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Optimal Pricing Policy With Strategic Consumers And Online Reviews

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Abstract. *In this paper, we study the influence of strategic consumers and online product reviews on the pricing and profit policies of retailers. Whereas previous studies of online reviews focused on factors that affect consumer purchasing behavior have been empirical in orientation, this article details consumers' valuation processes and analyzes pricing decisions and incomes with respect to the numbers of and comment ratings of online reviews. The research demonstrates that when the heterogeneity of consumers is taken into account retailers' optimal price and yield are related to product quality. When there is a difference between the quality of a product as it is presented by a retailer's publicity and its actual quality the product's optimal price is the one that encourages maximum initial purchases. But the optimal price should increase the number of consumers to buy in the second period. We also conclude that where retail sales indicate a superior product a retailer can benefit from online reviews, but where the product is of lower quality online reviews injure sales. It is further concluded that where an online review contains only opaque information the retailer derives no advantage. We found too that where a retailer's initial publicity informs consumers that the quality of the product is superior to its actual quality the optimal income is negatively related to the perceived quality fluctuation prior to purchase but positively related to the perceived quality fluctuation after purchase. On the contrary, the optimal benefits positively related to perceived quality fluctuation before buying, is negatively related to the perceived quality fluctuation after purchase*.

Keywords: *online reviews, retailers, strategic consumers, consumer preferences, pricing, profit.*

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I INTRODUCTION

With the continuous improvement of the internet technology, the parallel transformation of e-commerce has correspondingly changed lives and consumption habits. In this context, retailers' opportunities and challenges have also undergone change. In terms of opportunities, retailers can now sell without a physical store, thus enabling cost reductions, while the diminution of geographical restrictions has increased retailers' potential customer base. In terms of challenges, the improvement of network and the diversification of channel has made the integration of resource information easier, lowered entry thresholds, increased competition, and made more product information available to consumers who have simultaneously learned how to purchase and share information about retailers and their products. No more advantages of the lack of transparency in information exist.

With the rapid development of online shopping and online shopping platforms there has been an inevitable trend toward product network sales. For example, the online shopping of fashion clothes has being a main part of the network sales, in the meantime the network sales becomes the major channel of the sale of fashion clothes. However, since the invisibility and fraud of network sales, the character of online consumer demand has changed, with consumers demanding personalized combinations of price and quality, rather than low prices alone. Online shopping platforms have emerged that provide consumers with product information, such as consumer product reviews (whose importance also has a quantitative aspect). Online retailers and agents are increasingly concerned about the number and character of the reviews they and their products receive and are seeking means to ensure that these favor the sales of their products. An example of such a means is the provision of incentives such as points to encourage consumers to give products high ratings and positive reviews. Plainly, it is in retailers' interests to study the impact of online reviews on their pricing decisions and profit.

Consultation of online reviews is an important part of the process whereby people determine to buy or not to buy a product, particularly a new product. Early reviews of a new product are particularly important [2]. Most of the existing research into social learning about products in e-commerce is empirical: researchers studied the influence of online reviews by questionnaire survey. Hu[4]evaluated the benefits of online reviews by the

combinatorial analysis method with the use of transaction cost economics and uncertainty reduction theory.

To the end of clear and concise analysis of the impact on online products reviews, we work with the following definitions. We call those consumers who will defer purchase decisions until after online reviews have come in "prospective consumers". We call those consumers who will either buy on the basis of the retailers' product information and publicity, or, should there be a problem with availability, purchase an alternative product, "spontaneous producers". In this paper, we study optimal pricing decisions in online retailing and its influence on the profit by theoretical models and case studies with the assumption that consumers are heterogeneous and early consumers influence the purchase behaviors of later consumers.

II LITERATURE REVIEW

The internet is used to promote the development of online media platform, and this kind of platform often uses user generated content to develop new business. One of the generated data sources is online reviews, online reviews in the spread of information, promote trust and play an important role in e-commerce development. Online media platforms use user-generated content to develop new businesses

Social learning is the process by which individuals learn by observing the behavior of others. In the real world, however, individuals learn both by observing the behavior of others and by seeking advice. Bogaçhan[1] argues that social learning improves on the basis of recommendations, with the result that wealth increases. An online review can be seen as a recommendation. Park[8]points out that online reviews are actually positive or negative product reviews. Mudambi & Schuff[6]define online reviews as product reviews published on corporate or third-party websites. As early as 1993, O'Leary[7]pointed out that film review databases provide accurate, accessible information about products, anticipating the functionality of online review databases. www.rogerebert.com, an example of an online film review database, provides readers with detailed information about film storylines as well as other information, for example about new and upcoming film releases. It also includes negative assessments of films.

