

# Firm review revelation policy considering social ties among consumers

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**Abstract:** An optimization model is proposed to analyze the optimal review revelation policies and consumer online social network management strategies of e-commerce firms. The results show that displaying friend reviews to consumers does not necessarily increase firms' profits. Only when positive reviews account for a large proportion of all the reviews and when the cost of showing friend reviews is not high, can showing friend reviews be more profitable than not showing such information. The distribution of social ties among consumers can affect firms' profits. Even in the case that showing friend reviews to consumers is more profitable, an increase in the proportion of strong ties is not necessarily beneficial to firms. Only when the proportion of positive reviews is large enough, can firms' profits increase with the increase in the proportion of strong ties among consumers. Moreover, the degree of consumer distrust in the average quality rating can also affect firms' strategies for managing consumer online social networks. As the degree of consumer distrust in the average quality rating rises, firms are more likely to obtain higher profits by taking measures to increase the proportion of strong ties among consumers on their websites.

**Key words:** online product review; social tie; review revelation policy; social commerce

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In recent years, online product reviews have become an important source of information for consumers to learn about product quality in the e-commerce environment. Since many e-commerce websites have added social capabilities to encourage consumers to establish social connections with each other, current e-commerce websites can not only show consumers crowd reviews, but also show them reviews posted on the websites by their friends. For example, Dianping allows users to follow their WeChat friends as well as other unknown users and then shows users the reviews posted by the people they

follow. Taobao has also established a review sharing community called "Yangtao" where users can read product reviews from their friends. The above examples indicate that the sociality of online product reviews is gradually increasing, and it has been a trend for e-commerce websites to display friend reviews to consumers. However, there are still numerous e-commerce websites that do not provide consumers with friend reviews, such as Jingdong and UNIQLO. Why do some websites display friend reviews and others do not? Which of these two review revelation strategies is more profitable?

This paper is related to the literature that investigates the effects of online product reviews on consumers and firms. Chevalier et al.<sup>[1-3]</sup> argued that online reviews are important for consumers to learn about the product quality. Weinburger et al.<sup>[4-6]</sup> found that negative reviews have stronger effects on consumers than positive reviews. Numerous studies have examined firm information revelation policies on the displaying of product reviews. Yi et al.<sup>[7]</sup> investigated how firms can strategically manage product reviews by highlighting authentic reviews selected by themselves. Li et al.<sup>[8]</sup> examined the conditions in which showing average star ratings on the product list is more profitable than not showing this information. Chen and Xie<sup>[9]</sup> proposed a normative model to study when the seller can benefit from allowing consumers to post product reviews on its website. Liu et al.<sup>[10]</sup> found that although more informative reviews can reduce price competition, such information can still hurt firms.

Another stream of relevant literature concerns friend reviews. Sun et al.<sup>[11]</sup> pointed out that product reviews have become increasingly social, consumers can get product reviews not only from the general community but also from their own online social connections. Zhang and Godes<sup>[12]</sup> investigated the impact of the review source on the quality of consumer decisions. Brown and Reingen<sup>[13]</sup> analyzed word-of-mouth referral behavior in a natural environment and found that strong ties are perceived as more influential than weak ties by recipients. Bitter et al.<sup>[14-15]</sup> also obtained similar results in their experiments which show that the product information from strong ties is perceived to be more diagnostic.

Research on online product reviews has gradually expanded from crowd reviews to friend reviews. While prior research on friend reviews has mostly focused on ana-

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lyzing how the reviews from friends with different tie strengths affect consumer decisions, few of them have explored the impact of the emergence of friend reviews on firm decisions. To fill this gap, we study firms' optimal review display strategies by considering the social ties between consumers and review publishers. More specifically, under which conditions can showing friend reviews be more profitable than not showing this information? When a firm decides to show friend reviews, does the distribution of tie strength among consumers affect its profit?

