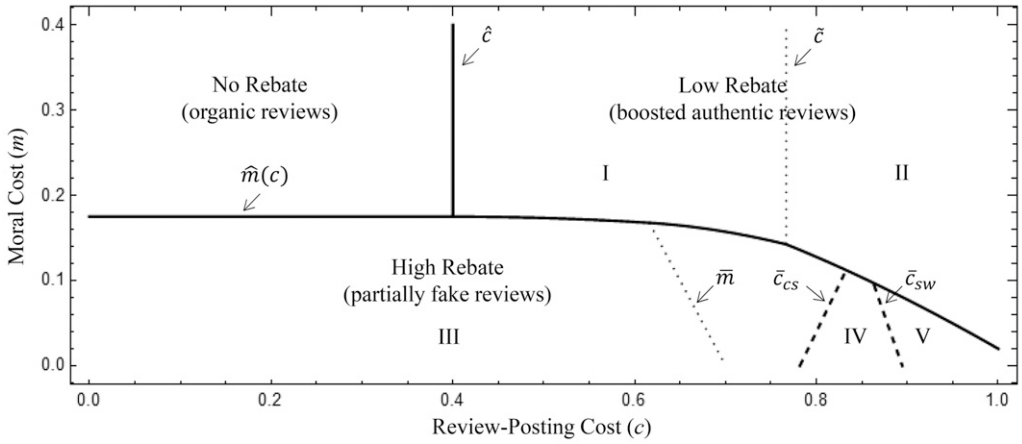
Similar to the baseline model, Proposition 5 shows three types of equilibrium strategies: the no-rebate equilibrium where only consumers with high digital-attribute value purchase in the second period (the first expression in Equation (8)), the low-rebate equilibria in which either only consumers with high digital-attribute value (the second expression) or all consumers (the third expression) purchase in the second period, and the high-rebate equilibrium in which all consumers purchase in the second period (the fourth and fifth expressions). Consequently, we can derive the seller's equilibrium profit (which can be found in the proof of Proposition 5). As in Proposition 3, the seller is better off by strategically offering conditional rebates. Further, we can show how the rebate amount, second-period price, and profit change in review-posting and moral costs. The same insights as in Proposition 4 carry over.

As illustrated in Figure 6, the equilibrium rebate strategies of the extended model share the same pattern as in the baseline model. The main difference is that in this extended model, depending on market conditions, either all consumers or only consumers with high digital-attribute value purchase the product (whereas in the baseline model all consumers purchase because of the lack of valuation heterogeneity before purchase). In region I of Figure 6 when a low rebate is offered, because the rebate amount is small (due to the low review-posting cost, by Proposition 4), the boost to consumers' perceived nondigital-attribute valuation is limited. As a result, the heterogeneity among consumer valuation continues to be significant, and the seller optimally chooses the price to induce high-valuation consumers only to purchase. When a low rebate is offered in the presence of high review-posting costs (region II of Figure 6) or when a high rebate is offered, the boost of consumers' perceived nondigital-attribute valuation is significant, which dwarfs the heterogeneity in consumers' digital-attribute valuation and homogenizes their perceived overall product valuation. Consequently, in these cases, the seller optimally crafts the pricing strategy to induce both high- and low-valuation consumers to purchase.

This extended setting with heterogeneous valuation in both digital and nondigital attributes allows for a generic discussion for social welfare. We next examine the effect of a conditional rebate on social welfare and consumer surplus. Social value consists of two parts. First, the transaction between a consumer and the seller creates value $X + Y$. Second, consumers' review-posting behavior also creates value—posting their true opinions (either positive or negative) creates value $v - c$, and posting fake reviews creates value $(-c - m)$, where m is the moral cost of lying. Consumer surplus is the social welfare minus the seller's profit.