The early research on online reviews was empirical in the main. It concerned the impact on corporate sales and marketing strategies of online comments, the behavior of consumers during the process on online commentary, and the means by which online comments were mined for information.

Hu[4]assesses the impact of online reviews according to qualitative and quantitative criteria. Working with the theory of transaction cost economics and uncertainty reduction, Hu uses the method of portfolio analysis method to evaluate the benefits of online comment. Hu concludes that consumers are influenced by review numbers, but also by the reputations of the authors of the reviews. The higher the reputation of the commentator, the greater the exposure, the greater the effect on the market. Hu's final point is that the impact of comments on sales decreases over time, indicating the inutility to the retailer, after a certain time, of encouraging consumers to review a product. Zhang[3]conducted research on the relation between sales of digital cameras on Amazon and the reviews the cameras received. The study shows that customer review numbers, camera prices, and the actual physical characteristics of the cameras (such as pixel numbers and storage space) had a significant impact on sales. The study further shows that initial product information have a significant impact on future sales, as do price changes and comments on the product. Research shows that, given the impact of reviews on sales, retailers need to provide channels that stimulate consumers to write reviews, but also that they need help getting product attribute details to potential consumers. D. H. Dong, Y. Yang[16], draws on the well-known TAM model in the field of information systems and classifies the perceived value of consumers under the network environment into three categories: result-based perceived value, program-based perceived value and perceived value. Yiangos et al[10]. studied the impact of social learning on firm pricing and inventory decision making. They conclude that it is not only pricing that affects potential consumers, but also comment content, and thus regulates the social learning process. The last point also further demonstrates that through optimal inventory management companies can anticipate approximate sales for dynamic pricing through fixed pricing. From the perspective of a monopolist, the back[14]studied how a retailer can develop a dynamic pricing strategy based on the influence of strategic consumers and social learning, gives an analysis of the impact of quality uncertainty and social learning on the purchasing behavior of strategic consumers, Expect to reach a win-win situation between vendors and consumers. M. Emmert and M. Schlesinger[15]based on the hospital's report design and the introduction of patient narrative reviews on consumer choice hospital impact. H. Yang and D. Zhang[14]studied the dynamic pricing strategy with limited capacity and stochastic demand in revenue management.

By providing a large amount of information about products and services online reviews have a growing impact on customer purchase decisions. Li[9]points out that online product reviews are subject to a self-selection bias that affects the purchasing behavior of consumers. Li established a model to explore how early buyers' special preferences affect long-term consumer buying behavior. Research by Cachon & Swinny[17] shows that when faced with strategic consumers, sellers can take advantage of rapid response and improve designs in the fashion product supply chain to boost revenue. Deploying the theory of uncertainty reduction Lee[8]studies

customer perceptions of online commentary and the impact the latter have on customer attitudes and behaviors associated with personal characteristics. The study finds that online reviews influence customer perceptions of the costs and benefits of products as well as their attitude to and use of online reviews. Individual characteristics, such as trust in information processing, sensitivity to the influence of other people, determine consumers' responses to reviews. Lee's conclusions can help retailers and marketers use online reviews to improve performance. Justin[5]points out that consumers rely heavily on online reviews when they make online purchasing decisions about products and services. Online reviews can affect the market. Sellers lose credibility if they sell defective products. One resultant behavior is the writing of fake positive reviews by retailer's marketing staff. Attention needs to be paid to this practice, since it creates an informational asymmetry between buyers and sellers, and thus undermines the functioning of the market mechanism.

You[12]extracts information from online reviews through text mining and econometric analysis. The analysis, which has been validated by a leading B2C website in China, seeks to identify the determinants of customer satisfaction with respect to product characteristics. Edwards[3]points out that although, with the emergence of online commentary websites, anyone with an opinion can now express it publicly, companies' success need not only rely on the positivity of these comments. The more commentary on a product, positive or negative, the more likely is the product to appear high in search engine lists. This also explains why research is conducted in how to gain a high position in such lists.