## 1 Assumptions

Assume that a firm sells products on its website at price  $p$ . A product has two possible states: It either has quality defects or does not. The marginal production cost for each product is assumed to be 0. The total mass of consumers is normalized to 1. Consumers are all risk neutral. Each consumer has at most a unit demand. We assume that each early buyer submits a quality rating. If a buyer thinks that the product has no quality defects, she rates the product "1" (i.e., contributes a positive review), or "0" otherwise (i.e., contributes a negative review). The firm calculates the average product quality rating  $R$  based on all consumer ratings and displays it to consumers. The firm can also show consumers the reviews from their friends based on consumer social connections on the website. Therefore, the firm has two optional review revelation strategies: providing consumers with the average quality rating or providing consumers with both the average quality rating and ratings from their friends. We then make the following assumptions to describe our research problem.

Let  $v$  be the value that a consumer can obtain from the product.  $v$  is ex ante unknown and is the realization of a binary random variable,  $v \in \{0, 1\}$  with  $\Pr(v = 1) = q \in (0, 1)$ . Specifically, the probability that a product has no quality defects is  $q$ , and the utility that a consumer can obtain from the product is 1; the probability that a product has quality defects is  $1 - q$ , and the utility that a consumer can obtain from the product is 0.  $q$  essentially measures the true quality of the product, similar to the assumptions in Refs. [16–17].  $q$  is known to the firm but not to consumers. Consumers form their expectation  $E(q)$  of the product quality based on the average quality rating  $R$ . Assume that  $R = q + m$ ,  $0 \leq R \leq 1$ .  $q$  is the true quality of the product and  $m(0 \leq m \leq 1 - q)$  represents the positive bias in the average rating caused by the self-selection bias by early buyers and the firm's manipulation of online reviews. Moreover,  $R$  actually also represents the probability that a buyer posts a positive review. According to Hu et al. [18], consumers can be aware of the existence of the positive bias in the average rating and attempt to make corrections. Let  $h(0 < h < 1)$  be the correction of the average quality rating made by consumers. Then

consumers' expectation of the product quality is  $E(q) = R(1 - h)$ .  $h$  can also be understood as the degree of consumer distrust in the average quality rating. The value of  $h$  for each consumer is affected by the reviews from their friends.

If consumers purchase online, they have to wait for the delivery and may be worried about the security of online payments. Thus, purchasing online requires a hassle cost  $x$ . For simplicity, we assume that the hassle costs are different across consumers and that  $x$  is distributed uniformly in  $[0, 1]$ .

Based on the above assumptions, consumer  $i$ 's expected utility from the product is  $E(U)_i = R(1 - h) - x - p$ . Consumer  $i$  will buy the product only when  $E(U)_i \geq 0$ .

We model  $r$  as the tie strength between two consumers that have social connections with each other. Drawing on Kornish and Li [19], we use a two-point model of the distribution on  $r$  in the population, representing strong( $r_s$ ) and weak( $r_w$ ) ties,  $0 < r_w < r_s < 1$ . For a fraction  $\beta(0 \leq \beta \leq 1)$  of the population,  $r = r_s$ , and for the rest,  $r = r_w$ . Each consumer knows exactly the tie strength  $r$  between her and her friend, while the firm only knows the distribution over the possible values of  $r$  in the population but does not know the specific  $r$  of any one particular relationship.

## 2 Model and Analysis

### 2.1 Providing consumers only with the average rating

Suppose that when the firm does not display friend reviews, all consumers' corrections of the average quality rating are the same, expressed by  $\varepsilon(0 < \varepsilon < 1)$ , i.e.,  $h = \varepsilon$ . Consumer  $i$ 's expected utility from the product then can be expressed as  $E(U)_i = R(1 - \varepsilon) - x - p$ . Consumer  $i$  will buy the product only if  $E(U)_i \geq 0$ . Therefore, we can formulate the expected demand for the product as  $E(D) = R(1 - \varepsilon) - p$ . The firm maximizes its expected profit by choosing the optimal price,

$$\max_p E(\pi) = p[R(1 - \varepsilon) - p] \quad (1)$$

By solving the above optimization problem, the following proposition is obtained.

