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Abstract

In the context of increasing globalization, a new product may be sequentially released into markets in different countries and regions. The behavior of consumers in the market where a new product is first launched may have a huge impact on the purchasing behavior of consumers in later markets through the effects of herding and word of mouth (WOM). We suggest that these effects may significantly influence advertising when new products with short life cycles, such as movies, books, games, and music, are sequentially launched and not repeatedly purchased by consumers. Using a two-period advertising signaling model, this study theoretically demonstrates that the effects of herding and WOM affect the existence of separating (signaling quality) and pooling (hiding quality information) equilibria, but the number of potential consumers in different markets has no impact. Importantly, we investigate the firm's strategic choices by comparing the profits generated under different equilibria and find that if the strength of WOM or the unit advertising cost increases, or if the herding effect decreases, a pooling equilibrium is likely to be the best, and a win-win, strategy before a new product is first released and consumed; otherwise, a separating equilibrium dominates. We also find that the cost of signaling decreases as WOM increases, whereas it increases with the herding effect or the mass of consumers in Period 1. Our findings provide several managerial implications relating to releasing product quality information for those industries in which products without repeat purchase are sequentially released in different markets.

Keywords: Word of mouth; Herding effect; Advertising; Product quality; Signaling game

1. Introduction

In the context of increasing globalization, a new product may be sequentially launched in different countries and regions at different times. For instance, the Indian movie *Bajrangi Bhaijaan* was initially released in India on July 17, 2015, and it was later released in China on February 19, 2018.[1] The American film *The Shape of Water* was released in two theaters in New York City on December 1, 2017, and then it was released in several other cities over the following weeks, but it was not set to release in China until 2018.[2] In cases such as these, customers who consume the product in the early period may provide word of mouth (WOM), such as online and offline reviews and opinions on discussion boards, chat rooms, and blogs. WOM not only reveals a product's true quality to potential consumers but also influences their purchase decisions (Duan et al., 2008). In addition, consumers in the later period may simply follow the prior consumers' purchasing behaviors, especially when product sales volume is high in the early period (Bonabeau, 2004). This is referred to as the herding effect. Therefore, it is important to understand how the behavior of consumers in the early period affects the behavior of consumers in later periods (captured by the effects of WOM and herding in this paper) and their collective impact on a firm's profit.

In practice, firms spend huge amounts to advertise new products in the prelaunch period to create awareness, reveal information, and stimulate large initial demand. This is especially true for new products with short life cycles, such as movies, books, electronic games, and music (Caves, 2001), for which repeat purchases are not common. For example, advertising takes a significant portion of a movie studio's total expenditure, and nearly 88% of television (TV) advertising is spent before a movie is released (Elberse & Anand, 2007). Another important reason for advertising is to reduce the risk of negative WOM hurting subsequent sales (Eliashberg et al., 2006). However, there are exceptions where firms, such as those in the movie industry, do not advertise heavily in the early stage. For instance, the prelaunch advertising budget for the Chinese movie *Lost on Journey* was not large, but the movie nevertheless enjoyed great success at the box office in China.[3] The studio attributed this tremendous success to positive WOM created in the postlaunch period. Thus, especially for the sequential release of a new product, it is important to carefully assess the interplay between a firm's advertising strategy for the prelaunch period and WOM during the postlaunch

[1] https://www.imdb.com/title/tt3863552/releaseinfo?ref_=tt_dt_dt

[2] https://www.imdb.com/title/tt5580390/releaseinfo?ref_=tt_dt_dt

[3] http://ent.qq.com/a/20100713/000319.htm

period.

The firm's decision depends on its quality type. A high-quality firm might choose to conceal its product quality to reduce the initial demand in Period 1[4], instead relying on positive WOM in Period 2 to create high demand (i.e., the experienced quality exceeds consumers' expectations in Period 1). However, the high-quality firm can also reveal the quality of its product to generate high initial demand in Period 1, but benefit from little WOM in Period 2 (i.e., no difference between consumers' expected quality and experienced quality in Period 1). In contrast, a low-quality firm may preemptively reveal its product quality in Period 1 to limit negative WOM in Period 2, which may increase the demand in Period 2. If the low-quality firm pretends to be a high-quality firm in Period 1, it may achieve high initial demand, but the demand in Period 2 will be significantly lower due to negative WOM (i.e., the experienced quality is lower than the expectation for the consumers in Period 1). In sum, a firm should consider the benefits of signaling product quality and the effects of positive (negative) WOM to make strategic decisions on whether to signal product quality before releasing a new product. In the marketing and economics literature, most studies have investigated the role of advertising as a signal of product quality (Horstmann & MacDonald, 2003; Kihlstrom & Riordan, 1984; Milgrom & Roberts, 1986). However, few studies have investigated the effects of WOM and herding on the role of advertising.

As mentioned above, the herding effect will also arise when consumers in Period 2 imitate the behavior of consumers in Period 1 rather than making decisions based on their own information. This herding behavior affects the market demand in Period 2 such that it is beneficial to stimulate a higher demand in Period 1. Furthermore, advertising serves the purpose of raising awareness, and it directly affects the demand in Periods 1 and 2. Therefore, firms face a complex challenge when determining advertising amounts in Periods 1 and 2, especially when WOM and herding depend on the demand in Period 1.

This paper extends existing theoretical research by considering the effects of WOM and herding on the potential demand in Period 2 as well as the effect of advertising on demand in both Periods 1 and 2. We investigate two important research questions:

(1) How do WOM and herding influence a firm's advertising decision when the role of advertising—raising awareness and signaling quality—changes over time for new products that are sequentially released in different markets, but for which there will be no repeat purchases?

[4] In terms of the division of Period 1 and Period 2, please see Figure 1.

(2) Under what conditions can the pooling equilibrium outperform the separating equilibrium (i.e., the firm's preference for different advertising and signaling strategies), considering the effects of WOM and herding on consumers' purchase decisions?

To address these questions, we establish a two-period signaling model in which a firm sequentially releases its new product in different markets with different numbers of consumers. Consumers do not have complete information about the product's quality before making a purchase in Period 1. Therefore, as they must rely on advertising to learn about the product's quality, advertising both signals product quality and raises awareness in Period 1. In Period 2, utilizing the quality information provided by WOM, consumers have complete information about the product's quality. Therefore, the role of advertising in Period 2 is simply to raise awareness. In our demand function, we consider the relevance of social media by incorporating the herding effect and the potential gap between experienced and expected quality formed by WOM, which also captures the impact of consumers in the early period on consumers in the later period—that is, the interaction between different markets.

Our analysis reveals that a stable separating equilibrium always exists, but a stable pooling equilibrium might arise under different conditions depending on factors such as price, advertising cost, the strength of WOM, and the herding effect. The results indicate that the interaction between consumers in Periods 1 and 2 does affect the firm's information release strategy. The number of consumers in different markets does not affect the existence of equilibrium and the firm's strategy preference, but it has an impact on the firm's advertising investment. Furthermore, by comparing high- and low-quality firms' profits, we investigate which strategy firms prefer when stable separating and pooling equilibria coexist. In particular, we find that if the strength of WOM or the unit advertising cost increases or if the herding effect decreases, the firm is likely to have a stable pooling equilibrium in Period 1 (i.e., both high- and low-quality firms spend the same amount on advertising). Otherwise, the separating equilibrium dominates. Moreover, this study shows that the signaling cost increases with the level of herding, but decreases with the strength of WOM. The cost of signaling also increases as the mass of potential consumers increases in Period 1.