When a low rebate or no rebate is offered (i.e., when $m \geq \hat{m}(c)$), only a proportion of purchasing consumers post their true opinions. In the cases where only consumers with high digital-attribute value purchase and where all consumers purchase

Figure 6. Effect of a Conditional Rebate on Social Welfare and Consumer Surplus



in the second period, the respective social welfare can be formulated as

$$\begin{cases}\left[\frac{1}{2}(2x+y)+\frac{1}{2}(2x+y)\right]+\frac{1}{4}\int_{c-s}^{1}(v-c)dv+\frac{1}{4}\int_{c}^{1}(v-c)dv\\ \left[\frac{1}{2}(2x+y)+(x+y)\right]+\frac{1}{4}\int_{c-s}^{1}(v-c)dv+\frac{1}{4}\int_{c}^{1}(v-c)dv\end{cases} \tag{9}$$

The two terms in the brackets capture the social value created by the transactions in the first and second periods, respectively. The first and second integrals represent the social value created by satisfied and unsatisfied consumers who post their true opinions, respectively. Notice that $s = 0$ in the first expression corresponds to both the no-rebate equilibrium case and the benchmark case. Similarly, we can formulate social welfare when a high rebate is offered.

By deriving social welfare and consumer surplus and comparing the equilibrium outcomes with the benchmark case, Proposition 6 summarizes the effects of the conditional rebate.

Proposition 6. *In the equilibrium prescribed by Proposition 5, compared with the benchmark case,*

(a) *when a low rebate is offered, social welfare and consumer surplus are greater if and only if the review-posting cost is relatively high; that is,* $c > \tilde{c}$, *where* $\tilde{c}$ *is defined in Proposition 5.*

(b) *when a high rebate is offered, social welfare and consumer surplus are greater if and only if the review-posting cost is relatively low; that is,* $c < \bar{c}_{sw} \equiv \frac{-m+\sqrt{m^2+12y}}{3}$ *concerning social welfare, and* $c < \bar{c}_{cs}$ *concerning consumer surplus, where* $\bar{c}_{cs}$ *is defined in Equation* (36) *in the online appendix.*

Compared with the benchmark case where no rebate is offered, the social gain associated with a conditional rebate comes from the additional transactions resulting from consumers' boosted expected utilities because of the additional positive reviews induced by the monetary incentive. The social loss associated with a conditional rebate stems from consumers who post reviews when their review-sharing benefits are below their review-posting cost and from some consumers being induced to post fake reviews, incurring both review-posting and moral costs. In the absence of a rebate, consumers post reviews if and only if the review-sharing benefit is greater than or equal to the review-posting cost, which is socially efficient. The rebate distorts the consumers' review-posting behavior, and the degree of distortion depends on the rebate amount.

Under the conditional rebate strategy, social welfare increases in areas II, III, and IV in Figure 6. As shown in Proposition 6 and area I in Figure 6, when a conditional rebate does not generate additional transactions in the second period, the social gain diminishes and the conditional rebate fails to increase social welfare. In other words, because prices and rebates represent internal transfers within the social system, only if the conditional rebate results in additional transactions could social welfare increase. However, the additional transactions do not guarantee an increase in social welfare, as shown by Proposition 6 and illustrated as area V in Figure 6. When a high rebate is offered, many unsatisfied consumers are induced to post fake reviews. In this case, the social loss is considerable because these consumers do not derive any review-sharing benefit but incur moral cost in addition to the review-posting cost. As a result, when the review-posting cost is very high or when both the moral and review-posting costs are relatively high, the social loss could outweigh the social gain and the conditional rebate decreases social welfare.

The effect of conditional rebates on consumer surplus follows a similar pattern as that on social welfare.

Compared with the benchmark case where no rebate is offered, consumer surplus is likely to be boosted when the rebate is high or the second-period product price is low. Under these conditions, conditional rebates can bring in additional transactions and might improve social welfare. However, the conditions for social welfare and consumer surplus improvement are not identical. First, the increase of consumer surplus can only occur when social welfare increases because social welfare is the sum of the seller's profit and consumer surplus. In equilibrium, the seller chooses to offer conditional rebates only if doing so is profitable. Therefore, consumers can benefit from conditional rebates only if the total "pie" (social welfare) is enlarged and the seller transfers a proportion of its gains to consumers. Second, under some conditions, social welfare increases but consumer surplus decreases, and the seller benefits from conditional rebates at the cost of consumers. This occurs when the review-posting cost is high and the moral cost is low under a high-rebate equilibrium, as shown in area IV in Figure 6. In this case, the seller charges a high equilibrium second-period price because the second-period price increases in review-posting cost and decreases in moral cost (as discussed in Proposition 4(b)), hurting consumer surplus.

