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Deterring Sellers' Cheap Talk Actions via Online Rating Schemes

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Abstract: This paper develops a two-period game theoretic model to investigate a seller's quality claims in a cheap-talk setting. In this model, consumers are reference-dependent with respect to product quality, and consumers who have purchased items can share their quality assessments via online ratings; additionally, consumers may be naive or experienced: naive consumers simply believe the quality claims and quality assessments, whereas experienced consumers can accordingly make rational quality inferences. We find that, in the scenario with only naive consumers, when the reference effect is weak, the seller will always claim the highest quality; when the reference effect is strong, the low-quality seller will claim the highest quality, whereas the high-quality seller will understate its products' quality. In the scenario with only experienced consumers, the seller will claim some moderate quality levels. In the scenario with both types of consumers, in period one, the low-quality seller will always claim some moderate quality levels to serve both types of consumers, whereas the high-quality seller will claim the highest quality when the reference effect is extremely weak and thus serve only naive consumers, or it will adopt truth-telling otherwise; in period two, the low-quality seller will charge a higher price to serve only experienced consumers, whereas the high-quality seller will charge a lower price to serve both types of consumers.

Keywords: cheap talk; online word of mouth; reference-dependent preference; sequential selling; game theory; backward induction

MSC: 91A25; 91A26; 91A80; 91A99

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1. Introduction

From a global perspective, e-commerce platforms have become one of the most prevalent shopping channels. Examining the balance sheets of representative e-commerce platforms, for example: in 2021, Airbnb's annual revenue was USD 5.99 billion; eBay's annual net revenue was USD 10.42 billion; Alibaba, Taobao's parent company, earned CNY 717.29 billion; JD.com, another e-commerce giant in China, earned CNY 951.59 billion; Amazon, the world's largest e-commerce platform, generated USD 469.82 billion in annual net sales revenue. The reason behind these phenomenal cases is primarily due to the enormous advantages of e-commerce platforms in assisting sellers in marketing their products more economically [1] and in helping consumers collect product information more easily [2].

Nevertheless, consumers still cannot have the same shopping experience in online scenarios as they can in offline stores, since they cannot ex ante try the product, which, however, enables the seller to mislead about the quality of its product. Scholars often refer to such dishonesty as "cheap talk" [3]: a sender with private information sends a costless and facially unverifiable message to a receiver, who then decides its own action accordingly, and the action affects the welfare of both the sender and the receiver. Further, scholars have demonstrated that if the interests of the sender and the receiver are in conflict, the message will be always uninformative [3,4]. For example, in a classic cooperative game, it is apparent

that the interests of two players are highly aligned, thus they must be truthful to each other in pursuit of higher common interests; whereas in a classic non-cooperative game, since the interests of two players are in conflict, maintaining their private information unraveled is essential in obtaining higher equilibrium personal profits, thus their communications (if there be any) will always be uninformative. A well-known cheap talk case is the market for "lemons" [5], in which second-hand car owners always claim that their cars are in good condition in order to bargain for a high price. In such scenarios, a buyer's ex-post quality evaluation may deviate from the product's genuine quality since the product is not as claimed by the seller. This potential deviation can be explained by reference dependent theory [6,7]: A buyer's ex-post quality evaluation depends on both the product's genuine quality and the disconfirmation between the genuine quality and a reference point.

In practice, to deter sellers' cheap talk behaviors, online platforms commonly adopt online reputation systems [8,9], thus enabling consumers who have purchased items to release their ex-post quality evaluations for consumer reference. In practice, Airbnb, Taobao, and Amazon have built online review systems; additionally, there also exist some third-party online review platforms, such as TripAdvisor and Yelp, that allow consumers to comment on scenic spots or restaurants regardless of whether they have yet visited them. This process is also referred to as digitalized word of mouth [10] or electronic word of mouth (eWOM) [11]. Note that e-commerce platforms typically require consumers to rate the "item as described" on a scale of one to five, implying that platforms are attempting to induce consumers to generate ex-post quality evaluations on a product by comparing the product's genuine quality and the seller's quality claim. That is, in these cases, the seller's quality claim naturally serves as the reference point. Accordingly, if the seller overstates the product's quality, consumers who have purchased items will generate lower quality evaluations [6]; whereas if the seller understates the product's quality, consumers who have purchased items will generate higher-quality evaluations [12]. In this process, a critical question arises: How does a seller's quality claim affect reference-dependent consumers' ex-ante quality expectations and ex-post quality evaluations?

On the other hand, the adoption of online review systems also enables subsequent consumers to learn about product quality from earlier consumers' quality evaluations, implying that with quality evaluations as a medium, the seller's cheap-talk actions can affect the ex-ante quality expectations of not only earlier consumers, but also of later consumers. Note that after observing the seller's quality claims and the released quality assessments, consumers' quality expectations differ in their ability to make rational quality inferences. In practice, there are two representative consumers: naive consumers simply believe all the observations [13], whereas experienced consumers can make rational quality inferences from the observations [2]. Therefore, when selling products to different types of consumers, the seller needs to consider two critical questions: How do different types of consumers form their quality expectations based on the seller's quality claims and the released quality evaluations? Considering the consumers' types and reference-dependent preferences, how will the seller decide on its quality claims?

To address these already-raised questions, we develop a two-period game theoretic model. In this model, the seller's product quality is exogenously determined; consumers sequentially arrive in two periods, denoted as adopters and followers, respectively. In period one, the seller initially claims a quality and charges a price commensurate with the quality claim; then, adopters form their quality expectations and make purchase decisions accordingly. At the end of period one, adopters who have purchased items generate their ex-post quality assessments based on the product's genuine quality and the seller's quality claim (i.e., the reference point), and release them to the public. In period two, the seller strategically adjusts the price based on the released quality assessments; then, based on the quality claim and quality assessments, followers form their quality expectations and make purchase decisions. According to the consumers' types, we identify three scenarios: the scenario with only naive consumers (denoted by N), the scenario with only experienced

consumers (denoted by E), and the scenario with a mixture of both types of consumers (denoted by M).

We highlight some major findings as follows. In the scenario with only naive consumers, adopters simply take the quality claim as their quality expectation. Correspondingly, when the reference effect is weak, the seller will always claim the highest quality to boost adopters' demand and thus maximize the first-period profit. When the reference effect is strong, the seller with low product quality will claim the highest quality to boost adopters' demand and thus maximize the first-period profit; whereas the high-quality seller will understate its quality to boost adopters' quality assessment, thus fully exploiting the strong reference effect and maximizing the second-period profit.