Our research contributes to the extant literature in three areas. First, we establish a two-period advertising model to capture the different roles that advertising plays in different periods when a firm introduces a new product in different markets (e.g., different countries) at different times. In the later period, the purchasing behavior of consumers who observe postlaunch advertising may be affected by the behavior of consumers in the early period. Advertising plays a signaling role and also informs consumers of the existence of new

products before they are released. Yet advertising mostly serves to raise product awareness after a product is launched as information about the product's quality is disseminated through WOM. Such situations arise if the communication among consumers is perfect, such that each consumer's experience of initial purchase becomes common knowledge (Kihlstrom & Riordan, 1984). Our results provide new insight into the debate on the informative role of advertising as a signal of product quality. Second, our research explores how WOM and herding affect the role of advertising (i.e., signaling product quality and increasing awareness) and firms' advertising and signaling strategy preferences (i.e., pooling and separating strategies) in a signaling system with different consumers in different periods. The influence of WOM and herding may be the key factor in understanding the role of advertising in the early period. Third, because our two-period signaling game model is based on a practical scenario in which a firm may launch its product in different countries and regions at different times, the model can be applied to situations where WOM and herding, which capture the initial consumers' impact on subsequent consumers, influence consumer purchase decisions when there are different numbers of potential consumers in the two periods.

In the next section, we review the advertising literature before describing our theoretical model in Section 3. Subsequently, we analyze the complete information and asymmetric information cases in Sections 4 and 5, respectively, and present the analytical results in Section 6. We conclude the paper in Section 7. All proofs are available in the Online Appendix.

2. Literature Review

Although our work relates to a large number of literature published in the past several decades on advertising and WOM/herding, it is worth noting that few studies have examined the interaction between WOM/herding and the role of advertising in a two-period theoretical framework. The literature on the role of advertising is vast, but most studies have focused on issues other than its role in the subsequent release of a new product without repeat purchases. In this literature review, we focus on the roles of advertising and the effects of WOM and herding.

2.1. Roles of advertising

There exists a large stream of literature on the roles of advertising spending. Some studies have shown that advertising spending can be a signal of product quality. Advertising provides consumers with information that is vital to their purchase decision (e.g., Eckard, 1991). For example, consumers can learn about the quality of search goods whose attributes can be evaluated prior to purchase, such as price and weight, from the direct

information conveyed by advertising. Furthermore, the amount of advertising can serve as a signal of product quality. This view was pioneered by Nelson (1970, 1974) and has been investigated widely since then (e.g., Ambler & Hollier, 2004; Eckard, 1991; Kihlstrom & Riordan, 1984; Kirmani, 1990; Milgrom & Roberts, 1986; Moorthy & Hawkins, 2005; Sahni & Nair, 2018; Zhao, 2000). This is because advertising costs can be substantial, comprising not only direct costs but also potential costs that can arise when the revealed product quality does not meet the publicized quality. In this case, the level of advertising relates positively to, and serves as, a signal of product quality because consumers infer that highly advertised products possess better quality than less advertised products. If brand A spends much more on advertising than brand B, consumers have greater exposure to brand A and may expect its quality to be superior to that of brand B. However, if the amount of advertising is not actually related to product quality, this inference would be erroneous. To provide indirect information and serve as a signal of product quality, advertising must have a positive and significant relationship with product quality.

As the direct information conveyed by advertising is straightforward, and thus less controversial, studies on the informative role of advertising have been largely centered on indirect information. For example, Moorthy and Hawkins' (2005) experiment testing Nelson's theory shows that advertising spending has a positive impact on perceived quality, and this effect does not depend on whether the product is a search or experience good, which partially supports Nelson's theory. Nevertheless, these arguments have been challenged, for example, by Schmalensee (1978), who demonstrates that a separating equilibrium between low- and high-quality firms does not exist in certain conditions. Using a two-period model, Horstmann and Macdonald (1994, 2003) show that advertising is an imperfect signal of quality. Using data on Taiwanese international tourist hotels, Chiu and Chen (2014) show that a higher advertising expenditure does not necessarily signal higher service quality. Further, Chenavaz and Jasimuddin (2017) identify the condition that dictates when the advertising–quality relationship will be positive or negative.

Some studies have considered the varying roles of advertising over time and the ways in which consumers use advertising to facilitate their purchase decision process. For example, Song et al. (2015) conduct an empirical investigation into whether advertising is a reliable indicator of quality before and after product launch, and they find that postlaunch advertising is a reliable quality indicator, while prelaunch advertising is not. Caulkins et al. (2017) consider how the impact of advertising on demand evolves over time, and they determine the optimal time paths for pricing, advertising, and quality for a profit-maximizing firm. Basuroy et al. (2006) find that while advertising can act as a signal of quality, third-party information sources, such as

critics' review consensus and WOM, attenuate advertising's quality signal. That is, consumers rely less on advertising to assess unobservable product quality when an independent source of information is available later.

Narayanan et al. (2005) also find that physicians rely on marketing, such as detailing and other communications, as a signal of quality and update their prior beliefs about drug quality. Ackerberg (2001) distinguishes empirically between the informative and prestige effects of advertising by assuming that advertising that contains product information should primarily affect inexperienced consumers, who have never tried the brand, whereas prestige advertising should influence both inexperienced and experienced consumers. He shows that advertising has a positive effect on inexperienced consumers' purchase probabilities, but does not affect the purchase probabilities of experienced consumers. Zhao (2000) constructs a signaling model in which advertising signals quality and also raises awareness of a product. By comparing complete and incomplete information games, he finds that in the separating equilibrium, a high-quality firm will spend less on advertising than a low-quality firm, resulting in a negative correlation between product quality and advertising spending. To the best of our knowledge, Zhao's (2000) study is unique in that it investigates advertising's dual purpose of signaling quality and raising awareness by establishing a one-period signaling model with repeat purchase. Our study diverges from Zhao's (2000) by considering the changing role of advertising over the subsequent releases of a new product without repeat purchase.

Some literature focuses on dynamic advertising (for reviews, see Feichtinger et al., 1994; Huang et al., 2012). Reddy et al. (2016) employ three classical dynamic optimal control models of advertising to examine the optimal advertising and investment in quality when quality may deteriorate over time. Clark et al. (2009) model advertising as a dynamic investment and use panel data to study the effect of advertising on brand awareness and perceived quality. Chutani and Sethi (2018) study dynamic cooperative advertising decisions by considering the role of competition at both the manufacturer and retailer levels. Considering that the sales growth of a new product evolves over time, Krishnan and Jain (2006) use an empirically proven diffusion demand function that explicitly incorporates the advertising component and then derives the optimal advertising policy. Based on the goodwill level enabled by advertising and quality, Nair and Narasimhan (2006) investigate the relationship between advertising/quality and goodwill when a firm dynamically chooses advertising and quality strategies.

2.2. Word of mouth and the herding effect

There is extensive empirical and theoretical literature on the impact of WOM on consumers' purchasing behavior (Chen & Xie, 2008) and product sales (Ajorlou et al., 2018; Chevalier & Mayzlin, 2006; El Ouardighi et al., 2016; Eliashberg et al., 2006; Hennig-Thurau et al., 2015). Some studies have investigated the impact of WOM and advertising on market outcomes (Chen et al., 2012; Burmester et al., 2015; Gopinath et al., 2013; Kim & Hanssens, 2017). Gutierrez and He (2015) assume that the underlying retail demand for an innovative, durable product is influenced by WOM from past adopters and follow a Bass-type diffusion process to demonstrate that revenue-sharing contracts can coordinate the innovative durable product's supply chain with both far-sighted and myopic retailers.