This paper, focusing on empirical research, using model hypothesis and statistical analysis tools, analyzes the impact of online reviews on sales volume and marketing strategies. It also analyzes the key elements in online reviews which affect consumer decisions, and the impact of reviews on information mining. Other studies (such as Yiangos et al. [2013]) have conducted quantitative analysis of the impact of online commentary on consumer decisions by modeling, as well as the impact of social learning on firm pricing and inventory decision making. But in these studies the focus is on the consumer social learning process, without analysis of the impact of the relevant parameters on reviews, assuming that all consumers are of the same type. However, consumer heterogeneity has been assumed here, on the basis that it is a more realistic hypothesis.

III MODELING

According to Li and Hitt[9], a product that has two sets of attributes. One set of attributes can be inspected before purchase and the other cannot. For example, the author of a book can be inspected before purchase but the content cannot. The set of attributes that can be inspected before purchase is defined to be "search attributes", and the set of attributes that cannot be inspected before purchase is defined to be "experience attributes" or "quality". Then an individual consumer's preferences over the product can be characterized by two components (y_i, q_i) (e.g.Li and Hitt[9], Papanastasiou and Savva[11]). The value of element y_i represents the preferences of consumer i over the "search attributes" of the product and is known by each consumer before purchasing. The value of element q_i represents the product's quality for consumer i, and each consumer may perceive quality of the same product differently. Consumers only learn q_i after buying the product. The valuation of the product of consumer i can be expressed as $v_i = ay_i + q_i$. We assume that y_i is distributed in the population according to the uniform distribution U[0,1] with average value $\bar{y}$, and the variance σ_y^2; q_i obeys the normal distribution $N(\hat{q}, \sigma_q^2)$, where $\hat{q}$ is the product's unobservable mean quality and σ_q is the standard deviation which captures the degree of heterogeneity in post-purchase quality perceptions. Based on previous literature (such as Li and Hitt 2008), we allow y_i and q_i to be correlated with correlation coefficient rho. Then given y_i, the expected value of q_i denoted by $E(q_i \mid y_i)$ can be expressed as

$$E(q_i \mid y_i) = \hat{q} + \rho\sigma_q \frac{y_i - \bar{y}}{\sigma_y}.$$

In this paper, we assume that there are two types of consumers on the market. One type is the short-sighted consumers; the other is the strategic consumers. The short-sighted consumers decide whether to buy products in the early release of new products, while the strategic consumers make their purchasing decisions based on the relevant online product reviews. In order to highlight the impact of strategic consumers, we assume that the retailer will fix the price of the product in the whole sale period, and the sale period is divided into two stages based on whether the product online reviews exist or not. Many companies use a fixed price strategy. Some companies such as Apple Inc. maintain a higher price based on the consideration of their brand and marketing, the others may use the everyday-low-price strategy to maintain a relatively stable price (Sin & Han, 2005, Chao, 2009). Based on the above content, the problem is described as follows: At the beginning of the

first stage, the retailer publishes product-related information which includes quality and price information, and then consumers evaluate the product according to the personal preference for the product and the perception of product quality. By comparing prices, short-sighted consumers choose whether to buy the product or not. For those short-sighted consumers who do not buy the product, they will choose to buy alternatives. All the short-sighted consumers who buy products are assumed to write the online reviews at the end of the first stage. At the beginning of the second stage, strategic consumers examine online reviews, and update the valuation of the product based on the content and the number of the online reviews and the review rating, and finally make their purchasing decision by the price comparison. Denote the total number of consumers by N, the ratio of the short-sighted consumers ω, and the price of the product p.

3.1 Consumers' decision-making process

At the beginning of the first stage, retailers released the related information of the new product, and there is no product reviews. Therefore, we assume that the consumers' perception of product quality is a random variable $\tilde{q}$ which is subject to the normal distribution $N(q_p, \sigma_p^2)$, where q_p is the mean and σ_p is the standard deviation. Then the short-sighted consumers' product valuation is

$$v_{i1} = ay_i + E(q_i \mid y_i) = ay_i + q_p + \rho\sigma_q \frac{y_i - \bar{y}}{\sigma_y}.$$