In the scenario with only experienced consumers, the adopters' quality expectation is independent of the quality claims. Correspondingly, the seller will always claim some moderate quality levels regardless of its genuine quality in order to maintain adopters' demand while exploiting their surpluses. Moreover, by doing so, the high-quality seller can maintain the quality assessment as positive, thus inducing followers to infer the true quality and thereby obtaining a second-period profit that is commensurate with its genuine quality.

In the scenario with a mixture of both types of consumers, we highlight two qualitative findings. One: in period one, the low-quality seller will overstate its quality to a subtle level at which both types of adopters are willing to purchase, thus exploiting the surpluses of both types of adopters and maximizing the first-period profit; whereas the high-quality seller will claim the highest quality to serve only naive adopters when the reference effect is extremely weak, or it will adopt truth-telling otherwise. Two: in period two, the low-quality seller will be underestimated by naive followers since the quality assessment is low, but not necessarily by experienced followers, due to their ability to make rational quality inferences, thus it will charge a higher price to serve only experienced followers; in contrast, the high-quality seller will charge a fair price to serve both types of followers.

We also extend the logic to investigate two scenarios: the scenario with consumers that are heterogenous in personal preferences, and the scenario with unbounded quality assessments. The results show that the findings derived from the main model remain qualitatively robust in these two extensions.

The remainder of this paper is organized as follows. Section 2 reviews the existing literature. Section 3 describes the proposed model. Section 4 analyzes the potential equilibria in each of three scenarios to generate the seller's optimal quality claims. Section 5 extends the logic to investigate two scenarios to verify the robustness of the main findings. Section 6 concludes this paper. The proofs of all results can be found in the Supplementary Materials.

2. Literature Review

At present, the existing literature on the seller's cheap talk behaviors mainly concentrates on the following aspects: (1) reference-dependent preferences and their impact on sellers' strategic actions, (2) cheap talk and its impact on consumers' quality expectations and purchase decisions, and (3) electronic word of mouth and online reputation. However, little research has been conducted to investigate the interaction between the seller's cheap talk action and consumers' reference-dependent preferences. In this section, we first review the representative literature on the above-mentioned research stream; then, by comparing the existing literature and the current paper, we aim to highlight the contribution of the current paper to the related research streams.

2.1. Reference Dependent Preference and Its Impact on Sellers' Strategic Actions

In this regard, the existing studies mainly focus on the impact of reference-dependent preferences on sellers' strategic actions [6,14–16]. In recent literature, Gneezy, Gneezy and Lauga [12] studied a winery case with a reference-dependent model and revealed an intriguing relationship between prices and quality. Wu et al. [17] studied a retailer's dynamic pricing and inventory strategies when facing strategic consumers who formed their reference prices based on past prices. Wang [18] proposed a cyclic pricing strategy as a

new form of price discrimination when facing consumers with reference prices. Amaldoss and He [19] studied the impact of consumers' reference-dependent utility on the price competition in a horizontally differentiated market, within which consumers were diverse in personal preferences. Guan, Wang, Yi and Chen [2] built a two-period model to investigate a seller's quality disclosure strategy when facing reference-dependent consumers, wherein earlier consumers could share their ex-post quality assessments with later consumers via reviews. The results showed that the seller could induce consumers' reviews via strategic quality disclosure. Den Boer and Keskin [20] investigated a seller's dynamic pricing decisions when facing loss-averse or gain-seeking consumers, wherein the seller had no prior knowledge about the demand function and consumers' reference prices. However, in the existing literature, little research has been conducted in a cheap talk setting.

To tackle this problem, the current paper focuses on a seller's quality claim in a cheap-talk setting when facing reference-dependent consumers. In this paper, earlier consumers can share their ex-post reference-dependent quality assessments with later consumers via eWOM. Among the existing literature, this paper is most related to the work of Guan, Wang, Yi and Chen [2], wherein they required the seller's quality message to be truthful. In contrast, in this paper, the seller's quality message may be uninformative. Additionally, in their model, consumers take their quality expectations as the reference point. Contrastingly, in this paper, the seller's quality claim naturally serves as the reference point. In practice, on e-commerce platforms' review systems, consumers are typically required to rate products on the scale of one to five based on whether a product is as described by the seller, and, indicating that that platforms are attempting to induce consumers to take the seller's quality claim as the reference point. Therefore, the setting in this paper is more suitable for scenarios with such e-commerce platforms.

2.2. Cheap Talk and Its Impact on Consumers' Quality Expectations and Purchase Decisions

From the perspective of cheap talk, the existing literature mainly investigates the role of cheap talk in shaping consumers' quality expectations and purchase decisions [3,4,21–23]. In the recent literature, by investigating the case of delay announcements, Allon et al. [24] demonstrated that, by providing vague and unverifiable messages, both the firm's profit and consumers' quality expectations will be improved. Allon and Bassamboo [25] studied a firm's decision on information provision when facing strategic consumers. The result showed that, when facing homogeneous consumers, the firm's information could not create any credibility with consumers. Mayzlin and Shin [26] suggested that a firm can adopt uninformative advertising to induce consumers to search for product information, thus revealing its quality. A similar result was also verified by Gardete [27], who developed a cheap-talk model to study a firm's advertising strategy in vertically differentiated markets and showed that the low-quality firm can induce consumers' search behaviors via strategically pooling its quality upward while convincing consumers that they can afford the product. Yu et al. [28] investigated how a firm adopts delay announcements to induce expectations of consumers with diverse sensitivities to time and value, in a case where the firm could prioritize among consumers. Ke and Zhu [29] investigated the freelance platform case to analyze how buyers can adopt cheap talk to attract high-quality freelancers while bargaining for lower prices via post-match renegotiation. Gardete and Guo [30] verified that when consumers can acquire information beforehand, quality claims in ads can be informative even if the firm can adopt cheap talk. However, the existing research rarely investigates the impact of the seller's cheap talk behavior on its reputation and its subsequent profit.

Correspondingly, the current paper introduces a posterior feedback scheme based on reference dependent theory, enabling reference-dependent consumers to share their ex-post quality assessments with followers. Under this scheme, the seller can strategically induce reference-dependent consumers' quality assessments via cheap-talk quality claims, thus further affecting followers' quality expectations with eWOM as a medium. In other

words, when deciding on its quality claims, the seller needs to consider the impact of the cheap-talk action on both earlier and later consumers.

2.3. Electronic Word of Mouth and Online Reputation

When it comes to online reputation, the existing literature has mainly focused on eWOM [10,11,31,32] and the online reputation mechanism [8,33]. In recent literature, Gu et al. [34] empirically verified that eWOM has a significant impact on a high-involvement product retailer's sales. Moreno and Terwiesch [35] empirically verified that, when facing high-profile service providers, buyers are willing to pay higher prices. Based on some experiments on Amazon Mechanical Turk, Benson et al. [36] examined the critical role of the reputation mechanism in disciplining the gig economy. However, the existing literature has failed to look into the essential reason behind a bad online reputation, that is, the seller's cheap talk action.