There is also a stream of research on the relationship between advertising and WOM. For instance, Mahajan et al. (1984) present a model of new product diffusion to reveal the relationship between WOM and the timing of advertising. Fossen and Schweidel (2016) find that TV advertising impacts the volume of online WOM for both the advertised brand and the TV program during which the advertisement was aired by using data pertaining to TV advertising instances and the volume of minute-by-minute social media mentions. Godes (2017) investigates the relationship between product quality and WOM. Abedi et al. (2014) study the joint design of a network of retail facilities and marketing strategies in the presence of WOM effects and a limited time horizon. Our work complements these studies by identifying the effects of WOM and herding on the role of advertising as a signal of product quality.

The majority of the herding effect literature strives to explain herding behavior by payoff externalities (Choi, 1997; Diamond & Dybvig, 1983; Scharfstein & Stein, 1990), correlated effects (Manski, 2000), information externalities (Banerjee, 1992; Simonsohn & Ariely, 2008; Willinger & Ziegelmeyer, 1998), or social preferences (Corazzini & Greiner, 2007; Croson & Shang, 2008; Goeree & Yariv, 2015; Jones, 1984). Chen et al. (2011) investigate the interaction between herding and WOM. Zhang and Liu (2012) use a unique panel dataset from Prosper.com to investigate the distinction between irrational and rational herding and find evidence of rational herding among lenders. Using eBay data, Simonsohn and Ariely (2008) find that bidders herd at auctions with more existing bids, even if those bids are a signal of no-longer-available lower starting prices rather than high quality, which indicates irrational herding among eBay bidders. In the finance and marketing fields, numerous studies have found evidence of herding behavior (Cakan & Balagyozyan, 2014; Cakan et al., 2018; T. Chen, 2013; P. Chen, 2016; Hammami & Boujelbene, 2015) and the impact of herding on performance (Hammami & Boujelbene, 2015; Hanson & Putler, 1996) or consumers' purchasing behaviors (Y.

F. Chen, 2008; Zhang et al., 2014). However, few studies have investigated the interplay between herding and the role of advertising.

3. The Model

We consider a risk-neutral firm that produces and sells a new short life-cycle product that consumers do not repeatedly purchase. The product quality (q) is either high ($q = q_h$) or low ($q = q_l$). If the firm produces a high-quality product, we call it a high-quality firm; if the firm produces a low-quality product, we call it a low-quality firm. In practice, the product may be introduced in different countries and regions. Therefore, we divide the time horizon into Period 1 and Period 2. The dividing point is when consumers in Period 1 experience the product and reveal its quality to potential consumers in other countries and regions through WOM. The firm has private information about product quality (q)before selling the product consumers in Periods 1 and 2, while potential consumers in Period 1 are unaware of the true product quality; however, potential consumers in Period 2 uncover the true quality by searching for information revealed by the first-period consumers (please see Figure 1).

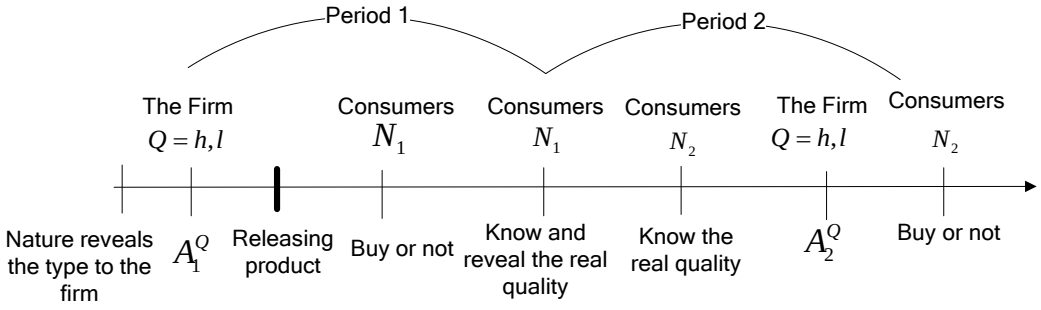


Figure 1. The sequence of events

The new product is in a perfectly competitive market or for some types of products, the product quality may have little relationship with the price, such as music, books, and movies; therefore, we assume that the new product is exogenously priced at p . Thus, we consider two decisions that the firm must make: how much advertising to provide in Periods 1 and 2, respectively. For convenience, we summarize all notations in Table 1 in the Appendix.

We assume that in Period 1, the nature reveals the quality type of firm, and the firm privately knows its product quality, but before observing the firm's expenditure on advertising, consumers only know that the product quality can either be high ($q = q_h$) with a probability of δ or low ($q = q_l$) with a probability of $1-\delta$. Prior knowledge of the firm's product quality stems from the firm's reputation and consumers' expectations of the firm's historical performance and other product attributes. In Period 1, a firm of the type $Q = h,l$ first makes advertising decision ($A_t^Q(t=1)$) before releasing the product. Consumers then observe the advertising and know of the new product's existence; thus, they use the advertising expenditure information to update their

beliefs about the product's quality. Therefore, at $t=1$, after observing A_1^Q, consumers update their beliefs about the product's quality, represented by $\rho_1 = p\{q_h \left| A_1^Q \right.\}$. That is, the consumers know that the quality can be high with an updated probability of ρ_1 after observing A_1^Q. Thus, the expected product quality is $\rho_1 q_h + (1-\rho_1) q_l$.

Once the new product has been released, consumers make purchase decisions based on their beliefs about product quality. Note that the advertising in Period 1 serves the dual purpose of signaling quality and raising awareness. After consuming the new product, the consumers become aware of the true quality of the product and they reveal this information to consumers in Period 2 by means such as writing reviews online and assigning scores. Some websites allow consumers to grade the quality of products, such as movies, books, and music (e.g., Rotten Tomatoes [www.rottentomatoes.com] and the Chinese website Douban [www.douban.com]). Therefore, in Period 2, consumers know the real quality of the product before making a purchase decision. This assumption is consistent with Nelson (1974), Milgrom and Roberts (1986), Horstmann and MacDonald (1994), and Zhao (2000). The firm then determines the advertising level ($A_t^Q(t=2)$) in Period 2. Consumers who know the real product quality then make purchase decisions in Period 2, meaning that advertising only serves to raise awareness about the product in Period 2.

We further assume that the mass of potential consumers in Period t is $N_t\,(t=1,2)$ (Bagwell, 2007). Following prior literature, we anticipate that these potential consumers are aware of the product through advertising, that consumers who observe the advertising may purchase the product (see, e.g., Zhao, 2000), and that the consumers can observe or infer the advertising expenditure (see Milgrom & Roberts, 1986; Zhao, 2000), for example, by noting the place and frequency of advertising. The number of consumers in Period t who observe advertising from the type $Q=h,l$ firm depends on the level of advertising, $A_t^Q\,(t=1,2)$, which may reflect minutes of TV or radio exposure, the number of advertising messages or fliers sent, and so on. The cost per advertising level is constant, given by k, and we require $k < p\left(1-\frac{p}{q_l}\right)$ to ensure non-negative advertising. For instance, A_1^h shows that a high-quality firm makes A_1^h advertising in Period 1, which means that a type h firm invests kA_1^h in advertising in Period 1.