**Proposition 1** When the firm only provides consumers with the average rating, the firm's optimal price is  $p^* = \frac{R(1 - \varepsilon)}{2}$  and its optimal expected profit is  $E(\pi^*) = \frac{R^2(1 - \varepsilon)^2}{4}$ .

### 2.2 Providing consumers with both the average rating and friend reviews

We assume that the market scale remains 1 when the firm shows friend reviews to consumers. To distinguish from the case where friend reviews are not available, in

the case where friend reviews are available, the mark “-” is added above the corresponding symbols.

For analytical tractability, we suppose that each consumer can see at most one review from one of her friends when the firm displays friend reviews, which is consistent with most actual situations. Furthermore, considering that, in reality, some consumers may not establish social connections with others on e-commerce websites or choose to submit anonymous reviews in order to protect their privacy, there may be some consumers for whom friend reviews are unavailable and so they will not be affected by friend reviews. We suppose that only  $\mu(0 < \mu < 1)$  of the consumers can see reviews posted by their friends, and for each of them, the probability of seeing a positive friend review is  $R$ , and the probability of seeing a negative friend review is  $1 - R$ . The expected value of the percentage of positive reviews in all the friend reviews displayed by the firm is also  $R$ .

Considering the fact that consumers rarely see friend reviews when shopping online, we assume that even if friend reviews are available, consumers will still use the average rating to infer the product quality. Friend reviews affect consumer purchase decisions by influencing  $h$ , i. e., consumers' corrections of the average quality rating. The value of  $h$  for a certain consumer is affected by the review posted by her friend, as well as by the tie strength  $r$  between them. Specifically, when the friend rates “1” (i. e., contributes a positive review), the consumer's correction of the average rating will decline on the basis of  $\varepsilon$ , and the greater the tie strength between the consumer and her friend, the smaller the correction will be. While when the friend rates “0” (i. e., contributes a negative review), the consumer's correction of the average rating will increase on the basis of  $\varepsilon$ , and the greater the tie strength between the consumer and her friend, the larger the correction will be. In addition, according to a widely accepted view in the field of word-of-mouth communication that negative product information has a greater impact on consumers than positive product information, the impact of negative friend reviews on consumers should be greater than that of positive friend reviews. Based on the above analysis, we assume that  $h$  and  $r$  satisfy  $h_p(r) = \varepsilon^{1+r}$  when the friend posts a positive review,  $h_n(r) = \varepsilon^{1-r}$  when the friend posts a negative review.

The corrections of consumers for whom friend reviews are available include the four possible situations shown in Tab. 1, while the corrections of consumers for whom friend reviews are unavailable remain  $\varepsilon$ . The firm will face five possible types of consumers if it displays friend reviews: 1) Type 1—Have no friend review; 2) Type 2—A friend with strong tie posts a positive review; 3) Type 3—A friend with strong tie posts a negative review; 4) Type 4—A friend with weak tie posts a positive review; 5) Type 5—A friend with weak tie posts a negative review.

**Tab. 1** Possible values of  $h$  when the firm shows friend reviews to consumers

Tie strength	Friend rating	Value of $h$	Probability
$r_s$ (strong tie)	1 (positive)	$\varepsilon^{1+r_s}$	$\mu\beta R$
$r_s$ (strong tie)	0 (negative)	$\varepsilon^{1-r_s}$	$\mu\beta(1-R)$
$r_w$ (weak tie)	1 (positive)	$\varepsilon^{1+r_w}$	$\mu(1-\beta)R$
$r_w$ (weak tie)	0 (negative)	$\varepsilon^{1-r_w}$	$\mu(1-\beta)(1-R)$