5.2. Effect of Review Manipulation on Consumer Satisfaction

In the baseline model, we assume that consumers' postpurchase satisfaction is determined by the realized value in the nondigital attributes. A more general case, similar to that explored by previous work (e.g., Ho et al. 2017b), could be that consumers' prepurchase belief (i.e., perceived likelihood of deriving a high value) on the nondigital attributes might play a role in affecting their postpurchase degree of satisfaction and word of mouth. In particular, when the perceived likelihood becomes higher, a consumer will feel more disappointed if the realized value turns out to be low, and will feel less excited if the realized value turns out to be high. In line with this argument, we incorporate the effect of review manipulation on the degree of consumer satisfaction and their review-posting decisions in this extension.

In the baseline model, without review manipulation, consumers have prior $\lambda = \frac{1}{2}$, the probability they derive a high value from nondigital attributes. In the presence of manipulated reviews, the consumers' updated belief is $\hat{\lambda}$, which is higher than the prior. In this extension, we consider that this inflated perception causes a negative postpurchase reaction and reduces the degree of satisfaction. In particular, in contrast to the review-posting benefit v in the baseline, we assume that satisfied consumers derive value $v - k(\hat{\lambda} - \lambda)(2y)$ from posting positive views, and unsatisfied consumers derive $v + k(\hat{\lambda} - \lambda)(2y)$ from posting true opinions. As a result, compared with the baseline case, satisfied consumers have less incentive to post positive reviews, and unsatisfied consumers have greater incentive to post negative reviews. The term $(\hat{\lambda} - \lambda)(2y)$ captures the distortion in the expected value of the nondigital attributes, and k is the coefficient capturing the sensitivity of consumer reaction to the distortion. Because there is no distortion for consumers in the first period, their review-posting decisions are not affected. To model the effect of review manipulation on consumers' review-posting decisions, we consider that a proportion θ of the second-period consumers are early arrivals and the other $(1-\theta)$ proportion late arrivals.[7] The early arrivals' reviews-posting behavior is influenced by distortion caused by the seller's review manipulation. The late arrivals' perceived value of the nondigital attributes is influenced by the accumulated reviews; that is, the reviews posted by the consumers in the first period and by the early arrivals in the second period. We assume that the proportion of late arrivals is not too small such that it is in the seller's best interest to serve them. Everything else remains the same as in the baseline model. When $\theta = 0$, this extension reduces to the baseline model.

Following the same approach as in the baseline model, we can derive the seller's optimal decisions in equilibrium, as summarized in the following proposition.

Proposition 7. *In the presence of the negative effect of review manipulation on consumer satisfaction, the seller's optimal first-period price is* $p_1^* = x + y$*; the optimal second-period price and rebate are*

$$(p_2^*, s^*) = \begin{cases} (x+y, 0) & \text{if } m \geq \hat{m}(c) \text{ and } c \leq \hat{c} \\ \left(x+y+\dfrac{(c+\phi y-1)\phi y}{4}, \dfrac{c+\phi y-1}{2}\right) & \text{if } m \geq \hat{m}(c) \text{ and } c > \hat{c} \\ \left(x+y+\dfrac{(-m+2\phi y-1)\phi y}{2}, \dfrac{m+2\phi y-1}{2}\right) & \text{if } m < \hat{m}(c) \text{ and } m \leq \bar{m}(c) \\ (x+y+c\phi y, c+m) & \text{otherwise,} \end{cases} \tag{10}$$

where $\phi = \frac{1-k\theta y}{1+\theta}$, $\hat{c} = 1 - \phi y$, $\bar{m}(c) = 2\phi y - 1 - 2c$, *and* $\hat{m}(c)$ *is defined in Equation* (46) *in the online appendix.*

Proposition 7 shows that the seller's optimal rebate offering shares the same pattern as that in the baseline model. In particular, there are three equilibrium rebate strategies (no rebate, low rebate, and high rebate), corresponding to three review outcomes (organic reviews, boosted authentic reviews, and partially fake reviews). We can derive the seller's equilibrium profit (in the proof of Proposition 7) and show the seller is better off by strategically offering conditional rebates as in

Proposition 3. Further, we can show the insights in Proposition 4 regarding how the rebate amount and profit change in the review-posting and moral costs remain the same.