When $v_{i1} \geq p$, the short-sighted consumers will buy products. That is, there exists a unique critical value $Y_1^* = \dfrac{p - q_p + \rho\frac{\sigma_q}{\sigma_y}\bar{y}}{a + \rho\frac{\sigma_q}{\sigma_y}}$. The short-sighted consumers will choose to buy products only when $y_i > Y_1^*$, otherwise they choose to buy alternatives. All the short-sighted consumers who buy products are assumed to write the online reviews at the end of the first stage. Then the number of consumers who buy the products in the first stage is $n_s(p) = N\omega\left\{1 - \min(1, \max(0, Y_1^*))\right\}$, and the average rating of online reviews according to Li and Hitt (2008) can be expressed as

$$\bar{R}_s(p) = E(q_i \mid y_i > Y_1^*) = \hat{q} + \rho\frac{\sigma_q}{\sigma_y}\left(\frac{1 + Y_1^*}{2} - \bar{y}\right).$$

At the beginning of the second stage, potential strategic consumers examine online product reviews; update the product valuation based on the content and the number of the online reviews and the review rating. Let the updated value of the quality be $\dot{q}$ which obeys normal distribution $N(q_u, \sigma_u^2)$ with the mean value q_u and the standard deviation σ_u. In the paper of Yiangos et al. (2013), it showed that

$$q_u = \frac{\sigma_q^2(1-\rho^2)}{n_s\sigma_p^2 + \sigma_q^2(1-\rho^2)} q_p + \frac{n_s\sigma_p^2}{n_s\sigma_p^2 + \sigma_q^2(1-\rho^2)}\left(R_s - \rho\sigma_q \frac{y_s - \bar{y}}{\sigma_y}\right),$$

where $y_s = \dfrac{1}{n_s}\sum_{i \in s} y_i$, $R_s = \dfrac{1}{n_s}\sum_{i \in s} q_i$. Then for the given price p, the updated quality mean can be expressed as

$$\bar{q}_u = \frac{\sigma_q^2(1-\rho^2)}{n_s(p)\sigma_p^2 + \sigma_q^2(1-\rho^2)} q_p + \frac{n_s(p)\sigma_p^2}{n_s(p)\sigma_p^2 + \sigma_q^2(1-\rho^2)} \hat{q}.$$

The strategic consumers then update the product valuation

$$v_{i2} = ay_i + E(q_i \mid y_i) = ay_i + q_u + \rho\sigma_q \frac{y_i - \bar{y}}{\sigma_y}.$$

When $v_{i2} \geq p$, the strategic consumers will buy products and there is a unique critical preference value $Y_2^* = Y_1^* - \dfrac{\bar{q}_u - q_p}{a + \rho\frac{\sigma_q}{\sigma_y}}$. The strategic consumers will choose to buy products only when $y_i > Y_2^*$. Then the number of consumers who buy products in the second stage is

$$n_{s_2}(p) = N(1-\omega)\{1 - \min(1, \max(0, Y_2^*))\}.$$

From the change of the numbers of consumers during the two stages, it is easy to obtain that Y_1^* increases when the product price increases, and then the purchase number $n_s(p)$ in the first stage decreases.

Let $\theta = \dfrac{\sigma_q^2(1-\rho^2)}{n_s(p)\sigma_p^2 + \sigma_q^2(1-\rho^2)}$, then $\bar{q}_u = \hat{q} + \theta(q_p - \hat{q})$ and

$$\frac{\partial \bar{q}_u}{\partial p} = -(\hat{q} - q_p)\frac{\sigma_q^2(1-\rho^2)\sigma_p^2}{\left[n_s(p)\sigma_p^2 + \sigma_q^2(1-\rho^2)\right]^2}\frac{N\omega}{a + \rho\frac{\sigma_q}{\sigma_y}}.$$

Therefore, when $q_p > \hat{q}$, $\bar{q}_u < q_p$ and $\bar{q}_u$ is monotonically increasing with respect to p; when $q_p < \hat{q}$, $\bar{q}_u > q_p$ and $\bar{q}_u$ is monotonically decreasing with respect to p. $Y_2^* = Y_1^* - \dfrac{\bar{q}_u - q_p}{a + \rho\frac{\sigma_q}{\sigma_y}}$. When $q_p < \hat{q}$, Y_2^* is monotonically increasing with respect to the price p, and then the purchase quantity in the second stage $n_{s_2}(p)$ is monotonically decreasing with respect to p; when $q_p > \hat{q}$, $n_{s_2}(p)$ may increase or decrease when p increases.

In summary, we obtain that when the quality perception before buying is less than the product quality ($q_p < \hat{q}$), the purchase quantity in the two stages decreases with respect to the price p; When the quality perception before buying is greater than the product quality ($q_p > \hat{q}$), the purchase quantity in the two stages may increase with respect to the price p.