The probability that a consumer belongs to Type 1 is  $1 - \mu$  and the expected utility of consumers of this type is  $E(U)_1 = R(1 - \varepsilon) - x - \bar{p}$ . Thus, we can obtain the expected demand of consumers of Type 1:  $E(D)_1 = (1 - \mu) \cdot [R(1 - \varepsilon) - \bar{p}]$ . The expected demands of the other four types of consumers can be calculated in the same way. By summing up the expected demands of all the above five types of consumers, we can obtain the total expected demand of the product:

$$E(\bar{D}) = \sum_{i=1}^5 E(D)_i = R(1 - \varepsilon) - \bar{p} + \mu R \varepsilon(1 - t) \quad (2)$$

where  $t = \beta R \varepsilon^{r_s} + \beta(1 - R) \varepsilon^{-r_s} + (1 - \beta) R \varepsilon^{r_w} + (1 - \beta)(1 - R) \varepsilon^{-r_w}$ . The firm chooses its price to optimize its profit, that is

$$\max_p E(\bar{\pi}) = \bar{p} \cdot [R(1 - \varepsilon) - \bar{p} + \mu R \varepsilon(1 - t)] - c \quad (3)$$

where  $c$  denotes the cost of displaying friend reviews. By solving the above optimization problem, Proposition 2 is obtained.

**Proposition 2** When the firm provides consumers with both the average rating and friend reviews, the optimal price is  $\bar{p}^* = \frac{R(1 - \varepsilon) + \mu R \varepsilon(1 - t)}{2}$ , and the optimal expected profit is  $E(\bar{\pi}^*) = \frac{[R(1 - \varepsilon) + \mu R \varepsilon(1 - t)]^2}{4} - c$ .

### 2.3 Comparison of different review revelation strategies

A formal comparison of the optimal results in Proposition 1 and Proposition 2 leads to Proposition 3, which states the conditions under which each review revelation strategy dominates the other.

**Proposition 3** If and only if the proportion of positive reviews in friend reviews  $R$  and the cost of displaying friend reviews  $c$  satisfy  $R > R_1$ ,  $c < c_1$ , can the firm obtain a higher expected profit by showing friend reviews to consumers; otherwise, it is more profitable for the firm to only provide the average quality rating.

$$R_1 = \frac{1 - \beta \varepsilon^{-r_s} - (1 - \beta) \varepsilon^{-r_w}}{\beta(\varepsilon^{r_s} - \varepsilon^{-r_s}) + (1 - \beta)(\varepsilon^{r_w} - \varepsilon^{-r_w})}$$

$$c_1 = \frac{[2R(1 - \varepsilon) + \mu R \varepsilon(1 - t)] \mu R \varepsilon(1 - t)}{4}$$

Proposition 3 shows that displaying friend reviews to

consumers does not necessarily increase firms' profits. Displaying friend reviews is more profitable than not displaying such information when two conditions hold: 1) Positive reviews account for a high proportion of friend reviews; 2) The cost of showing friend reviews is not very high.

It can be easily proved that, when  $R > R_1$ , the optimal price and expected demand of the product will both increase after the firm displays friend reviews to consumers. This means that when positive reviews account for a high proportion, the positive impact of displaying friend reviews exceeds the negative, the firm can charge a higher price and sell more products by showing friend reviews to consumers. However, if the cost of displaying friend reviews is too high, the increased sales still cannot make up for the above cost. Therefore, firms may consider showing friend reviews to consumers only when the cost is within an acceptable range. The above analysis indicates that if an e-commerce firm wants to jump on the bandwagon of showing friend reviews, it should either have a high development efficiency or take measures to improve its development efficiency so as to reduce the cost of developing social modules in review systems. Moreover, since the proportion of positive reviews is related to the true quality of the product and the positive deviation of reviews, Proposition 3 shows that when the cost of displaying friend reviews is not too high, firms with different qualities should also adopt different review display strategies. For firms selling high quality products, regardless of the deviation of quality information in the reviews, the proportion of positive reviews must be at a high level, so high-quality firms should always show friend reviews to consumers. However, low-quality firms should dynamically adjust their review display strategies according to changes in the proportion of positive reviews. For example, when a product just enters the market, if the early quality ratings show a large positive deviation due to either early buyers' self-selection bias or other reasons, so that positive reviews account for a relatively high proportion, the firm should then show friend reviews to consumers. As the market gradually matures, the positive deviation of quality ratings decreases. When the proportion of positive reviews drops to a certain low level, the firm should change its review display strategy and stop showing friend reviews.