The primary quantitative difference from the baseline model is that in this case the seller is less likely to offer conditional rebates, manifested by an incentive-dilution factor ϕ, $\phi \le 1$. Intuitively, the purpose of offering conditional rebates is to boost consumers' perceived value. Considering the subsequent negative effect of inflated perceptions on consumer satisfaction, the seller has less incentive to offer conditional rebates because although inflation allows the seller to take advantage of immediate buyers, these buyers are more likely to post negative reviews due to the inflation, negatively affecting the seller's subsequent profitability. Essentially, in addition to the trade-off between the valuation inflation and rebate costs, the negative effect of review manipulation on consumer satisfaction serves as an additional force to prevent the seller from overusing conditional rebates. Qualitatively, the underlying driving forces and the rebate-offering patterns in the baseline model continue to hold, and the same insights carry over.

5.3. Sophisticated Consumers

In the baseline model, we assume that consumers are naïve in the sense that they do not factor in the effect of the rebate on reviews in their expectations. Realizing that the seller could manipulate reviews, consumers might discount the observed positive reviews in their belief formation. In this extension, we consider this general case.

Note that the perceived likelihood of being satisfied in the baseline model is $\hat{\lambda} = \frac{n_g + 0.5n_o}{n_g + n_b + n_o}$, which can be rewritten as $(\frac{n_g + n_b}{n_g + n_b + n_o} \cdot \frac{n_g}{n_g + n_b} + \frac{n_o}{n_g + n_b + n_o} \cdot \frac{1}{2})$; that is, similar to that in Bayesian updating, the perceived likelihood is the weighted average of the positive review ratio $\frac{n_g}{n_g + n_b}$ and consumers' prior $\frac{1}{2}$, and the weights are the proportions of purchasing consumers who write reviews and who do not, respectively. In this extension, we consider that consumers discount the ratio of observed positive review by a factor α, $\alpha \in (0, 1]$, and consequently, the perceived likelihood becomes

$$\hat{\lambda} = \alpha \cdot \frac{n_g + n_b}{n_g + n_b + n_o} \cdot \frac{n_g}{n_g + n_b} + \left(1 - \alpha \cdot \frac{n_g + n_b}{n_g + n_b + n_o}\right) \cdot \frac{1}{2} \tag{11}$$

where α reflects the degree of consumers' naïveté or, equivalently, $(1 - \alpha)$ measures the degree of consumers' sophistication. Everything else stays the same as in the baseline model. When $\alpha = 1$, this general model reduces to the baseline model.

Following the same approach as in the baseline model, we can replicate all the main results. Proposition 8 shows the seller's equilibrium choice.

Proposition 8. *When consumers are sophisticated, the seller's optimal first-period price is $p_1^* = x + y$; the optimal second-period price and rebate are*

$$(p_2^*, s^*) = \begin{cases} (x + y, 0) & \text{if } m \ge \hat{m}(c) \text{ and } c \le \hat{c} \\ \left(x + y + \dfrac{(c + \alpha y - 1)\alpha y}{4}, \dfrac{c + \alpha y - 1}{2}\right) & \text{if } m \ge \hat{m}(c) \text{ and } c > \hat{c} \\ \left(x + y + \dfrac{(-m + 2\alpha y - 1)\alpha y}{2}, \dfrac{m + 2\alpha y - 1}{2}\right) & \text{if } m < \hat{m}(c) \text{ and } m \le \bar{m}(c) \\ (x + y + c\alpha y, c + m) & \text{otherwise,} \end{cases} \tag{12}$$

where $\hat{c} = 1 - \alpha y$, $\bar{m}(c) = 2\alpha y - 1 - 2c$, and $\hat{m}(c)$ is defined in Equation (47) in the online appendix.