Therefore, the current paper focuses on the interaction between eWOM and the seller's quality claims in a cheap-talk setting, rather than solely on eWOM or on the reputation mechanism.

3. Model

Consider a market with a seller selling homogenous products to reference-dependent consumers in two periods. The product is exogenously endowed with a genuine quality q, $q \sim U[0,\ 1]$, which can only be ex ante observed by the seller, whereas the distribution is common knowledge. Note that we use the term "quality" to represent all the potential attributes of the product that may appeal to consumers [2,37]. Therefore, a quality of zero represents that the product can only fulfill consumers' basic needs rather than being completely useless. After privately observing the product's endowed quality, the seller claims its quality as $\widetilde{q}$, $\widetilde{q} \in [0,\ 1]$, which is costless and ex ante unverifiable, and this quality claim persists for two periods. This setting is ubiquitous in practice, for example, on Airbnb, hosts are required to display their listings in the form of texts and images.

Regarding consumers, they arrive sequentially in two periods, denoted as adopters and followers, respectively. Without loss of generality, the number of adopters is normalized as 1, and that of followers is denoted by m. In each period t, $t = 1,\ 2$, a consumer's ex-ante expected utility from the purchase is

$$\hat{U}_t = \hat{q}_t - p_t,$$

wherein $\hat{q}_t$ denotes the consumer's ex-ante quality expectation based on its observations, and p_t denotes the price. The consumer will decide to purchase when the expected utility from the purchase is non-negative, that is, $\hat{q}_t - p_t \geq 0$. Thus, it is evident that the seller always charges $p_t = \hat{q}_t$ to fully exploit the consumer surplus. The game proceeds as follows.

In the first period, nature endows the seller's product with a quality q. After privately observing q, the seller claims its quality as $\widetilde{q}$ and charges a price p_1. Next, after observing the quality claim $\widetilde{q}$, each adopter forms its quality expectation as $\hat{q}_1$. Note that in this paper, we consider two types of consumers: naive consumers (denoted by N) and experienced consumers (denoted by E). Specifically, naive consumers simply believe their observations [13]; in contrast, experienced consumers realize that the seller's quality claim may be uninformative [3]. As a result, in period 1, naive adopters' quality expectation is $\hat{q}_1^N = \widetilde{q}$, whereas experienced adopters form a quality expectation $\hat{q}_1^E$ based on rational inferences. Then, adopters make purchase decisions accordingly, and the seller's profit is realized. It should be noted that in this paper, the seller's profit can be realized as any value within the interval $[0,\ 1]$.

After purchasing, adopters learn the product's genuine quality. Then, each adopter who has purchased an item generates a subjective quality assessment (SQA) and releases it to the public. According to reference dependent theory [2,6,15], a reference-dependent adopter's SQA consists of the product's genuine quality and the disconfirmation between the genuine quality and the seller's quality claim. Denoting the adopter's SQA by q_r,

following the model settings of Kőszegi and Rabin [15] and Guan, Wang, Yi and Chen [2], we model the SQA by

$$q_r = \min\{\max\{q + \alpha(q - \widetilde{q}),\ 0\},\ 1\},$$

wherein α denotes the adopter's sensitivity to the seller's cheap-talk actions, that is, the disconfirmation between the product's genuine quality q and the seller's quality claim $\widetilde{q}$, $\alpha \in [0,\ 1]$. Note that q_r is restricted within the interval $[0,\ 1]$. In practice, the bounded rating scheme is widely adopted by e-commerce platforms, such as Airbnb, Amazon, and Taobao. In these cases, a purchased consumer can rate the product on a scale of one to five. However, if the consumer is extremely satisfied with the product, it can only rate no more than five; whereas if the consumer finds the product extremely terrible, it can only rate no less than one.

At the beginning of the second period, since purchased adopters released their SQA on the product, the seller adjusts the price to p_2 according to the released SQA in pursue of a higher profit. Next, after observing the quality claim $\widetilde{q}$ and the released SQA q_r, followers' quality expectations vary by type. Naive followers take q_r as their quality expectation, that is, $\hat{q}_2^N = q_r$; whereas experienced followers can infer the quality information via backward induction based on three rationales: one, if $0 < q_r < 1$, they can backwardly infer the genuine quality as $q = \frac{q_r + \alpha\widetilde{q}}{1+\alpha}$; two, if $q_r = 0$, they infer that there exists a unique quality point below which the seller will be better off inducing $q_r = 0$; three, if $q_r = 1$, they infer that there exists a unique quality point above which the seller will be better off inducing $q_r = 1$. The explicit backward induction process and the expression of experienced followers' quality expectation $\hat{q}_2^E$ in each scenario are presented in the Supplementary Materials. Then, followers make purchase decisions accordingly, and the seller's profit is realized. The timing of this game is illustrated in Figure 1.

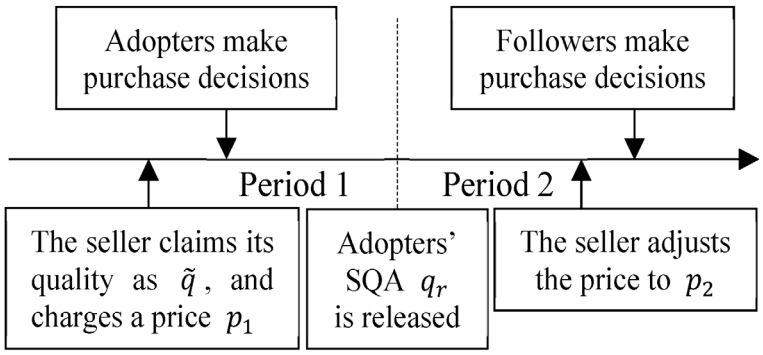

Figure 1. The timing of the game.

Furthermore, we assume that adopters are one-time consumers, and that both the seller and consumers are risk-neutral and self-interested. Each consumer demands one unit of product at most, and the seller's capacity is sufficient to supply the entire market. The seller's operational and production costs are normalized as zero, and no time discount is applied between two periods. Moreover, in the main body of this paper, we assume that consumers have no personal preferences, but in Section 5, this assumption will be relaxed. Last but foremost, to purely focus on the seller's cheap-talk actions, the potential signaling role of pricing is discarded, thus the seller's prices are commensurate with its quality claims. The main notation of this paper is summarized in Table 1.

Table 1. Summary of the main notation.