The probability of a consumer observing no advertising is $[1-1/N_t]^{A_t^Q} \approx e^{-A_t^Q/N_t}$ for N_t consumers (Bagwell, 2007). Thus, $N_t\left[1-e^{-A_t^Q/N_t}\right]$ consumers are aware of the product owing to advertising. However, the purchase decisions of these consumers depend on their utility. As consumers are heterogeneous in their willingness to pay for quality, we denote a consumer's quality preference by θ, which is uniformly distributed over [0,1]. A consumer's utility can be written as $\theta g_t(q) - p$, where $g_t(q)$ is the perception of product quality that the consumer forms in Period t before consuming the good. The consumer purchases the product

if and only if $\theta > \frac{p}{g_t(q)}$, so the market demand function is $D_t^Q(A_t^Q, g_t(q)) = N_t\left[1-e^{-A_t^Q/N_t}\right]\left[1-\frac{p}{g_t(q)}\right]$ when we consider only the impact of advertising, as is appropriate in Period 1.

In addition to informing consumers in Period 2 of the product quality, the consumers in Period 1 influence those in Period 2 through WOM and the herding effect. The behavior of consumers in Period 1 may have a stronger influence on consumers in Period 2 because more purchases occurred during Period 1. Therefore, the extent of the WOM and herding effects increases as demand increases in Period 1. The herding effect, denoted by h, suggests that people are influenced by others when making purchase decisions.

The WOM effect is captured by the disparity between consumers' expected and experienced quality in Period 1, and the WOM effect has a positive relationship with consumer satisfaction in Period 1 (Expectation Confirmation Theory; Anderson & Sullivan, 1993). When their satisfaction or dissatisfaction increases, consumers become more likely to spread WOM (Anderson, 1998), which then affects consumer behavior in Period 2. Thus, the strength of the WOM effect can be captured by the gap between the prepurchase perceived quality and the quality that consumers actually experience in Period 1. In this paper, the gap that captures the strength of the WOM effect per consumer on the product owned by the firm of type $Q = h, l$ can be written as $\Delta\mu^Q = g_1^{\#}(q) - g_1(q)$, where $g_1^{\#}(q)$ is the quality experienced after consuming the good in Period 1. $g_1^{\#}(q)$ is also the real quality of the product. That is, the strength of WOM is defined as $\Delta\mu^Q = g_1^{\#}(q) - g_1(q)$. Once consumers in Period 1 consume the product, they will disseminate information on the real product quality to potential consumers, who will be aware of the real quality of the product before they purchase it in Period 2. Therefore, we have $g_2(q) = g_1^{\#}(q)$ and $\Delta\mu^Q = g_2(q) - g_1(q)$. The greater the positive (or negative) gap, the greater the positive (or negative) WOM, and then the higher (or lower) the potential demand is in Period 2.

There are no herding and WOM effects in Period 1. Thus, the demand function in Period 1 is unchanged. However, in Period 2, both effects exist, and the demand function can be written as follows:

$$D_2^Q(A_1^Q, A_2^Q) = N_2\left[1-e^{-(A_2^Q+(h+\eta\Delta\mu^Q)D_1^Q(A_1^Q))/N_2}\right]\left[1-\frac{p}{g_2(q)}\right], \quad (1)$$

where η is defined as the factor showing the extent of the WOM impact and $\eta > 0$. The impact of WOM on the demand in Period 2 is somewhat complex. If the WOM is positive (i.e., $\Delta\mu^Q > 0$), the demand in Period 2 is increasing in WOM. If the WOM is negative (i.e., $\Delta\mu^Q < 0$), the demand in Period 2 is decreasing in WOM. The total demand in Period 1, $D_1^Q(A_1^Q)$, will amplify this impact. That is, the positive or negative impact of WOM on the demand in Period 2 will increase as the demand in Period 1 increases. In addition, the demand in Period 2 is increasing in the herding effect, and the extent of the herding effect is also increasing as the demand in Period 1 increases.

In addition, regardless of its strategy, the type Q firm's profit in Period 1 is

$$\pi_1^Q = pD_1^Q - kA_1^Q = pN_1\left[1-e^{-A_1^Q/N_1}\right]\left[1-\frac{p}{g_1(q)}\right]-kA_1^Q, \quad (2)$$

and its profit in Period 2 is

$$\pi_2^Q = pD_2^Q - kA_2^Q = pN_2\left[1-e^{-(A_2^Q+(h+\eta\Delta\mu^Q)D_1^Q)/N_2}\right]\left[1-\frac{p}{g_2(q)}\right]-kA_2^Q. \quad (3)$$

Thus, the overall profit of the type Q firm is

$$\begin{aligned}\pi^Q(A_1^Q,A_2^Q) &= \pi_1^Q + \pi_2^Q \\ &= pN_1\left[1-e^{-A_1^Q/N_1}\right]\left[1-\frac{p}{g_1(q)}\right]-kA_1^Q + pN_2\left[1-e^{-(A_2^Q+(h+\eta\Delta\mu^Q)D_1^Q)/N_2}\right]\left[1-\frac{p}{g_2(q)}\right]-kA_2^Q, \forall Q\in\{h,l\}.\end{aligned} \quad (4)$$

The product's true quality can be revealed perfectly after consumers experience it in Period 1 (Nelson, 1974; Zhao, 2000). Technically, we first compute the firm's optimal advertising by maximizing π_2^Q; then we insert this result into the whole profit of the firm, π^Q.

The following sections focus on the analysis of Period 1, which takes the Period 2 result into consideration. To demonstrate the impact of incomplete information about product quality on the advertising signaling effect, we first analyze a benchmark scenario in which consumers have complete information about product quality; then we proceed to a scenario in which consumers do not have complete product quality information.

4. Complete Information Case

In a scenario of complete information, all consumers in Periods 1 and 2 are informed of the product's quality before purchasing the product. Thus, the WOM effect is zero (i.e., $\Delta\mu^Q = 0$), and the perception of product quality that consumers form in Periods 1 and 2 equals the true quality (i.e., $g_1(q) = g_2(q) = q_Q$). We use A_1^Q and A_2^Q to denote the advertising levels, and the type Q firm's profit can be written as

$$\pi^Q(A_1^Q,A_2^Q) = pD_1^Q - kA_1^Q + pD_2^Q - kA_2^Q, Q\in\{h,l\}, \quad (5)$$

where $D_1^Q = N_1\left[1-e^{-A_1^Q/N_1}\right]\left(1-\frac{p}{q_Q}\right)$ is the demand in Period 1, and $D_2^Q = N_2\left[1-e^{-(A_2^Q+hD_1^Q)/N_2}\right]\left(1-\frac{p}{q_Q}\right)$.

Proposition 1*: When consumers have complete product quality information, the optimal advertising level of a type Q firm is $\tilde{A}_1^Q = -N_1\ln\frac{k}{(p+kh)\left(1-\frac{p}{q_Q}\right)}$ and $\tilde{A}_2^Q = -N_2\ln\frac{k}{p\left(1-\frac{p}{q_Q}\right)} - hD_1^Q$, where*

$D_1^Q = N_1\left(1-\frac{p}{q_Q}-\frac{k}{p+kh}\right)$ *and* $Q=h,l$.

We make several inferences from Proposition 1. First, in Period 1, the high-quality firm advertises more than the low-quality firm because Period 1's advertising level increases with quality; that is,

$$\frac{\partial \tilde{A}_1^Q}{\partial q_Q}=\frac{pN_1}{q_Q^2\left(1-\frac{p}{q_Q}\right)}=\frac{p}{q_Q}\frac{N_1}{(q_Q-p)}>0.$$

Second, in Period 2, the advertising level depends not only on the quality level but also on the relative mass of consumers in both periods. If $hN_1 p\frac{q_h-q_l}{q_h q_l}>N_2\ln\frac{q_l(q_h-p)}{q_h(q_l-p)}$, the low-quality firm advertises more in Period 2 than the high-quality firm does; otherwise, the high-quality firm advertises more in Period 2. This result reflects the herding effect. If this herding effect is sufficiently strong, the high-quality firm has a stronger incentive to advertise in Period 1 than the low-quality firm does, because of the higher consumer utility attained from the higher-quality product. Therefore, compared to the low-quality firm, for the high-quality firm, to a greater extent, the impact of the herding effect on the demand dominates the impact of the advertising done in Period 2. When the number of Period 1 consumers is greater, the high-quality firm shifts its advertising budget more significantly from Period 2 to Period 1. If there is no herding effect, the high-quality firm always advertises more than the low-quality firm does.