Notice that the seller's optimal price and rebate decisions and the corresponding boundary conditions take the same functional form as in Proposition 1 in the baseline model. The only difference is that now the seller's decisions depend on the degree of consumers' naïveté. When $\alpha = 1$, the extension reduces to the baseline model.

As in the baseline model, the above result shows that the seller's optimal price and rebate decisions critically depend on both the moral and review-posting costs. There are three equilibrium rebate strategies (no rebate, low rebate, and high rebate), corresponding to three review outcomes (organic reviews, boosted reviews, and fake reviews). Only when the moral cost is low and the review-posting cost is not too high would the seller offer a high rebate, which results in fake positive reviews. When the review-posting cost is high or when it is intermediate and the moral cost is high, the seller prefers to offer a low rebate, which leads to boosted authentic reviews. When the review-posting cost is low but the moral cost is high, the seller prefers to offer no rebate, yielding organic reviews. The intuition is the same as in the baseline model.

The difference is that now the degree of naïveté also plays a role in the seller's equilibrium rebate offering, manifested in the segmentation curves $\hat{c}$ and $\hat{m}(c)$. Intuitively, this is because when consumers are sophisticated, the seller cannot fully fool them by manipulating reviews with a monetary incentive, and thus the seller is less likely to offer a rebate than in the baseline model. Qualitatively, the underlying driving forces and the rebate-offering patterns continue to hold, and the same insights in the baseline model carry over.

5.4. Unequal Likelihood of Being Satisfied and Unsatisfied

In the baseline model, we assume that a consumer derive a high or low value with equal likelihood from the nondigital attributes and, consequently, the consumer is equally likely to be satisfied or unsatisfied. In this extension, we allow this likelihood to differ. In particular, we assume that with probability λ, a consumer derives a high value and with probability $(1-\lambda)$, a low value from nondigital attributes, where $\lambda \in (0,1)$. Everything else remains the same as in the baseline model. When $\lambda = \frac{1}{2}$, this extension reduces to the baseline model. For ease of exposition, we let $\lambda \geq \frac{1}{3}$; the other cases can be similarly analyzed and do not generate additional insights.

Following the same approach as in the baseline model, we can derive the seller's optimal decisions in equilibrium, as summarized in the following proposition.

Proposition 9. *The seller's optimal first-period price is* $p_1^* = x + 2\lambda y$*; the optimal second-period price and rebate are*

$$(p_2^*, s^*) = \begin{cases} (x+2\lambda y, 0) & \text{if } m \geq \hat{m}(c) \text{ and } c \leq \hat{c} \\ \left(x+2\lambda y + [c+2(1-\lambda)y-1](1-\lambda)\lambda y, \dfrac{c+2(1-\lambda)y-1}{2}\right) & \text{if } m \geq \hat{m}(c) \text{ and } c > \hat{c} \\ \left(x+2\lambda y + [(1-\lambda)(2y-m)-\lambda]y, \dfrac{m+2y+1}{2} - \dfrac{1}{2(1-\lambda)}\right) & \text{if } m < \hat{m}(c) \text{ and } m \leq \bar{m}(c) \\ (x+2\lambda y + 2(c-c\lambda)y, c+m) & \text{otherwise,} \end{cases}$$

where $\hat{c} = 1-2(1-\lambda)y$, $\bar{m}(c) = 1+2y-2c-\frac{1}{1-\lambda}$, *and* $\hat{m}(c)$ *is defined in Equation* (56) *in the online appendix.*