Notation	Explanation
m	The market size of followers
α	Consumers' sensitivity to the seller's cheap-talk actions, $\alpha \in [0,\ 1]$
q	The product's genuine quality, $q \in [0,\ 1]$
$\widetilde{q}$	The seller's quality claim, $\widetilde{q} \in [0,\ 1]$
$\acute{U}_t^k$	A type-k consumer's ex-ante expected utility in period t, $k = N,\ E,\ t = 1,\ 2$
$\hat{q}_t^k$	A type-k consumer's ex-ante quality expectation in period t, $k = N,\ E,\ t = 1,\ 2$
q_r	A purchased consumer's subjective quality assessment (SQA)
p_t	The product's price in period t, $t = 1,\ 2$
$T_{\widetilde{q}}^{ij}$	The seller's strategy when it claims its quality as $\widetilde{q}$ and serves type-i adopters and type-j followers, $i,\ j = N,\ E,\ M$.
$\pi_{\widetilde{q}}^{ij}$	The seller's total profit from adopting $T_{\widetilde{q}}^{ij}$, $i,\ j = N,\ E,\ M$
Π^{ij}	The seller's ex-ante expected profit, $i,\ j = N,\ E,\ M$

Note: N and E denote naive and experienced consumers, M denotes both types of consumers.

4. Equilibrium Analysis

In this section, we analyze the seller's total profit when facing different types of consumers to generate the optimal quality claims. Specifically, according to the consumers' type, we investigate three scenarios: the scenario with only naive consumers (denoted by N), the scenario with only experienced consumers (denoted by E), and the scenario with a mixture of both types of consumers (denoted by M). For the sake of simplicity, we denote by $T_{\widetilde{q}}^{ij}$ the seller's strategy when it claims its quality as $\widetilde{q}$ and serves type-i adopters and type-j followers, $i,\ j = N,\ E,\ M$, and denote by $\pi_{\widetilde{q}}^{ij}$ the seller's total profit from adopting $T_{\widetilde{q}}^{ij}$.

4.1. When Consumers Are Naive

In this scenario, consumers simply believe what they observe. Specifically, in period one, adopters simply take the seller's quality claim as their quality expectation, that is, $\hat{q}_1^N = \widetilde{q}$. Correspondingly, the seller charges $p_1 = \widetilde{q}$ to fully exploit adopters' surpluses. After purchasing, adopters generate a SQA (i.e., q_r) as already-shown and release it to the public. In period two, followers simply take q_r as their quality expectation, that is, $\hat{q}_2^N = q_r$. Correspondingly, the seller charges $p_2 = q_r$. Overall, the seller's total profit is given by

$$\pi_{\widetilde{q}}^{NN} = \begin{cases} \widetilde{q}, \text{ if } q_r = 0; \\ \widetilde{q} + mq_r, \text{ if } 0 < q_r < 1; \\ \widetilde{q} + m, \text{ if } q_r = 1. \end{cases}$$

Proposition 1. *In the scenario with only naive consumers, in equilibrium,*

(1) *when $m\alpha < 1$, the seller always adopts $T_{\widetilde{q}=1}^{NN}$;*

(2) *when $m\alpha \geq 1$, if $q \in \left[0,\ \frac{1}{m(1+\alpha)}\right]$, the seller adopts $T_{\widetilde{q}=1}^{NN}$; if $q \in \left(\frac{1}{m(1+\alpha)},\ \frac{1}{1+\alpha}\right)$, it adopts $T_{\widetilde{q}=0}^{NN}$; if $q \in \left[\frac{1}{1+\alpha},\ 1\right]$, it adopts $T_{\widetilde{q}=\frac{1+\alpha}{\alpha}q-\frac{1}{\alpha}}^{NN}$.*

Proposition 1 indicates that when facing only naive consumers, the seller's optimal quality claims are uninformative. This finding is inconsistent with the finding of the classic cheap talk literature [3]. Specifically, the seller's optimal quality claims are jointly determined by the genuine quality q, followers' population m, and the sensitivity parameter α. Analogous to the interpretation of Guan, Wang, Yi and Chen [2], we also interpret the term $m\alpha$ as the magnitude of the reference effect. The intuition behind this proposition is that when the reference effect is weak ($m\alpha < 1$), the seller is simply unable to sufficiently

boost the SQA and thus the demand of followers. Hence, the seller will always claim the highest quality regardless of its genuine quality to purely maximize the first-period profit. That is, the seller becomes strategically myopic: They only care about the maximization of the first-period profit while ignoring the maximization of the second-period profit.

When the reference effect is strong ($m\alpha \geq 1$), the seller's optimal quality claims hinge on the genuine quality as follows. If the genuine quality is extremely low ($0 \leq q \leq \frac{1}{m(1+\alpha)}$), the subsequent SQA is destined to be relatively low. Therefore, the seller will claim the highest quality to maximize the first-period profit. If the genuine quality is moderate ($\frac{1}{m(1+\alpha)} < q < \frac{1}{1+\alpha}$), the seller can claim the lowest quality to sufficiently boost the SQA. By doing so, the seller can fully exploit the strong reference effect to boost the second-period profit. If the genuine quality is sufficiently high ($\frac{1}{1+\alpha} \leq q \leq 1$), the seller can already obtain the highest SQA by claiming a moderate quality. Therefore, the seller will claim its quality as high as possible while maintaining the highest SQA, so that he can maximize the second-period profit with the strong reference effect while seeking the highest first-period profit.

Based on Proposition 1, we then analyze the seller's ex-ante expected profit as follows. When $m\alpha < 1$, the seller's ex-ante expected profit is:

$$\Pi^{NN}_{m\alpha<1} = \int_0^{\frac{\alpha}{1+\alpha}} 1dq + \int_{\frac{\alpha}{1+\alpha}}^1 \{1 + m[(1+\alpha)q - \alpha]\}dq;$$

when $m\alpha \geq 1$, the seller's ex-ante expected profit is:

$$\Pi^{NN}_{m\alpha\geq1} = \int_0^{\frac{1}{m(1+\alpha)}} 1dq + \int_{\frac{1}{m(1+\alpha)}}^{\frac{1}{1+\alpha}} m(1+\alpha)qdq + \int_{\frac{1}{1+\alpha}}^1 \left(\frac{1+\alpha}{\alpha}q - \frac{1}{\alpha} + m\right)dq.$$

Corollary 1. *In the scenario with only naive consumers, when $\alpha < \frac{1}{m}$, the seller's ex-ante expected profit decreases in α; when $\alpha \geq \frac{1}{m}$, the seller's ex-ante expected profit increases in α.*

Corollary 1 shows that when facing only naive consumers, the seller's expected profit exhibits a V-shape relationship with respect to the sensitivity parameter. This is because when consumers are less sensitive to cheap-talk actions ($\alpha < \frac{1}{m}$), the seller's optimal quality claims (i.e., $\widetilde{q} = 1$) greatly reduce the SQA and thus the followers' demand, leading to a reduction in the second-period profit; moreover, this dampening effect is enhanced as consumers' sensitivity rises, leading to a greater profit reduction. In contrast, as consumers become more sensitive to the seller's cheap-talk actions ($\alpha \geq \frac{1}{m}$), the seller turns to understate its quality to boost the SQA, thus exploiting the reference effect to boost the second-period profit; moreover, as consumers' sensitivity rises, the reference effect is also enhanced, leading the profit to be further boosted.