Regardless of these factors, the high-quality firm always earns a higher total profit because

$$\frac{\partial \pi^Q}{\partial q_Q}\Big|_{A_1^Q=\tilde{A}_1^Q,A_2^Q=\tilde{A}_2^Q}=\frac{p}{q_Q^2}\left\{\left(p+h-k/\left(1-\frac{p}{q_Q}\right)\right)N_1+N_2\left(p-k/\left(1-\frac{p}{q_Q}\right)\right)\right\}>0,$$

and because $\tilde{A}_1^Q>0$ and $\tilde{A}_2^Q>0$, we have $k<p\left(1-\frac{p}{q_Q}\right)$, $Q=h,l.$ Thus, we assume that $k<p\left(1-\frac{p}{q_l}\right)$ to ensure non-negative advertising levels. The above results also can be seen as the results when the role of advertising is simply to raise awareness about the product in both Periods 1 and 2.

5. Asymmetric Information Case

In reality, it may be costly or infeasible for consumers to obtain complete information about product quality before a new product is on the market. Therefore, we also study the case where consumers in Period 1 are uncertain about the firm's quality without experiencing its product; that is, consumers have prior probability information about product quality before they consume the product in Period 1. In this case, advertising not only raises awareness about the product but also may signal product quality. Therefore, the

model can be solved by using a typical signaling game approach.[5] For both types of firms, there are two strategies: different advertising spending levels (separating equilibrium) and the same advertising spending level (pooling equilibrium). If the firm chooses a separating equilibrium strategy such that it advertises more when its product quality is high, consumers can infer product quality information from the advertising expenditure. However, if the firm chooses a pooling equilibrium strategy and advertises the same amount, regardless of quality, consumers cannot infer quality and must instead form their quality expectation on the basis of their prior beliefs.

To identify the firm's best strategy (or perfect Bayesian equilibrium), we first suppose that there is a pooling or separating equilibrium and then verify whether the strategy or equilibrium is a perfect Bayesian equilibrium (Gibbons, 1992; Peters, 2015). In fact, there may be many perfect Bayesian equilibria, making it necessary to select among them. One method for ruling out equilibria is to apply the intuitive criterion (Cho & Kreps, 1987). The intuitive criterion means that for an equilibrium, there are some off-equilibrium strategies that are equilibria dominated for one type firm, but not the other, regardless of the consumers' beliefs. We use the intuitive criterion to refine the equilibria in our model. The equilibrium that satisfies the intuitive criterion is called the stable equilibrium. If there are multiple stable equilibria, we employ the Pareto dominance rule, where all equilibria in which the payoffs of the two firm types are less than those under some other equilibria are excluded. The stable equilibrium that involves the Pareto dominance strategy is called the Pareto dominant stable equilibrium.

5.1. Separating equilibrium

In a separating equilibrium, the firms advertise differently, and the advertising level signals the quality of the product. Accordingly, consumers can infer product quality on the basis of the advertising level.

Now we try to find the firm's separating equilibrium. It is convenient to define:

$$\pi^{Q,Y}(A_1^{Q,Y}, A_2^{Q,Y}) = pD_1^{Q,Y} - kA_1^{Q,Y} + pD_2^{Q,Y} - kA_2^{Q,Y}, \tag{6}$$

where $D_1^{Q,Y} = N_1\left[1-e^{-A_1^{Q,Y}/N_1}\right]\left(1-\frac{p}{q_Y}\right)$, $D_2^{Q,Y} = N_2\left[1-e^{-(A_2^{Q,Y}+(h+\eta\Delta\mu^{Q,Y})D_1^{Q,Y})/N_2}\right]\left(1-\frac{p}{q_Q}\right)$, $\forall Q,Y \in \{h,l\}$.

$\pi^{Q,Y}$ and $A_t^{Q,Y}$ represent the profit and advertising level, respectively, of a type Q firm that is perceived to be of type Y in Period t. $\Delta\mu^{Q,Y}$, capturing the strength of WOM, is defined as the gap between experienced quality and prepurchase perception of quality, and we let $\Delta\mu^{Q,Y} = q_Q - q_Y$. Note that if $Q = Y$, then the advertising level signals the firm's true product quality, which means that mimicry does not occur. We

[5] A signaling game belongs to an important class of dynamic games of incomplete information that has been widely used in economics. Some literature in the marketing field uses signaling games to study whether advertising can be a signal of product quality, such as Milgrom and Roberts (1986), Horstmann and MacDonald (1994), and Zhao (2000). In our paper, the perfect Bayesian equilibrium falls into two categories: separating equilibrium and pooling equilibrium.

have $\Delta\mu^{Q,Q} = \Delta\mu^{Y,Y} = 0$ for Q=Y. If the low-quality firm pretends to be a high-quality firm, then the strength of WOM is $\Delta\mu^{l,h} = q_l - q_h$, and $\Delta\mu^{l,h} < 0$ because $q_l < q_h$.

If the firm reveals its quality type and does not imitate the other quality type, the following incentive compatibility must be satisfied:

$$\pi^{h,h}(A_1^{h,h}) \geq \pi^{h,l}(A_1^{h,l}), \tag{7}$$

$$\pi^{l,l}(A_1^{l,l}) \geq \pi^{l,h}(A_1^{l,h}). \tag{8}$$

That is, constraint (7) guarantees that the high-quality firm is not willing to imitate low quality in the separating equilibrium, and constraint (8) assures that the low-quality firm will signal its quality rather than be mistaken for a high-quality firm.

Lemma 1: *i)* $\pi^{Q,Y}$ *is concave and maximized at* $\hat{A}_1^{Q,Y}$ *and* $\hat{A}_1^{l,Y} < \hat{A}_1^{h,Y}$ *for* $Q,Y \in \{h,l\}$, *where* $\hat{A}_1^{Q,Y} = -N_1 \ln \dfrac{k}{(p + k(h + \eta\Delta\mu^{Q,Y}))\left[1 - \dfrac{p}{q_Y}\right]}$;

ii) $\dfrac{d\pi^{h,Y}(A_1)}{dA_1} \geq \dfrac{d\pi^{l,Y}(A_1)}{dA_1}$ *for* $Y \in \{h,l\}$;

iii）$\pi^{Q,h}(A_1) - \pi^{Q,l}(A_1) > 0$ *if* $\eta < \dfrac{(p+kh)(1-C)}{k\Delta\mu^{h,l}}$ *for* $Q \in \{h,l\}$, *where* $\dfrac{1 - \dfrac{p}{q_l}}{1 - \dfrac{p}{q_h}} = C$.

Lemma 1(i) shows that the firm's profit, $\pi^{Q,Y}$, is strictly concave and there exists a unique advertising level that maximizes the firm's profit. The optimal advertising level in Period 1 is increasing in the strength of positive WOM or the herding effect, but the optimal advertising level in Period 2 decreases (increases) as the strength of (negative) positive WOM or the herding effect increases (see the proof of Lemma 1). The effects of WOM and herding dramatically affect the firm's advertising investment in different periods, especially when the firm exhibits imitative behavior. This result, to some extent, explains the phenomenon of overinvestment in advertising before the new product is released. Lemma 1(ii) reveals that $\pi^{h,Y}$ does not increase slower than $\pi^{l,Y}$ as advertising level A_1 increases. This result implies that the same advertising level cannot be costlier for the high-quality firm than for the low-quality firm.