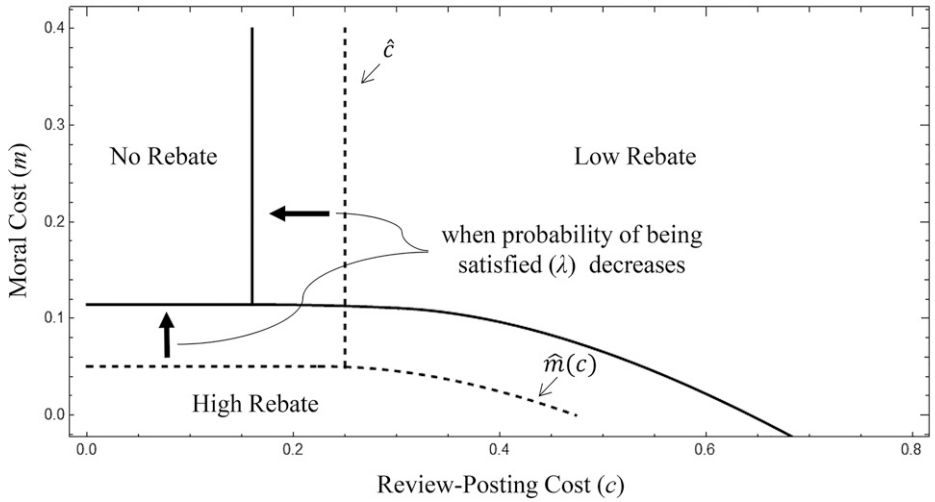
As in the baseline model, the no-rebate, low-rebate, and high-rebate strategies could arise in equilibrium, and the equilibrium pattern and insights remain the same. As shown in Figure 7, the proposition also reveals the effect of λ on the seller's optimal strategies—as λ decreases, the seller is more likely to adopt the conditional-rebate strategy (the $\hat{m}(c)$ line moves upwards and the $\hat{c}$ line moves to the left). Intuitively, when λ decreases, the number of satisfied consumers who would otherwise have posted positive reviews without monetary incentive decreases. Because offering a rebate to this group of consumers incurs a pure cost to the seller, the reduced size in this group provides the seller a greater incentive to offer rebates, benefiting from inflated nondigital-attribute valuation. Moreover, because under the high-rebate strategy all the satisfied consumers would redeem the rebate, whereas under the low-rebate strategy only part of the satisfied consumers redeem, the reduction in the size of the satisfied consumer group has more significant effect on the seller's cost under the high-rebate strategy. As a result, between the high-rebate and low-rebate strategies, the seller is more likely to prefer the high-rebate strategy (i.e., $\hat{m}(c)$ line moves upwards for $c \geq \hat{c}$) when λ decreases. In sum, our analysis reveals that a lower likelihood of consumer satisfaction provides the online sellers stronger incentives to adopt conditional-rebate strategies and vice versa.

Further, as in the baseline model, we can derive the seller's equilibrium profit (which can be found in the proof of Proposition 9) and show that the seller is better off by strategically offering conditional rebates. We can also show that the insights of how the rebate amount, second-period price, and profit change in review-posting and moral costs carry over.

5.5. Alternative Updating Rule

In the baseline model, we assume that when consumers in the second period form their beliefs about

Figure 7. Effect of Probability of Being Satisfied



the proportion of purchasing consumers who are satisfied (i.e., the probability of deriving a high value in the nondigital attributes $\hat{\lambda}$), they consider the number of purchasing consumers who do not post reviews in the first period. This assumption is motivated by the practice that sales information is typically disclosed to consumers on sellers' web pages (e.g., Liu et al. 2017). In this extension, we assume that such sales information is unavailable and consumers form their beliefs solely based on the numbers of positive and negative reviews. In particular, we let $\hat{\lambda} = \frac{n_g}{n_g+n_b}$. Everything else remains the same as the baseline model.

Following the same approach as in the baseline model, we can derive the seller's optimal decisions in equilibrium, as summarized in the following proposition.

Proposition 10. *The seller's optimal first-period price is* $p_1^* = x + y$*; the optimal second-period price and rebate are*

$$(p_2^*, s^*) = \begin{cases} (x+y, 0) & \text{if } m \geq \hat{m}(c) \text{ and } c \leq \hat{c} \\ \left(x+y+\dfrac{s_l^* y}{2-2c+s_l^*}, s_l^*\right) & \text{if } m \geq \hat{m}(c) \text{ and } c > \hat{c} \\ \left(x+y+\dfrac{(-m+2y-1)y}{2}, \dfrac{m+2y-1}{2}\right) & \\ \qquad \text{if } m < \hat{m}(c) \text{ and } m \leq \bar{m}(c) & \\ (x+y+cy, c+m) \quad \text{otherwise,} & \end{cases}$$

where $\hat{c} = 1-\sqrt{y}$, $\bar{m}(c) = 2y-1-2c$, $s_l^* = \{s \in (0,1) | (1-c+2s)(2-2c+s)^2 - 4y(1-c) = 0\}$, *and* $\hat{m}(c)$ *is defined in Equation* (59) *in the online appendix.*