**Corollary 1** When the proportion of positive reviews reaches the threshold  $R_1$ , the cost interval, within which displaying friend reviews is more profitable than not displaying such information, expands with the increase in the proportion of consumers who can see friend reviews when the firm shows consumers the reviews posted by their friends, that is,  $\frac{\partial c_1}{\partial \mu} > 0$  if and only if  $R > R_1$ .

If the proportion of positive reviews is large enough,

the positive impact of displaying friend reviews exceeds the negative one, displaying friend reviews will ultimately have a positive impact on firms' profits. Furthermore, as the proportion of consumers affected by friend reviews increases, the above positive impact will be enhanced, so that the increase in profits from showing friend reviews can still exceed the cost, even if the cost is high. Corollary 1 suggests that when the proportion of positive reviews and the proportion of consumers affected by friend reviews are both large, firms are more likely to increase their profits by displaying friend reviews. It means that if high-quality firms want to benefit from showing friend reviews to consumers, they should take effective measures to encourage consumers to establish and expand their social circles on the websites as well as encourage buyers to publish real-name reviews, so that more potential consumers can see reviews from their friends.

## 2.4 Impact of the distribution of social ties

The social ties between reviewers and potential consumers can affect the latter's purchase decisions by influencing their corrections of the average quality rating. Thus, the distribution of social ties among consumers will ultimately affect firms' profits. When a firm decides to show friend reviews to consumers, by analyzing the impact of the increase in the proportion of strong ties within the crowd on the firm's profit, we obtain the following proposition.

**Proposition 4** When the proportion of positive reviews is large enough, the expected profit of the firm will increase with the increase in the proportion of strong ties among consumers, that is,  $\frac{\partial E(\bar{\pi}^*)}{\partial \beta} > 0$  if and only if  $R \in (R_2, 1]$ ; otherwise, the expected profit of the firm will decrease with the increase in the proportion of strong ties among consumers, that is,  $\frac{\partial E(\bar{\pi}^*)}{\partial \beta} \leq 0$  if  $R \in (R_1, R_2]$ ,

where  $R_2 = \frac{\varepsilon^{-r_s} - \varepsilon^{-r_i}}{\varepsilon^{r_i} - \varepsilon^{-r_i} + \varepsilon^{-r_s} - \varepsilon^{r_s}}$  and it can be easily proved that  $R_2 > R_1$ .

Since the impact of reviews from strong ties on consumers is stronger than that from weak ties, an increase in the proportion of strong ties among consumers has two opposite effects on firms' profits when the total number of friend reviews is fixed: 1) The positive impact of favorable reviews posted by friends will be enhanced; 2) The negative impact of unfavorable reviews posted by friends will also be enhanced. This paper analyzes the situation that the reviews have reached a stable state, so the total number of friend reviews will not change. The changing trend of firms' profits with the proportion of strong ties thus depends on the proportion of positive reviews in all the reviews that will be shown as friend reviews. Since the effect of negative reviews is stronger than that of posi-

tive ones, when the proportion of positive reviews from friends is not large enough (i. e.  $R \leq R_2$ ), the enhancement of negative impact exceeds the enhancement of positive impact, so that an increase in the proportion of strong ties will weaken the profitability of firms. When the proportion of positive reviews from friends is large enough (i. e.  $R > R_2$ ), the positive impact supercedes the negative impact, so that an increase in the proportion of strong ties will enhance the profitability of firms. Based on the above analysis, Corollary 2 is obtained.

**Corollary 2** Even in the case that showing friend reviews to consumers can increase firms' profits, a large proportion of strong ties among consumers is not necessarily beneficial to the firm.