Lemma 1(iii) indicates that if η is small, the profit of the firm that is high quality or pretends to be high quality is larger than that of the firm that is or pretends to be low quality. That is, the high-quality firm has no incentive to mimic the low-quality firm, but the low-quality firm does have an incentive to pretend to be a high-quality firm. For the low-quality firm, the benefit of mimicry is increased demand in Period 1, but the mimicry hurts the demand in Period 2 due to the first-period consumers' behavior after purchase—that is, the

negative WOM (the negative gap between experienced quality and prepurchase perception of quality). However, for the high-quality firm, mimicry decreases the demand in Period 1, but increases the demand in Period 2 because of the positive WOM. When η is small—that is, when WOM has a weak impact—the benefit of mimicry for the high-quality firm is not high enough, and the damage of mimicry for the low-quality firm is not low enough. Thus, the high-quality firm will not imitate a low-quality firm, but the low-quality firm will mimic a high-quality firm. The converse is true when η is high. Lemma 1(iii) also shows that a greater herding effect results in a higher chance of mimicry on the part of the low-quality firm. In this paper, we discuss problems under the situation where $\eta < \frac{(p+kh)(1-C)}{k\Delta\mu^{h,l}}$.

Lemma 2: *i) There exists a unique* $A_1^{ha} < \hat{A}_1^{h,h}$ *and a unique* $A_1^{hb} > \hat{A}_1^{h,h}$ *such that* $\pi^{h,h}(A_1^{hi}) = \pi^{h,l}(\hat{A}_1^{h,l})$, $i = a,b$ *and a unique* $A_1^{la} < \hat{A}_1^{l,h}$ *and a unique* $A_1^{lb} > \hat{A}_1^{l,h}$ *such that* $\pi^{l,l}(\hat{A}_1^{l,l}) = \pi^{l,h}(A_1^{li}), i = a,b$.

ii) Both A_1^{ha} *and* A_1^{la} *increase in* η*; both* A_1^{hb} *and* A_1^{lb} *decrease in* η*;*

iii) $A_1^{hb} \geq A_1^{lb}$*; if* $\eta\Delta\mu^{h,l}\left(C-1+e^{-A_1^{ha}/N_1}\right)\left(1-\frac{p}{q_h}\right) > \ln\frac{p+k(h+\eta\Delta\mu^{h,l})}{p+kh}$ *then* $A_1^{ha} > A_1^{la}$*; otherwise,* $A_1^{ha} \leq A_1^{la}$.

In the above Lemma 2(i), A_1^{ha} and A_1^{hb} represent the smallest and largest amounts of advertising, respectively, that the firm is willing to create to avoid being perceived as low quality. A_1^{la} and A_1^{lb} represent the smallest and largest amounts of advertising, respectively, that the firm creates to pretend to be high quality. Lemma 2(ii) indicates that the width of interval $[A_1^{ha}, A_1^{hb}]$ or $[A_1^{la}, A_1^{lb}]$ decreases as η increases. Naturally, advertising levels between A_1^{ha} and A_1^{hb} exist such that the high-quality firm does not imitate a low-quality firm; if advertising levels between A_1^{la} and A_1^{lb} do not exist, then the low-quality firm has no incentive to mimic a high-quality firm. Thus, if the advertising levels are in the range $[A_1^{ha}, A_1^{hb}]$, but outside the range $[A_1^{la}, A_1^{lb}]$, then the separating equilibrium can arise, and we can show that this condition holds (see the proof of Lemma 2(iii)). Thus, the following result is given:

Proposition 2: *There exists a separating equilibrium in Period 1 if and only if the firm's advertising level* $A_1 \in [A_1^{lb}, A_1^{hb}]$ *or* $A_1 \in [A_1^{ha}, A_1^{la}]$ *when* $\eta\Delta\mu^{h,l}\left(C-1+e^{-A_1^{ha}/N_1}\right)\left(1-\frac{p}{q_h}\right) \leq \ln\frac{p+k(h+\eta\Delta\mu^{h,l})}{p+kh}$, *where*

$$\frac{1-\frac{p}{q_l}}{1-\frac{p}{q_h}} = C .$$

As $A_1^{hb} > \hat{A}_1^{h,h}$ and $A_1^{lb} > \hat{A}_1^{l,h}$, to prevent mimicry on the part of the low-quality firm, the high-quality firm may have to increase its advertising to differentiate itself. Proposition 2 also shows that there exist many separating equilibria. Next, we will use the intuitive criterion to refine these equilibria and obtain Proposition 3.

Proposition 3: i) *There exists a unique separating equilibrium that is stable, in which the firm's advertising decision follows*

$$A_{1,s}^{*}(q_Q) = \begin{cases} \hat{A}_1^{l,l} & \text{if } Q = l, \\ \max\{\hat{A}_1^{h,h}, A_1^{lb}\} & \text{if } Q = h. \end{cases}$$

ii) $\hat{A}_1^{h,h}$ *or* A_1^{lb} *increases in* N_1.

As Proposition 3(i) suggests, in the separating equilibrium, the high-quality firm advertises at its optimal level if its optimal advertising level in the complete information case is greater than or equal to A_1^{lb} (i.e., $\hat{A}_1^{h,h} \geq A_1^{lb}$). However, it might have to increase its advertising spending from its respective complete information levels to prevent a low-quality firm from mimicking it (i.e., $\hat{A}_1^{h,h} = \tilde{A}_1^{h} < A_1^{lb}$). When the high-quality firm's advertising level is too high to mimic, the low-quality firm settles on its own optimal advertising level, which is equal to that when complete information exists.

Proposition 3(i) also indicates that $A_{1,s}^{*}(q_h) > A_{1,s}^{*}(q_l)$ because of $\hat{A}_1^{h,h} > \hat{A}_1^{l,l}$, which means that there is a positive relationship between product quality and advertising spending. This result is consistent with the results of the signaling game when advertising serves the sole purpose of signaling quality, but it is in contrast to the findings of Zhao (2000), who investigates the dual purpose of advertising. The high-quality firm faces the following trade-off when it chooses to reveal its true quality: the demand in Period 1 increases, but positive WOM decreases in Period 2. Moreover, the existence of the herding effect will benefit the firm when the advertising in Period 1 increases for the purpose of preventing imitation. Thus, the firm gains the additional benefit of increasing its advertising. As the advantage of the herding effect increase outweighs the disadvantage of the decrease in positive WOM, the high-quality firm will be willing to invest more in advertising to avoid mimicry on the part of a low-quality firm. In addition to the impact of initial consumers on

subsequent consumers, the exogenous price also may lead to a result that contradicts Zhao (2000).

Given the unit advertising cost, we use $A_{1,s}^{*}(q_h)$ to present the signaling cost, and the signaling cost increases as the high-quality firm's advertising level in Period 1 increases. Proposition 3(ii) indicates that more potential consumers in Period 1 will result in a higher cost of signaling. According to Lemma 2(ii), we know that A_1^{lb} decreases in the extent of the WOM impact (η). Therefore, the signaling cost decreases as the extent of the WOM impact increases when $A_{1,s}^{*}(q_h) = A_1^{lb}$. That is, strong WOM is helpful to a firm that wants to cut down on its cost of signaling. However, an increase in the herding effect increases the signaling cost because $\hat{A}_1^{h,h}$ increases in the herding effect and A_1^{lb} also increases in the herding effect (see Figure 2(a)). The negative WOM in response to mimicry reduces the firm's incentive to pretend to be the other type of firm by hurting the firm's demand in Period 2, while the high herding effect always makes the firm benefit more in Period 2 from imitation in Period 1.