3.2 Retailer's decision-making process

The decision variable of the retailer is the price of the product, and the goal is to maximize the total profit of the two stages. For the sake of convenience, we assume that the cost is zero. Then the objective function can be written as

$$\pi(p) = pN\omega\{1 - \min(1, \max(0, Y_1^*))\} + pN(1-\omega)\{1 - \min(1, \max(0, Y_2^*))\}.$$

The retailer's inventory decision is determined by the market demand in this paper, that is, the inventory is the sum of the purchasing numbers during the two stages,

$$Q = N\omega\{1 - \min(1, \max(0, Y_1^*))\} + N(1-\omega)\{1 - \min(1, \max(0, Y_2^*))\}.$$

We assume that $0 \le Y_1^*, Y_2^* \le 1$. This assumption ensures that there exist consumers who buy the product for each of the two sales stages, and excludes the unimportant circumstance that nobody buys the product or there are buyers just in one stage. Then the profit function can be simplified to

$$\pi(p) = pN\omega(1 - Y_1^*) + pN(1-\omega)(1 - Y_2^*).$$

From the previous section we can see that when $q_p < \hat{q}$, the purchase of two periods with the price changes in the same direction. When $q_p > \hat{q}$ is uncertain. The following is studied from $q_p < \hat{q}$ and $q_p > \hat{q}$. When $q_p < \hat{q}$ and $0 \le Y_1^*, Y_2^* \le 1$, the price p should meet the inequalities $Y_1^* \le 1$ and $Y_2^* \ge 0$. When $q_p > \hat{q}$ and $0 \le Y_1^*, Y_2^* \le 1$, the price p should satisfy the inequalities $Y_1^* \ge 0$ and $Y_2^* \le 1$. The above results can be expressed as follows:

Property 1:

(1) When $q_p \le \hat{q}$, retailers has a feasible pricing interval $\left[\hat{q} - \frac{1}{2}\rho\frac{\sigma_q}{\sigma_y},\ \ a + \frac{1}{2}\rho\frac{\sigma_q}{\sigma_y} + q_p\right]$;

(2) When $q_p > \hat{q}$, retailers has a feasible pricing interval

$$\left[\hat{q} - \tfrac{1}{2}\rho\tfrac{\sigma_q}{\sigma_y}, \min\left(\tfrac{\sigma_q^2(1-\rho^2)(a+\rho\frac{\sigma_q}{\sigma_y})}{N\omega\sigma_p^2} + a + \hat{q} + \tfrac{1}{2}\rho\tfrac{\sigma_q}{\sigma_y}, a + \tfrac{1}{2}\rho\tfrac{\sigma_q}{\sigma_y} + q_p\right)\right].$$

In the domain of the objective function $\pi(p)$, it is continuous. Then there must be the optimal price so that the retailer has the maximum profit. By taking derivatives, we have the following properties of the objective

function $\pi(p)$ when $0 \le Y_1^*, Y_2^* \le 1$: (1) When $q_p \le \hat{q}$, $\frac{\partial^2 \pi}{\partial p^2} < 0$ and $\pi(p)$ is a concave function; (2) When $q_p > \hat{q}$ and $p < a + q_p + \frac{1}{2}\rho\frac{\sigma_q}{\sigma_y}$, $\frac{\partial^2 \pi}{\partial p^2} < 0$ and $\pi(p)$ is an unimodal function. From the above analysis, we can obtain the following proposition.

Proposition 1:

(1) When $q_p \le \hat{q}$, $\frac{\partial^2 \pi}{\partial p^2} < 0$ within the domain, so there is a single best price to make the maximum profit, and the profit increases when $\hat{q}$ increases; (2) When $q_p > \hat{q}$, the objective function is a unimodal function, and there is also a single optimal price that maximizes the profit and the profit increases when $\hat{q}$ increases.

Yiangos et al. (2013) in this paper, it is assumed that all consumers are short-sighted consumers, and it is concluded that the return of the firm is independent of the mean of the product quality. In this paper, it is concluded that the retailer's earnings are related to the mean of the mass. The presence of prospective consumers, the early rally of businesses to raise awareness of the quality of consumer activities, the positive impact on earnings has decreased. As a result, as forward-looking consumers increase, companies need to improve product quality to win the market.