Proposition 4 and Corollary 2 reveal that, though it has been a major trend for traditional e-commerce websites to add social capabilities to make use of the power of social networks, firms should strategically manage consumer online social networks rather than blindly promote social connections and interactions among consumers. Specifically, when the proportion of positive friend reviews is large enough, i. e. ,  $R > R_2$ , firms should take measures to increase the proportion of strong ties among consumers on their websites, such as promoting social interactions among consumers or providing a social login with social platforms characterized by strong ties (e. g. WeChat) and then recommending friends with a high interaction intensity for consumers. When  $R \leq R_2$ , firms should adopt opposite strategies to restrain the increase in the proportion of strong ties among consumers.

**Corollary 3** The threshold  $R_2$  will decrease with the increase in the degree of consumer distrust in the average quality rating, i. e. ,  $\frac{\partial R_2}{\partial \varepsilon} < 0$ .

Corollary 3 suggests that the degree of consumer distrust in the average quality rating will also affect firms' strategies for managing consumer online social networks. Interestingly, as the degree of consumer distrust in the average quality rating rises, firms are more likely to obtain higher profits by taking measures to increase the proportion of strong social ties among consumers. This means that when consumers are skeptical of the average quality rating, more firms can benefit from promoting social connections among consumers. However, when consumers trust the average quality rating very much, firms can hardly benefit from the increase in the proportion of strong social ties among consumers.

### 3 Conclusions

1) With the increase in the sociality of online product reviews, how to choose an optimal review display strategy has become one of the important issues for e-commerce firms. Moreover, when firms choose to display friend reviews to consumers, they should also decide how

to strategically manage consumer online social networks to increase their profits. In this paper, an optimization model is proposed to address the problems mentioned above.

2) Results show that though it has been a trend for e-commerce websites to display friend reviews to consumers, revealing such information does not necessarily increase firms' profits. Only when positive reviews account for a large proportion of all the reviews and the cost of showing friend reviews is not high, can showing friend reviews be more profitable than not showing such information. In addition, the distribution of social ties among consumers can also affect firms' profits. An increase in the proportion of strong ties is not necessarily beneficial to firms, even in the case that showing friend reviews to consumers is more profitable. Specifically, the expected profits of firms will increase with the increase in the proportion of strong ties among consumers only when the proportion of positive reviews is large enough, which indicates that e-commerce firms should be cautious about managing consumer social networks instead of promoting social interactions among consumers blindly. Additionally, the degree of consumer distrust in the average quality rating will also affect firms' strategies for managing consumer online social networks.

3) Our analysis still has limitations. For instance, we assume that each consumer has at most one friend who has posted a review of the product, that is, each consumer will at most be influenced by one friend when making a purchase decision. But actually, it is possible that a consumer may have multiple friends with different tie strengths who have purchased the same product and have posted different reviews. Therefore, future research will focus on analyzing how multiple friend reviews jointly affect consumer purchase decisions.

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## 考虑消费者间社交关系的评论展示策略研究

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**摘要:**构建优化模型分析了电商企业的最优评论展示策略以及对消费者在线社交网络的管理策略. 研究表明, 为消费者展示朋友评论不一定能为企业带来利润增加, 仅当好评占比较高且为消费者展示朋友评论付出的成本较低时, 展示朋友评论才能增加企业利润. 人群中社交关系分布情况会影响企业利润, 即使在展示朋友评论可以增加企业利润的情况下, 人群中强关系占比的提高也并非一定对企业有利, 仅当好评占比足够高时, 消费者群体中强关系占比的增加才能提高企业利润. 此外, 消费者对产品质量平均评分的不信任程度也会影响企业对消费者在线社交网络的管理策略. 随着消费者对产品质量平均评分不信任程度的提高, 企业更有可能通过采取措施增加网站用户间强关系占比实现利润增长.

**关键词:**在线产品评论; 社交关系; 评论展示策略; 社交商务

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