4.2. When Consumers Are Experienced

In this scenario, experienced consumers can make rational quality inferences from their observations. Specifically, in period one, adopters form a quality expectation $\hat{q}_1^E$. Correspondingly, to maintain adopters' demand, the seller's quality claims and prices must satisfy $p_1 = \widetilde{q} \leq \hat{q}_1^E$. After purchasing, adopters generate a SQA (i.e., q_r) as shown above. In period two, after observing the quality claim $\widetilde{q}$ and the released SQA q_r, followers form their quality expectation as $\hat{q}_2^E$ via backward induction based on three rationales: one, if $0 < q_r < 1$, they backwardly infer the genuine quality as $q = \frac{q_r + \alpha\widetilde{q}}{1+\alpha}$; two, if $q_r = 0$, they infer that there exists a unique quality point below which the seller will be better off inducing $q_r = 0$; and three, if $q_r = 1$, they infer that there exists a unique quality point above which the seller is better off inducing $q_r = 1$. Correspondingly, the seller charges

$p_2 = \hat{q}_2^E$. The backward induction process and the explicit expression of $\hat{q}_2^E$ are presented in the Supplementary Materials. Overall, the seller's total profit is given by:

$$\pi_{\widetilde{q}}^{NN} = \begin{cases} \widetilde{q} + m\hat{q}_2^E(q|q_r = 0), \text{ if } q_r = 0; \\ \widetilde{q} + mq, \text{ if } 0 < q_r < 1; \\ \widetilde{q} + m\hat{q}_2^E(q|q_r = 1), \text{ if } q_r = 1. \end{cases}$$

Lemma 1. *Experienced adopters cannot make any further quality inferences, their quality expectation is* $\hat{q}_1^E = E(q|0 \le q \le 1) = \frac{1}{2}$.

The intuition behind Lemma 1 is quite straightforward: Since the seller can claim the same quality regardless of its genuine quality, experienced adopters cannot ex ante verify if the seller's quality claim is informative even when the seller does tell the truth. In addition, Lemma 1 implies that when facing experienced consumers, to maintain adopters' demand, the seller's quality claims and prices must satisfy $p_1 = \widetilde{q} \le \frac{1}{2}$. Based on Lemma 1, we proceed to analyze the seller's optimal quality claims. The result is summarized in Proposition 2, while the explicit expression of q_l^E can be found in the Supplementary Materials.

Proposition 2. *In the scenario with only experienced consumers, in equilibrium, if* $q \in \left(q_l^E, \frac{\alpha}{2+2\alpha}\right]$, *the seller adopts* $T^{EE}_{\widetilde{q} \to (\frac{1+\alpha}{\alpha}q)^-}$; *otherwise, it adopts* $T^{EE}_{\widetilde{q}=\frac{1}{2}}$.

Proposition 2 indicates that when facing only experienced consumers, the seller's optimal quality claims remain uninformative. This finding is also inconsistent with the finding of the classic cheap talk literature [3]. The underlying reason is that experienced consumers' quality expectations are independent of the seller's quality claims; thus, the seller must cater to experienced consumers' quality expectations. Consequently, the low-quality seller ($q \le q_l^E$) will moderately overstate its quality to maximize the first-period profit, whereas the high-quality seller ($q > q_l^E$) will claim some moderate quality to maintain the SQA as positive. By doing so, the seller can induce followers to make rational quality inferences, thus obtaining a second-period profit that is commensurate with its genuine quality.

Based on Proposition 2, we can write the seller's ex-ante expected profit as follows:

$$\Pi^{EE} = \int_0^{q_l^E} \left(\frac{1}{2} + m\frac{q_l^E}{2}\right) dq + \int_{q_l^E}^{\frac{\alpha}{2+2\alpha}} \left(\frac{1+\alpha}{\alpha}q + mq\right) dq + \int_{\frac{\alpha}{2+2\alpha}}^{\frac{2+\alpha}{2+2\alpha}} \left(\frac{1}{2} + mq\right) dq + \int_{\frac{2+\alpha}{2+2\alpha}}^{1} \left(\frac{1}{2} + m\frac{4+3\alpha}{4+4\alpha}\right) dq.$$

Note that for technical tractability, we replace $\pi^{EE}_{\widetilde{q} \to (\frac{1+\alpha}{\alpha}q)^-}$ with $\frac{1+\alpha}{\alpha}q + mq$.

Corollary 2. *In the scenario with only experienced consumers, the seller's ex-ante expected profit decreases in the sensitivity parameter* α.

Corollary 2 indicates that the seller is worse off as experienced consumers become more sensitive to the cheap-talk actions. The underlying reason is that if the genuine quality is sufficiently high ($q \ge \frac{2+\alpha}{2+2\alpha}$), the seller will incur losses from being underestimated by not just adopters but also followers; moreover, this quality interval further expands downward as α increases, leading followers to form lower quality expectations. In other words, as α increases, on the one hand, the seller is further underestimated by followers, while on the other hand, the underestimated quality interval further expands. Consequently, these two negative effects jointly lead to a greater profit reduction.

4.3. When Consumers Are a Mixture of Both Types

In this section, we investigate a specific scenario, one in which half of the consumers are naive, whereas the other half are experienced, and the ratio is common knowledge. In this scenario, except for the decision on quality claims, in each period, the seller also faces

the alternative of serving only consumers who form a higher quality expectation, or serving both types of consumers, leading the equilibrium analysis to be much more complicated.

Specifically, in period one, after observing the quality claim $\widetilde{q}$, naive adopters simply take $\widetilde{q}$ as their quality expectation, that is, $\hat{q}_1^N = \widetilde{q}$; whereas experienced adopters form a quality expectation $\hat{q}_1^E = \frac{1}{2}$. Correspondingly, the seller faces the alternative of whether to claim $\widetilde{q} \leq \frac{1}{2}$ and charge $p_1 = \widetilde{q}$ to serve experienced adopters. After purchasing, adopters generate a SQA q_r, as shown above.