As in the baseline model, Proposition 10 shows that three types of rebate strategies (i.e., the no-rebate, low-rebate, and high-rebate strategies) arise in equilibrium in the same pattern. We can derive the seller's equilibrium profit (in the proof of Proposition 10) and show the seller is better off by strategically offering conditional rebates as in Proposition 3. Further, we can show the insights in Proposition 4 remain the same regarding how the rebate amount, second-period price, and profit change in the review-posting and moral costs.

The only quantitative difference from the baseline model is that in this case the low-rebate strategy is more likely to arise as an equilibrium. Technically, for example, the $\hat{c}$ curve shifts toward the left, compared with that in the baseline model. Intuitively, in the baseline model, consumers consider the purchasing consumers who post no reviews and use their prior to update beliefs about the likelihood of being satisfied. In contrast, in this alternative setting, consumers solely rely on the number of consumers who post positive or negative reviews, ignoring the number of consumers posting no reviews and the prior. Therefore, they can be influenced more easily by manipulated reviews. This difference manifests saliently under the low-rebate strategy because of the nonnegligible proportion of consumers posting no reviews. The high-rebate strategy is unaffected because the rebate is high enough to induce all purchasing consumers to post reviews. Consequently, the low-rebate strategy is more likely to occur in equilibrium in this alternative setting than in the baseline model.

6. Discussion and Conclusion

Today, manipulated reviews have become a common problem and major concern on many online platforms. Leading platforms such as Google and Amazon have developed sophisticated algorithms to combat the bots and click farms often used to produce fake likes and reviews. Although advanced technologies are increasingly capable of detecting accounts with unusual activity or fake users, strategic sellers turn to bribing legitimate users into leaving positive reviews by, for example, providing underhanded conditional-rebate offerings offline in the form of mail-in rebates. This study analyzes the seller's optimal pricing and rebate strategies and their impact on consumers' review-posting behavior and social welfare. Our findings provide important new insights to inform future platform management and review policies.

First, it is not always profitable for strategic sellers to adopt the conditional-rebate strategy. The rebates are a double-sided sword. On the one hand, they may motivate consumers who would otherwise not provide feedback to post positive reviews. On the other hand, they might also be redeemed by satisfied consumers who would have voluntarily posted positive reviews, which could be costly for the seller. Sellers considering this option must evaluate consumers' review-posting and moral costs, as well as the product's nondigital-attribute valuation, to determine whether to offer a conditional rebate and in what amount. Although positive reviews are valuable, blindly offering incentives may not help achieve the goal of review manipulation. In particular, when nondigital-attribute valuation (the part of product valuation that can be influenced by reviews) is small, the cost of offering a conditional rebate might not be compensated by its benefit and thus sellers should not offer rebates. Even in the presence of high nondigital-attribute valuation, if the review-posting cost is low but the moral cost is high, the seller's optimal strategy is to offer no rebate.

Second, the conditional-rebate strategy does not always result in fake reviews. Fake reviews occur only if the moral cost is low and the review-posting cost is not too high. Further, when consumers are sophisticated in interpreting the

observed review signals or cautious about the sellers' potential review manipulation, online sellers are less likely to use the conditional-rebate strategy and, consequently, less likely to induce fake reviews. Platforms, on the one hand, may help consumers distinguish authentic reviews from fake reviews by, for example, allowing consumers to rate reviews based on their helpfulness so that consumers can easily learn the informativeness and quality of a review and become less likely to be fooled by fake reviews. On the other hand, in addition to developing effective information policies or countermeasures to fight incentivized reviews, it is equally (if not more) important to educate consumers and retailers. When consumers have high moral standards, care about truth telling, and are willing to keep feedback instructive, it would become very costly for sellers to game the review system and execute the conditional-rebate strategy.