When $q_p > \hat{q}$, the optimal price for the first period has the upper limit, that is, the purchase rate must reach a certain level, indicating that in poor quality, retailers should tend to focus on sales in the first period.

3.3 The impact of the ratio of the short-sighted consumers

By taking the first derivative of the profit function $\pi(\omega)$, we know that the equation $\frac{\partial \pi}{\partial \omega} = 0$ have solutions. Then taking the second derivative, we obtain that when $q_p > \hat{q}$, $\frac{\partial^2 \pi}{\partial^2 \omega} > 0$, which means that the profit function has a minimum value ; and when $q_p \le \hat{q}$, $\frac{\partial^2 \pi}{\partial^2 \omega} < 0$, which means that the profit function has a maximum value. We summarize the above result in the following proposition:

Proposition 2:

(1) When $q_p \le \hat{q}$, $\frac{\partial^2 \pi}{\partial^2 \omega} < 0$ and then there exists a maximum value of $\pi(\omega)$, which implies that the profit first increases with respect to the ratio ω and then decreases within the domain of $\frac{\partial^2 \pi}{\partial^2 \omega} < 0$;

(2) When $q_p > \hat{q}$, $\frac{\partial^2 \pi}{\partial^2 \omega} > 0$ and then there exists a minimum value of $\pi(\omega)$, which implies that the profit first decreases with respect to the ratio ω and then increases within the domain of $\frac{\partial^2 \pi}{\partial^2 \omega} < 0$.

When $q_p \le \hat{q}$, the online product reviews have a positive effect, which means that the more the number of the online reviews, the better for retailers. Therefore when the ratio of the short-sighted consumers increases, the number of the online reviews increase, which causes that the profit increases. We know that the total number of consumers is fixed. The number of the strategic consumers will decrease when the number of the short-sighted consumers increases, and this will reduce the positive effect of the online reviews. When $q_p > \hat{q}$, in contrast to the previous case, the impact of the online reviews is negative for retailers. In this case, when the online reviews become less, the profit becomes larger. It means that the situation of the increase of the short-sighted consumers and then the increase of the online reviews is not good for the retailers. But when the number of the short-sighted consumers increases to a certain value, retailers can get more income from the first period.

IV SENSITIVITY ANALYSIS

In this section, we will explore the impact of model parameters on optimal profit. We discuss the influence of the ratio of short-sighted consumers, the online reviews rating and the consumer perceived quality. In the following analysis, unless otherwise indicated, we assume that $c = 0$, $\overline{y} = 0.5$, $\sigma_y^2 = \frac{1}{12}$, $\sigma_q^2 = \frac{1}{3}$, $a = 1$, $N = 1000$, $\rho = 0.1$ and $\omega = 0.5$. In the case of $q_p \ge \hat{q}$, we take $q_p = 1$ and $\hat{q} = 0.5$; and in the case of $q_p \le \hat{q}$, we take $q_p = 0.5$ and $\hat{q} = 1$.

4.1 The impact of the ratio of short-sighted consumers

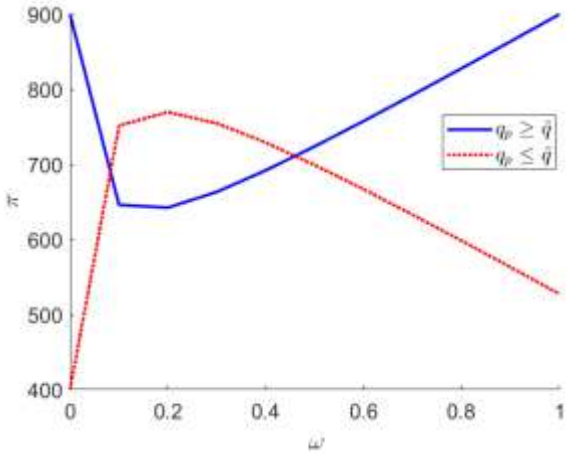

Fig. 1 The influence of the ratio of short-sighted consumers on the profit

The impact of the ration of short-sighted consumers on the profit for both case $q_p \geq \hat{q}$ and $q_p \leq \hat{q}$ is shown in Fig. 1, which shows that when the impact of the online reviews is great, which means the ratio of the short-sighted consumers and the prospective consumers is small, the higher and better quality of the product, the better for retailers, then in this case improving the product quality is very important; when the impact of the online reviews is small, which means the ratio of the short-sighted consumers and the prospective consumers is large, the profit becomes better when the perceived quality before buying the product q_p is larger, then in this case the early publicity of the product is very important.