In period two, after observing the quality claim $\widetilde{q}$ and the SQA q_r, naive followers simply take q_r as their quality expectation, that is, $\hat{q}_2^N = q_r$; whereas experienced followers' quality expectation $\hat{q}_2^E$ is formed via backward induction based on three rationales: one, if $0 < q_r < 1$, they backwardly infer the genuine quality as $q = \frac{q_r + \alpha\widetilde{q}}{1+\alpha}$; two, if $q_r = 0$, they infer that there exists a unique quality point below which the seller is better off inducing $q_r = 0$; and three, if $q_r = 1$, they infer that there exists a unique quality point above which the seller is better off inducing $q_r = 1$. The backward induction process and the explicit expression of $\hat{q}_2^E$ are presented in the Supplementary Materials. Again, the seller faces the alternative of charging $p_2 = \max\{\hat{q}_2^N, \hat{q}_2^E\}$ to serve only followers who form a higher quality expectation, or charging $p_2 = \min\{\hat{q}_2^N, \hat{q}_2^E\}$ to serve both types of followers.

Employing backward induction, we analyze the seller's total profit to generate its optimal strategies. The result is summarized in Proposition 3, wherein the explicit expressions of q_{l1}^M and q_{l2}^M can be found in the Supplementary Materials.

Proposition 3. *In the mixture scenario, the seller's optimal strategies are as follows:*

(1) *When* $m\alpha < \frac{1}{2}$, *if* $q \in \left[0, q_{l1}^M\right] \cup \left(\frac{\alpha}{2+2\alpha}, \frac{\alpha}{1+2\alpha}\right]$, *it adopts* $T^{ME}_{\widetilde{q}=\frac{1}{2}}$; *if* $q \in \left(q_{l1}^M, \frac{\alpha}{2+2\alpha}\right]$, *it adopts* $T^{ME}_{\widetilde{q}\to\left(\frac{1+\alpha}{\alpha}q\right)^-}$; *if* $q \in \left(\frac{\alpha}{1+2\alpha}, \frac{\alpha}{1+\alpha}\right]$, *it adopts* $T^{MM}_{\widetilde{q}=\frac{1}{2}}$; *if* $q \in \left(\frac{\alpha}{1+\alpha}, 1\right]$, *it adopts* $T^{NM}_{\widetilde{q}=1}$;

(2) *When* $\frac{1}{2} \leq m\alpha < 1$, *if* $q \in \left[0, q_{l1}^M\right] \cup \left(\frac{\alpha}{2+2\alpha}, \frac{\alpha}{1+2\alpha}\right]$, *it adopts* $T^{ME}_{\widetilde{q}=\frac{1}{2}}$; *if* $q \in \left(q_{l1}^M, \frac{\alpha}{2+2\alpha}\right]$, *it adopts* $T^{ME}_{\widetilde{q}\to\left(\frac{1+\alpha}{\alpha}q\right)^-}$; *if* $q \in \left(\frac{\alpha}{1+2\alpha}, \frac{\alpha}{1+\alpha}\right]$, *it adopts* $T^{MM}_{\widetilde{q}=\frac{1}{2}}$; *if* $q \in \left(\frac{\alpha}{1+\alpha}, \frac{1}{2}\right]$, *it adopts* $T^{MM}_{\widetilde{q}=q}$; *if* $q \in \left(\frac{1}{2}, 1\right]$, *it adopts* $T^{NM}_{\widetilde{q}=q}$;

(3) *When* $1 \leq m\alpha < 2$, *if* $q \in \left[0, q_{l1}^M\right] \cup \left(\frac{\alpha}{2+2\alpha}, \frac{1}{2+m}\right]$, *it adopts* $T^{ME}_{\widetilde{q}=\frac{1}{2}}$; *if* $q \in \left(q_{l1}^M, \frac{\alpha}{2+2\alpha}\right]$, *it adopts* $T^{ME}_{\widetilde{q}\to\left(\frac{1+\alpha}{\alpha}q\right)^-}$; *if* $q \in \left(\frac{1}{2+m}, \frac{1}{2}\right]$, *it adopts* $T^{MM}_{\widetilde{q}=q}$; *if* $q \in \left(\frac{1}{2}, 1\right]$, *it adopts* $T^{NM}_{\widetilde{q}=q}$;

(4) *When* $m\alpha \geq 2$, *if* $q \in \left[0, q_{l2}^M\right]$, *it adopts* $T^{ME}_{\widetilde{q}=\frac{1}{2}}$; *if* $q \in \left(q_{l2}^M, \frac{1}{2}\right]$, *it adopts* $T^{MM}_{\widetilde{q}=q}$; *if* $q \in \left(\frac{1}{2}, 1\right]$, *it adopts* $T^{NM}_{\widetilde{q}=q}$.

Proposition 3 indicates that in the mixture scenario, as the reference effect intensifies, the seller with relatively high quality will turn to adopt truth-telling in some parameter spaces, depending on the magnitude of the reference effect $m\alpha$ and the product's genuine quality q. Overall, we extract two qualitative findings and their supporting intuition as follows. One: In period one, if the seller's product quality is relatively low, it will overstate its quality while maintaining experienced adopters' demand, thus exploiting the surpluses of both types of adopters and maximizing the first-period profit. In contract, if the seller's product quality is relatively high, when the reference effect is extremely weak ($m\alpha < \frac{1}{2}$), it will claim the highest quality to serve only naïve adopters, thus maximizing the first-period profit while obtaining a higher second-period profit than claiming a moderate quality (i.e., $\widetilde{q} = \frac{1}{2}$); otherwise ($m\alpha \geq \frac{1}{2}$), it will adopt truth-telling to disclose the genuine quality to both types of adopters, so that it can obtain a second-period profit that is commensurate with its genuine product quality.

Two: In period two, if the seller's product quality is relatively low, the SQA will be extremely low. Meanwhile, experienced followers may not underestimate the product quality. Thus, the low-quality seller will serve only experienced followers. Contrarily, if the seller's product quality is relatively high, due to the adoption of truth-telling, the

high-quality seller will charge a price commensurate with the genuine quality and serve both types of followers.

5. Discussion

In the preceding analyses, we have verified the validity of the online feedback mechanism in deterring the seller's cheap-talk behaviors under the assumptions of homogenous consumers and bounded SQAs. Nonetheless, in practice, consumers may be heterogenous in personal preferences; additionally, they may be able to share their quality assessments in the form of texts, images, and videos. In such scenarios, how will the firm decide on its quality claims? This is the question we intend to address in this section. Specifically, we investigate two scenarios: the scenario with consumers that are ex ante heterogenous in personal preferences, and the scenario with unbounded SQAs.

5.1. When Consumers Have Heterogenous Personal Preferences

This scenario relates to cases where consumers hold different personal preferences towards the product, which is quite ubiquitous in practice, such as the preference to a certain brand or to a certain type of game. In this scenario, reference-dependent adopters' SQAs differ by their personal preferences, and as a result, followers can only observe an aggregate quality assessment (AQA).