5.2. Pooling equilibrium

In the pooling equilibrium, high- and low-quality firms choose to advertise at the same level in Period 1; thus, consumers cannot infer product quality from their advertising before they experience the product. Consumers' beliefs about product quality remain unchanged, and the probability that the product quality is high is consistently δ. Before consuming the product, consumers' expectations of its quality can be represented by $g_1(q) = \delta q_h + (1-\delta) q_l := g(q)$. The strength of WOM in the pooling equilibrium, $\Delta Q^{Q,m}$, can be written as $\Delta Q^{Q,m} = q_Q - g(q)$. As discussed in Section 3, in Period 2, consumers learn about product quality from WOM. Therefore, the firms use a separating equilibrium in Period 2 such that $g_2(q) = q_Q$. For example, for the high-quality firm, $g_2(q) = q_h$.

Let $\pi^{Q,m}$ be the type $Q \in \{h, l\}$ firm's expected profit if the firm chooses the pooling equilibrium. $A_1^{Q,m}$ and $A_2^{Q,m}$ are the type Q firm's level of advertising in Periods 1 and 2 in the pooling equilibrium, respectively. The firm's total profit can be written as

$$\pi^{Q,m}(A_1^{Q,m}, A_2^{Q,m}) = pD_1^{Q,m} - kA_1^{Q,m} + pD_2^{Q,m} - kA_2^{Q,m}, \tag{9}$$

where $D_1^{Q,m} = N_1\left[1 - e^{-A_1^{Q,m}/N_1}\right]\left[1 - \frac{p}{g(q)}\right] - kA_1^{Q,m}$, $D_2^{Q,m} = N_2\left[1 - e^{-(A_2^{Q,m} + (h + \eta\Delta\mu^{Q,m})D_1^{Q,m})/N_2}\right]\left[1 - \frac{p}{q_Q}\right]$,

$$\Delta\mu^{Q,m} = \begin{cases} q_h - g(q) & \text{if } Q = h, \\ q_l - g(q) & \text{if } Q = l. \end{cases}$$

Lemma 3: *i)* $\pi^{Q,m}(A_1^{Q,m})$ *is concave and maximized at* $\hat{A}_1^{Q,m}$ *, and* $\hat{A}_1^{Q,m} = -N_1 \ln \frac{k}{\left[p + k(h + \eta \Delta\mu^{Q,m})\right]\left[1 - \frac{p}{g(q)}\right]}$ *for* $Q \in \{h, l\}$ *which is increasing in* N_1 *or* h *or* $\left|\Delta\mu^{Q,m}\right|$ *;*

ii) $\frac{d\pi^{h,m}(A_1)}{dA_1} > \frac{d\pi^{l,m}(A_1)}{dA_1}$ *;*

iii) $\pi^{h,m}(A_1) - \pi^{l,m}(A_1) > 0$.

Lemma 3(i) shows that $\pi^{Q,m}(A_1^{Q,m})$ is concave and has a maximum value. Since $\Delta\mu^{h,m} > \Delta\mu^{l,m}$, we have $\hat{A}_1^{h,m} > \hat{A}_1^{l,m}$. The optimal advertising level in Period 1 increases (decreases) as the herding effect or positive (negative) WOM increases or the number of consumers in Period 1 increases. Lemma 3(ii) indicates that $\pi^{h,m}$ increases faster than $\pi^{l,m}$ as advertising level A_1 increases. The same amount of advertising leads to different payoffs for the two types of firms. The high-quality firm earns a larger profit than the low-quality firm when the same levels of advertising are made (see Lemma 3(iii)).

If both types of firms make the same advertising level, A_1 — that is, they are in a pooling equilibrium—the following incentive compatibility constraints must be satisfied: for all $A \neq A_1$,

$$\pi^{h,m}(A_1) > \pi^{h,l}(A), \tag{10}$$

$$\pi^{l,m}(A_1) > \pi^{l,l}(A). \tag{11}$$

Constraints (10) and (11) assure that the high-quality firm is worse off by deviating from A_1 .

To facilitate our discussion, we define $\bar{A}_1^{Qm} = \{A_1 > \hat{A}_1^{Q,m} \,|\, \pi^{Q,m}(A_1) = \pi^{Q,l}(\hat{A}_1^{Q,l})\}$ and $\underline{A}_1^{Qm} = \{A_1 < \hat{A}_1^{Q,m} \,|\, \pi^{Q,m}(A_1) = \pi^{Q,l}(\hat{A}_1^{Q,l})\}$. If $\pi^{Q,m}(A_1) \geq \pi^{Q,l}(\hat{A}_1^{Q,l})$ is satisfied, the type $Q \in \{h, l\}$ firm is willing to choose the pooling equilibrium. $\bar{A}_1^{Qm}$ ($\underline{A}_1^{Qm}$) represents the smallest (largest) amount of advertising that the type Q firm is willing to make, if, by doing so, the firm can successfully lead consumers to believe that the firm does not reveal anything about its quality. Define $\underline{A}_1^{m} = \max\left\{\underline{A}_1^{hm}, \underline{A}_1^{lm}\right\}$ and $\bar{A}_1^{m} = \min\left\{\bar{A}_1^{hm}, \bar{A}_1^{lm}\right\}$, then we have the following result.

Proposition 4: *If the advertising level is* $A_1 \in [\underline{A}_1^{m}, \bar{A}_1^{m}]$, *there exists a pooling equilibrium.*

As we show in our proof of Proposition 4, $\pi^{Q,m}(A_1) - \pi^{Q,l}(\hat{A}_1^{Q,l})$ is concave in the advertising level. The high-quality firm's profit is higher than the low-quality firm's profit at the same advertising level, so $\underline{A}_1^{m}$

becomes the lower bound of the advertising level at which both firms can be profitable with a pooling equilibrium strategy, and $\bar{A}_1^m$ is the upper bound for this advertising level. Accordingly, $[\underline{A}_1^m, \bar{A}_1^m]$ constructs a feasible domain for the pooling equilibrium.

Proposition 5: *Let* $B = \dfrac{1-\dfrac{p}{g(q)}}{1-\dfrac{p}{q_h}}$. *i) When* $\eta \geq \dfrac{(p+kh)(1-B)}{Bk\Delta\mu^{h,m}}$, *there exists a rang of stable pooling equilibria, but a unique Pareto dominant stable equilibrium exists that is a pooling equilibrium with* $A_1^{m*} = \hat{A}_1^{h,m}$; *ii) when* $0 < \eta < \dfrac{(p+kh)(1-B)}{Bk\Delta\mu^{h,m}}$, *there does not exist any stable pooling equilibrium.*

Proposition 5 indicates that if η is high, many stable pooling equilibria exist, but there is a unique stable pooling equilibrium where Pareto dominates all other equilibria. In this equilibrium, the firm makes the same advertising level—that is, $\hat{A}_1^{h,m}$ —and consumers cannot receive any additional information about the product's quality by observing the advertising level made by the firm. However, when η is small, many pooling equilibria exist, but none of them survives the intuitive criterion.

We also explain Proposition 5 in consideration of Proposition 3. From Propositions 3 and 5, we find that when η is high, there is a separating equilibrium that survives the intuitive criterion, but many stable pooling equilibria exist. If η is small, none of the pooling equilibria satisfies the intuitive criterion, but a stable separating equilibrium exists. Therefore, we derive Lemma 4(i).