Third, although transparent sales information discourages sellers from adopting the conditional-rebate strategy, they generally have stronger incentives to adopt the strategy when consumers are less likely to derive a high value from the nondigital attributes of their products. Moreover, when the moral cost is low and moral standards cannot be raised in the short term, sellers with high nondigital-attribute-valuation products might offer high rebates, leading to fake reviews. When sellers induce fake reviews from purchasing consumers, information is distorted. In this case, sellers might gain from the inflated positive product reviews at the consumers' expense, leading to socially undesirable outcomes. This finding helps explain the reason many e-commerce platforms combat such practices using policy guidelines and legal tools. To keep the online platform a safe and trusted place for shopping, platforms should implement methods to monitor and identify fake reviews (especially associated with high nondigital-attribute-valuation products) and penalize any underhanded tactics to artificially manipulate reviews that go against the platforms' review policies.

In addition, we find that sellers' profits (weakly) decrease in review-posting cost in the high-rebate, partially-fake-review equilibrium, whereas they increase in the low-rebate, boosted-authentic-review equilibrium. This finding underscores the importance of platforms' review management. Because the high-rebate equilibrium outcome causes serious concerns about fake reviews, this finding suggests that the platform can mitigate the occurrence of fake reviews by raising the review-posting standard such as imposing a minimum number of words in reviews or requiring attachment of photos or videos. Doing so not only increases the review quality, but also increases consumers' review-posting cost. The increased review-posting cost will decrease the seller's profit of offering a high rebate and increase its profit of offering a low rebate, making the seller more likely to choose the low-rebate strategy over the high-rebate strategy and leading to boosted authentic reviews rather than inducing fake reviews. Instead of purely relying on costly technical methods to detect fake reviews, our research suggests economic means to combat fake reviews.

Finally, our results show that offering a conditional rebate might be socially beneficial. The social gain associated with conditional rebates comes from the additional transactions due to boosted product reviews, and the social loss comes from distorted consumer review-posting behavior. We find that social gains may outweigh social losses, and the conditional rebate may lead to an increase in both social welfare and consumer surplus. In addition to the social-welfare gain, the platform can benefit from more sales and greater seller success. Thus, our result sheds new light on the debate about whether platforms should completely ban incentivized reviews. Overall, our findings offer new insights into the fake-review phenomenon induced by the conditional-rebate strategy on many e-commerce platforms.

This study leads to several important directions for future research. First, we make a simplified assumption that consumers who lie would incur a constant moral cost of lying. Future work that examines fake reviews may consider heterogeneous moral costs. Second, we capture fake reviews by simply considering unsatisfied consumers posting positive online reviews. Unreliable and untrustworthy reviews can take different forms and future research may develop sophisticated models to capture various types of fraudulent reviews and their impact on consumer behavior. Finally, the conditional-rebate strategy is just one of many tactics online retailers may pursue to manipulate their reviews and ratings. Modeling other forms of online review manipulation and their effects on seller profit, consumer surplus, and social welfare presents an interesting future research opportunity.

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Endnotes

[1] See https://play.google.com/about/storelisting-promotional/ratings-reviews-installs/.

[2] See https://www.theinquirer.net/inquirer/news/3068397/google-is-cracking-down-on-fake-play-store-reviews.

[3] See https://www.amazon.com/gp/help/customer/display.html?nodeId=201929730.

[4] See https://www.bbb.org/globalassets/local-bbbs/council-113/media/documents/12468-d-01_cbbb_report.pdf.

[5] See https://www.bostonwebdesigners.net/wp-content/uploads/POS_PUBLIC0819-1.pdf.

[6] The thin dotted line in the "High Rebate (partially fake reviews)" area is the curve $\bar{m}(c)$, which segments the third case in Proposition 1 (with an interior solution for the optimal rebate amount) from the fourth case (with a corner solution).

[7] We retain the two-period model setup to be consistent with our baseline model framework (i.e., the seller operates in two periods with the same market size). Our qualitative insights do not change if we adopt a three-period model in which an independent consumer group of size 1 arrives in each period.

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