Assume that each consumer ex ante holds a personal preference towards the product, denoted by v, $v \sim U\left(-\frac{1}{2}, \frac{1}{2}\right)$, the distribution is common knowledge. Note that we require this personal preference to be realized only after the purchase, whereas before, a consumer's expected preference is given by $\hat{v} = E\left(v \middle| -\frac{1}{2} < v < \frac{1}{2}\right) = 0$. This setting is realistic since a consumer can only know whether the a product fits its taste after physically using it [2]. Therefore, in period t, $t = 1, 2$, a consumer's ex-ante expected utility from the purchase is

$$\hat{U}_t = \hat{q}_t - p_t,$$

and the consumer will decide to purchase if the expected utility is non-negative. Correspondingly, the seller will charge $p_t = \hat{q}_t$ to fully exploit consumer surplus. Denote by q_r^v each adopter's SQA, after purchasing, each adopter generates its SQA by

$$q_r^v = \min\{\max\{v + q_r, 0\}, 1\}$$

wherein $q_r = (1+\alpha)q - \alpha\widetilde{q}$.

Then, in period two, followers can only observe the following AQA (denoted by R):

$$R = \int_{-\frac{1}{2}}^{\frac{1}{2}} q_r^v dv = \begin{cases} \int_{-\frac{1}{2}}^{-q_r} 0 dv + \int_{-q_r}^{\frac{1}{2}} (v + q_r) dv = \frac{1}{8}(2q_r + 1)^2, \text{ if } q_r < \frac{1}{2}; \\ \int_{-\frac{1}{2}}^{1-q_r} (v + q_r) dv + \int_{1-q_r}^{\frac{1}{2}} 1 dv = \frac{1}{8}\left(-4{q_r}^2 + 12q_r - 1\right), \text{ if } q_r \geq \frac{1}{2}. \end{cases}$$

After observing the naïvenaive followers simply take R as their quality expectation, that is, $\hat{q}_2^N = R$; whereas experienced followers can make rational quality inferences via backward induction based on three rationales: One, if $R = \frac{1}{2}$, they backwardly infer that $q_r = \frac{1}{2}$ and thus the genuine quality as $q = \frac{1+2\alpha\widetilde{q}}{2+2\alpha}$; two, if $R < \frac{1}{2}$, they can infer that $q_r < \frac{1}{2}$ and there exists a unique quality point below which the seller will be better off inducing $q_r < \frac{1}{2}$; three, if $R > \frac{1}{2}$, they infer that $q_r > \frac{1}{2}$ and there exists a unique quality point above which the seller will be better off inducing $q_r > \frac{1}{2}$. The backward induction process and the explicit expression of experienced followers' quality expectations are presented in the Supplementary Materials. We first analyze the seller's optimal quality claims when facing only naive consumers. The result is summarized in Proposition 4, wherein the explicit expressions of $\widetilde{q}^v$ and q^v can be found in the Supplementary Materials.

Proposition 4. *When facing only naive consumers with heterogenous preferences, in equilibrium,*

(1) *when* $m\alpha < 1$, *the seller always adopts* $T^{NN}_{\widetilde{q}=1}$;

(2) *when* $1 \leq m\alpha < 2$, *if* $q \in [0,\ q^v)$, *the seller adopts* $T^{NN}_{\widetilde{q}=1}$; *if* $q \in \left[q^v,\ \frac{1+2\alpha}{2+2\alpha}\right)$, *it adopts* $T^{NN}_{\widetilde{q}=0}$; *if* $q \in \left[\frac{1+2\alpha}{2+2\alpha},\ 1\right]$, *it adopts* $T^{NN}_{\widetilde{q}=\widetilde{q}^v}$;

(3) *when* $m\alpha \geq 2$, *the seller always adopts* $T^{NN}_{\widetilde{q}=0}$.

Proposition 4 indicates that, in qualitatively consistent with Proposition 1, the seller's quality claims remain uninformative in this scenario. Additionally, compared to Proposition 1, we find many differences between these two propositions: One, when the reference effect is relatively strong ($1 \leq m\alpha < 2$) and the genuine quality is sufficiently high ($q \in \left[\frac{1+2\alpha}{2+2\alpha},\ 1\right]$), the seller's optimal quality claim is more exaggerated than in Proposition 1 (i.e., $\widetilde{q}^v > \frac{1+\alpha}{\alpha}q - \frac{1}{\alpha}$); two, when the reference effect is sufficiently strong ($m\alpha \geq 2$), the seller claims the lowest quality regardless of the genuine quality, which differs from that in Proposition 1. The intuition behind these differences is that adopters' diverse preferences distort the AQA and thus undermine the reference effect. Specifically, due to the restriction on the boundary of the SQA, if $q_r > \frac{1}{2}$, the AQA is distorted downward, that is, $R < q_r$; whereas if $q_r < \frac{1}{2}$, the AQA is distorted upward, that is, $R > q_r$. Consequently, to hedge such distortions, when the reference effect is relatively strong and the genuine quality is sufficiently high, the seller will further overstate its quality, thus gaining a higher first-period profit to recoup the second-period loss due to the downward distortion of the AQA; in contrast, when the reference effect is sufficiently strong, the seller will turn to claim the lowest quality to boost the AQA, thus exploiting the sufficiently strong reference effect to maximize the second-period profit.

Regarding experienced followers, after observing the AQA, they form their quality expectation as $\hat{q}^E_2$ based on rational quality inferences. Employing backward induction, we analyze the seller's total profit to generate the optimal quality claims. The result is summarized in Proposition 5.

Proposition 5. *When facing only experienced consumers with heterogenous preferences, in equilibrium, if* $q \in \left[\frac{1+\alpha}{2+(2+m)\alpha},\ \frac{1}{2}\right)$, *the seller adopts* $T^{EE}_{\widetilde{q}=\frac{1+\alpha}{\alpha}q-\frac{1}{2\alpha}}$; *otherwise, it adopts* $T^{EE}_{\widetilde{q}=\frac{1}{2}}$.

Proposition 5 indicates that, in qualitatively consistent with Proposition 2, the seller's quality claims remain uninformative in this scenario. Moreover, compared to Proposition 2, we find that when the genuine quality is relatively low ($\frac{1+\alpha}{2+(2+m)\alpha} \leq q < \frac{1}{2}$), the seller turns from overstating to understating. The intuition behind this decision change is that consumers' diverse preferences dilute the informativeness of the AQA. That is, if the AQA is deviated from $R = \frac{1}{2}$, then experienced followers can no longer make precise quality inferences (i.e., $\hat{q}^E_2 = q$) as in the experienced-consumers-only scenario. Therefore, if the seller still wishes experienced followers to accurately infer the product's genuine quality, it must understate its quality to achieve $R = \frac{1}{2}$, so that experienced followers can accurately infer its genuine quality according to the first rational, and thus the seller can maintain a second-period profit that is commensurate with its genuine quality.