4.2 The impact of the online reviews rating

The impact of the online reviews rating on the profit for the case $q_p \geq \hat{q}$ is shown in Fig. 2. Online reviews have a negative impact on retailers. As the volatility of online review ratings increases, consumers' trust in reviews decreases and profit decrease.

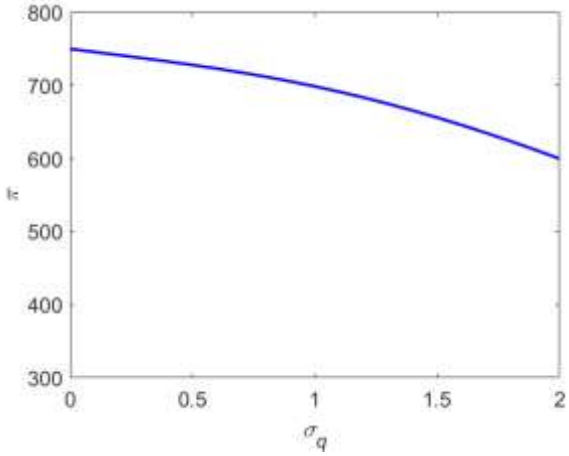

Fig. 2 The influence of the online reviews rating on the profit when $q_p \geq \hat{q}$

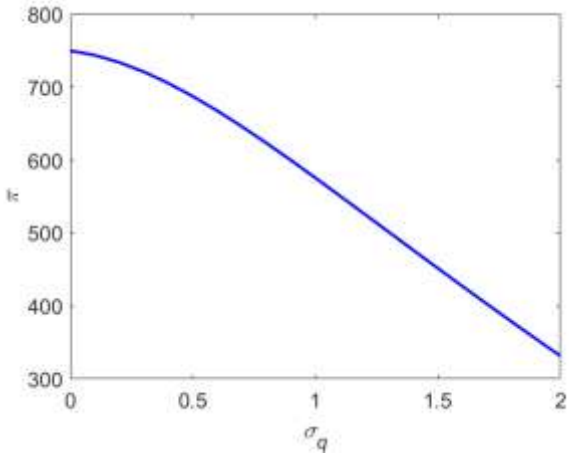

Fig. 3 The influence of the online reviews rating on the profit when $q_p \le \hat{q}$

The impact of the online reviews rating on the profit for the case $q_p \le \hat{q}$ is shown in Fig. 3. When $q_p \le \hat{q}$, the impact of fluctuations in online comment ratings on the company's earnings is negative. As the rating of reviews increases, the company's profit decline. Due to the decrease in actual purchases, the company's profit decreases.

Comparing the above two cases, whether $q_p \ge \hat{q}$ or $q_p \le \hat{q}$, the impact of fluctuations in online comment ratings on corporate profit is always negative, and corporate earnings will gradually decline as the volatility of ratings increases, but when the perceived quality before purchase is lower than the product quality, the company's profit declines significantly faster, so in order to increase the company's profit, it is necessary to reduce fluctuations in the online rating.

4.3 The impact of the consumer perceived quality

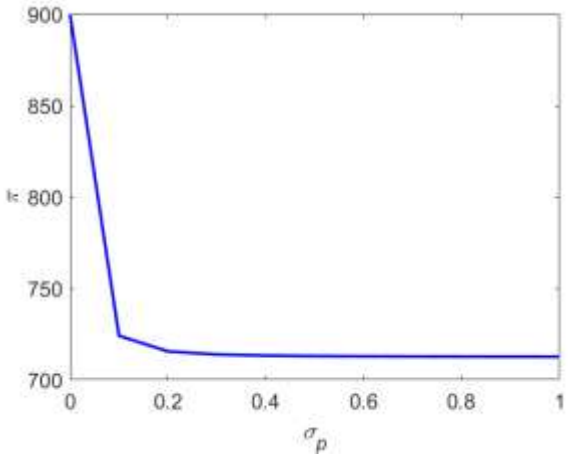

Fig. 4 The influence of the consumers perceived quality on the profit when $q_p \ge \hat{q}$

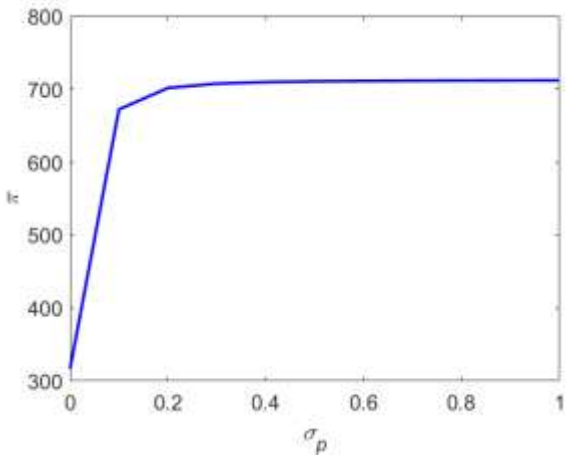

Fig. 5 The influence of the consumers perceived quality on the profit when $q_p \le \hat{q}$

The decrease in the retailer's optimal profit as perceived by the consumer before purchasing quality decreases as shown in Fig 4. When $q_p \ge \hat{q}$, online reviews have a negative impact on retailers, and the greater the perceived quality fluctuation value, the more likely the consumer quality update value will be on the online review rating. Therefore the profit will be reduced.

The retailer's optimal profit increases with the perceived fluctuations in consumer perception before purchase as shown in Fig 5. When $q_p \le \hat{q}$, early online reviews of consumers help potential customers to increase their perception of quality. The greater the perceived quality fluctuations before purchase, the more emphasis consumers place on online reviews, and thus benefit retailers.

Compare the above two cases, it can be seen that when $q_p \le \hat{q}$, the greater the perceived quality fluctuations before purchase, the more favorable to the retailers; when $q_p \ge \hat{q}$, the larger the perceived quality fluctuation before purchase, the more unfavorable the retailers.

V CONCLUSION

With the rapid development of online shopping and continuous optimization of online shopping platform, online sales of products have become an inevitable trend. More and more consumers browse online reviews before purchasing, so it's important for retailers to study the impact of online reviews on their pricing and profit.

In order to study the impact of online comments, this article has simplified the sales cycle of online commentary into two periods. The type of consumers studied in the first period were short-sighted consumers and the second period was forward-looking consumers. Assuming that all consumers who purchase products in the first period participate in online reviews, simple model settings and assumptions can better help study the impact of online reviews. We have some conclusions and management inspiration, mainly including the following four aspects:

i) Retailers have the only optimal pricing to make the most of their profit. When the consumer perceived quality is higher than the product quality average, the optimal price tends to make the number of purchases in the first period as much as possible; on the contrary, the optimal price tends to make the number of purchases in the second period as much as possible.

ii) The retailer's profit increases as the average quality (mean quality) of perceived quality increases after purchase. When the perceived quality value of the consumer before purchase is higher than the average value of the product quality, the profit increases with the fluctuation of the rating of the online review, and decreases with the fluctuation of the perceived quality value before the purchase; on the contrary, the profit decreases with the increase of the fluctuation of the online review rating, with the purchase the pre-perceived mass value increases by increases.

iii) Consumers' pre-purchase perceived quality is higher than the product quality average ($q_p \ge \hat{q}$),The retailer's optimal profit decreases with the proportion of short-sighted consumers, and when the proportion of short-sighted consumers increases to a certain value, the optimal profit begins to increase. Conversely, the optimal profit increases with the proportion of short-sighted consumers, and when the proportion of short-sighted consumers reaches a certain value, the retailer's optimal profit begins to decrease. It is

concluded that when the online commentary function is large, the higher the product quality, the better the gain; and when the online commentary function is small, the higher the perceived quality of the consumer before the purchase, the better the profit. At this time, early publicity is very important for the retailer.

iv) When the perceived quality value of the consumer before purchase is lower than the average value of the product quality, the total inventory decreases as the price increases; otherwise, the inventory quantity may increase as the price increases.

This article's conclusion on the impact of online reviews on retailers' pricing and returns has practical significance for enterprises and helps companies to strategically select appropriate pricing strategies. The future can be further studied in the following areas. Firstly, we can study the impact of online reviews under dynamic pricing; secondly, we study the impact of online reviews on total social wealth; finally, in order to deal with the losses caused by forward-looking consumers, many companies use deliberate measures such as out-of-stock. Can companies also increase their online ratings by restricting supply and selling products to consumers with a high degree of product preference? What happens to quantitative restrictions when both forward-looking consumer and online reviews are present? These can be further studied.

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