5.2. When Subjective Quality Assessments Are Unbounded

This scenario refers to cases where consumers release their reviews in the form of texts, images, and videos. In this scenario, denote by q^u_r purchased adopters' SQA, it is modeled by:

$$q^u_r = q + \alpha(q - \widetilde{q}).$$

Correspondingly, naive followers' quality expectation is $\hat{q}^N_2 = q^u_r$; whereas experienced followers can always backwardly infer the genuine quality as $q = \frac{q_r + \alpha\widetilde{q}}{1+\alpha}$. We first investigate the scenario with only naive consumers. The seller's optimal quality claims are summarized in Proposition 6.

Proposition 6. *When the SQA is unbounded, in the scenario with only naive consumers, in equilibrium, when $m\alpha < 1$, the seller adopts $T^{NN}_{\tilde{q}=1}$; when $m\alpha \geq 1$, the seller adopts $T^{NN}_{\tilde{q}=0}$.*

Proposition 6 indicates that, in qualitatively consistent with Proposition 1, the seller's optimal quality claims remain uninformative in this extension. Additionally, compared to Proposition 1, we find that when the reference effect is strong ($m\alpha \geq 1$), the seller will always claim the lowest quality. The intuition behind this decision change is quite straightforward: Because consumers can fully express their ex-post experiences, the seller is always incented to claim the lowest quality to sufficiently boost the SQA, thus fully exploiting the strong reference effect and maximizing the second-period profit.

Regarding experienced consumers, when the SQA is unbounded, they can always precisely infer the genuine quality from the released SQA, implying that the seller's second-period profit solely hinges on its genuine quality. Therefore, it is straightforward that in period one, the seller will always claim a quality that is the same as experienced adopters' quality expectation to exploit experienced adopters' surpluses and thus maximize the first-period profit.

6. Conclusions

In this paper, we build a two-period game theoretic model to investigate a seller's optimal quality claims in a cheap-talk setting. In this model, consumers are reference dependent with respect to product quality, and purchased adopters can share their SQAs with followers; additionally, consumers may be naive or strategic, depending on if they can make rational quality inferences from the seller's quality claims and the released SQAs. According to consumers' types, we identify three scenarios: the scenario with only naive consumers, the scenario with only experienced consumers, and the scenario with a mixture of both types of consumers.

Our findings are as follows. In the scenario with only naive consumers, when the reference effect is weak, the seller will always claim the highest quality to boost adopters' demand and thus maximize the first-period profit. When the reference effect is strong, the low-quality seller will maintain their claiming of the highest quality, whereas the high-quality seller will understate its quality to boost the SQA, thus exploiting the strong reference effect and thereby maximizing the second-period profit. In the scenario with only experienced consumers, the low-quality seller will overstate its quality while maintaining adopters' demand to maximize the first-period profit, whereas the high-quality seller will claim some moderate quality levels to seek for the highest first-period profit while maintaining the SQA as positive, thus inducing followers' quality inferences and obtaining a second-period profit that is commensurate with its genuine quality.

In the mixture scenario, the results are twofold. One, in period one, the low-quality seller will overstate its quality while maintaining the experienced adopters' demand; whereas the high-quality seller will claim the highest quality when the reference effect is extremely weak, and will adopt truth-telling otherwise. Two, in period two, the seller will charge a higher price to serve only experienced followers; contrarily, the high-quality seller will charge a fair price that commensurate with the genuine quality to serve both types of followers.

Our findings provide some meaningful managerial insights. First, we suggest that when deciding on quality claims, high-quality sellers should take full consideration of the reference effect (i.e., the future market size and consumers' sensitivity to their cheap-talk actions) and the type of consumers; regarding low-quality sellers, we suggest that they should always claim the highest quality. In this sense, we also explain the existence of the market for "lemons" from a cheap-talk perspective. Second, our findings reveal that by adopting the online feedback scheme, online platforms can deter sellers' cheap talk behaviors. Further, we suggest that online platforms adopt easy-to-implement and easy-to-interpret feedback schemes, such as the five-level rating and the binary rating schemes. Under these discrete schemes, despite the fact that consumers' ex-post quality evaluations

are less precise, they can generate their evaluations more easily and determinedly; moreover, discrete ratings are easier to interpret [38]. For example, on YouTube, if an audience member notices that a video has obtained many "likes", he or she will intuitionally know that the video content is of high quality; whereas if the audience only views the comments below the video, it will take a considerable period of time to merely draw a vague impression on the quality of the video content. Third, we suggest that consumers search for third-party information before making purchase decisions, so that they can have better knowledge as to whether the product is worth the price, and thus in turn compelling sellers to claim some informative information [30].

We conclude this paper by pointing out some limitations of the proposed model and providing some potential future directions. First, in this model, to purely focus on the cheap talk process, we assume that consumers are ex ante homogenous, so that their purchase decisions are the same, and the seller's prices and quality claims are commensurate with each other. Whereas in practice, consumers may ex ante hold heterogenous personal preferences. In such scenarios, considering consumers' reference preferences, how will the seller decide on its quality claims and prices? This question remains uninvestigated. Second, in this model, we assume that the seller induces adopters' SQAs via cheap-talk quality claims, whereas in practice, the seller can also directly manipulate the overall feedback via faking sales data and reviews [39]. In such scenarios, how will the seller decide on its manipulation action? How will followers form quality expectations and make purchase decisions? These questions can be intriguing while complicated. Third, in this model, we ignore the potential signaling role of pricing. In practice, consumers usually interpret high prices as a sign of high quality [40]. In such cases, jointly considering the signaling role of pricing and consumers' reference preferences, how will the seller decide on its quality claims and prices? Fourth, in this model, we assume that adopters are one-time consumers, whereas in certain scenarios, such as the non-durable product market, adopters may be repeat consumers. In such scenarios, how will the firm decide on its quality claims and prices? To address this question, the analysis process will be quite challenging. Last, except for costless claims, the seller can also adopt costly claims, that is, advertising, to signal its quality and induce consumers' quality expectations [41]. In such scenarios, jointly considering the signaling role of advertising and consumers' reference preferences, how will the seller decide on its advertising and pricing strategies? This question deserves further investigation.

Supplementary Materials: Due to the space limitation, the proofs of all the lemmas, propositions, and corollaries have been uploaded as supplementary materials, which can be downloaded at: https://www.mdpi.com/article/10.3390/math11061304/s1.

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