Lemma 4. *i) If* $0 < \eta < \dfrac{(p+kh)(1-B)}{Bk\Delta\mu^{h,m}}$, *only a stable separating equilibrium exists; otherwise, if* $\eta \geq \dfrac{(p+kh)(1-B)}{Bk\Delta\mu^{h,m}}$, *a stable separating equilibrium and a unique Pareto dominant stable pooling equilibrium coexist.*

ii) The stable separating equilibrium and the unique Pareto dominant stable pooling equilibrium are less likely to coexist as k *(or* q_h*) decreases or herding effect* h *increases.*

Lemma 4(i) indicates that when the extent of the WOM impact is small, a unique equilibrium exists that is a stable separating equilibrium; otherwise, there exists not only a unique stable separating equilibrium but also many pooling equilibria surviving the intuition criterion. In addition, we find a unique stable pooling equilibrium where Pareto dominates all other equilibria. Lemma 4(ii) shows that as the unit cost of advertising increases, it is more likely that the stable separating equilibrium and stable pooling equilibrium coexist. Given q_l, as $q_h - q_l$ increases, the probability that stable separating and pooling equilibria coexist increases. That is,

the strength of WOM has a huge impact on the firm's strategy choice. However, the increased herding effect reduces the probability that the stable pooling equilibrium exists.

We have identified the conditions for stable separating and pooling equilibria. Since the stable separating and pooling equilibria coexist in some situations, the question of which strategy is better naturally arises. The firm's final purpose is to maximize its profit. Therefore, to compare the high-quality firm's profits in the separating and pooling equilibria, we define $\Delta\prod^{Q} = \pi^{Q,Q}(A^{*}_{1,s}(q_Q)) - \pi^{Q,m}(A_1^{m*})$. The type Q firm chooses the separating (pooling) equilibrium if $\Delta\prod^{Q} > 0$ (<0). For example, if $\Delta\prod^{h} > 0$, the high-quality firm earns a higher profit from the separating equilibrium than the pooling equilibrium, so it prefers the former equilibrium. However, if $\Delta\prod^{h} < 0$, the high-quality firm earns a lower profit from the separating equilibrium than the pooling equilibrium, which indicates that the pooling equilibrium is better for it.

Proposition 6: *i) If* $\eta \geq \dfrac{(p+kh)(1-B)}{Bk\Delta\mu^{h,m}}$*, the Pareto dominant stable pooling equilibrium is a best and win-win strategy; otherwise, if* $\eta < \dfrac{(p+kh)(1-B)}{Bk\Delta\mu^{h,m}}$*, the stable separating equilibrium is a unique, and the best, strategy.*

ii) The Pareto dominant stable pooling equilibrium is less likely to be the best and a win-win strategy as q_h *or* k *decreases or the herding effect,* h*, increases.*

Proposition 6(i) shows that if η is small, then the stable separating equilibrium is the best strategy. However, if the extent of the WOM impact, η, is large, the Pareto dominant stable pooling equilibrium is the best strategy for both the high- and low-quality firms. If the firm chooses to advertise at the same level and reveal nothing about product quality, without this knowledge, consumers cannot update their information. Thus, the high-quality firm will suffer from a decline in product purchase in Period 1 (disadvantage), but benefit from positive WOM in Period 2 (advantage). The low-quality firm will benefit from a demand increase (advantage) because of consumers' unchanged information in Period 1, but will have to face negative WOM in Period 2 (disadvantage). The increase in the extent or strength of WOM will enhance the advantage of the pooling equilibrium for the high-quality firm, but weaken it for the low-quality firm. In this case, the advantage or disadvantage of the pooling equilibrium in Period 1 becomes a key determinant for the low-quality firm.

Proposition 6(ii) shows that the chance of observing a stable pooling equilibrium increases as the herding effect decreases. We can find that the impact of herding on the existence of the pooling equilibrium is contrary to that of WOM. The firm always benefits from the herding effect, and the extent of the benefit depends on the demand in Period 1. Given other factors, such as the extent of the WOM impact, for the low-quality firm, using a pooling equilibrium will result in an increase in demand in Period 1 (because consumers do not have sufficient quality information) and a demand increase in Period 2 (because of the impact of the herding effect). However, due to the absence of updated information in Period 1, the high-quality firm has to undertake the

demand reduction which leads to a loss in Period 2 because the herding effect depends on the demand in Period 1, and the loss increases as the herding effect increases. Therefore, the high-quality firm will not be willing to reveal nothing to consumers, and thus the separating equilibrium appears.

Proposition 6(ii) also indicates that as the cost per advertising increases, the pooling equilibrium is more likely to be the best strategy for both high- and low-quality firms. The increase in unit advertising cost, which results in a decrease in the advertising level in Period 1, has a greater impact on the optimal advertising level in the pooling equilibrium than that in the separating equilibrium. The decrease in the total advertising cost outweighs the decrease in WOM impact, which decreases as the demand in Period 1 decreases. Therefore, the pooling equilibrium is more likely to be chosen as the unit advertising cost increases.

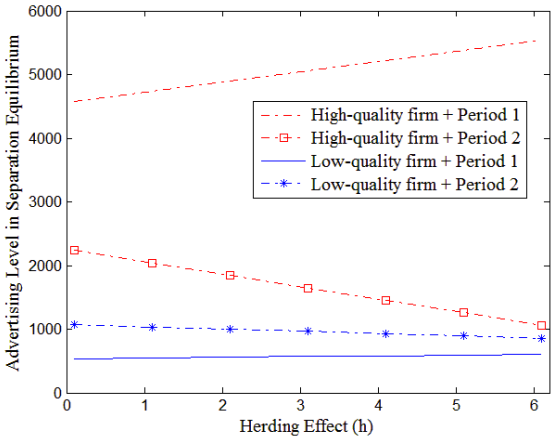
6. Numerical Results

In this section, we will investigate the value of WOM and the herding effect in different periods for the pooling and separating equilibria. Finally, the impact of different parameters on the firm's preference for the pooling or separating equilibrium will be addressed.

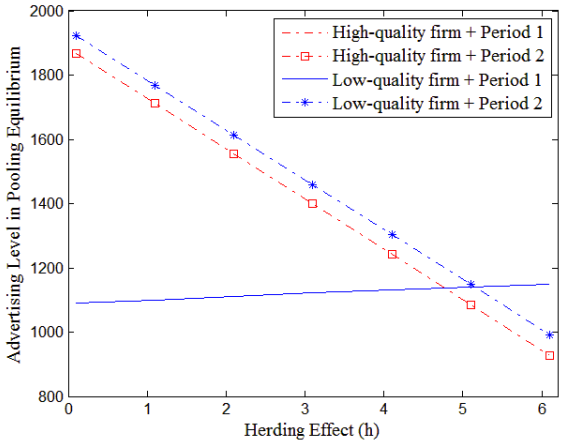
We use the following parameters to provide a sufficiently large, feasible domain: $q_h = 47$, $q_l = 27$, $N_1 = 400$, $N_2 = 800$, $p = 24$, $h = 2$, $\delta = .7$, $\eta = .4$, and $k = .7$.

6.1. The value of WOM and the herding effect

Figures 2 and 3 show that the total advertising of the high-quality firm is greater than that of the low-quality firm in the separating equilibrium, but this may yield different results in the pooling equilibrium. The high-quality firm advertises more in Period 1 in the separating equilibrium than in the pooling equilibrium. This supports that more quality information to be revealed means a higher signaling cost. Given the unit advertising cost, the high-quality firm's first-period advertising level in the separating equilibrium is used to capture the signaling cost.



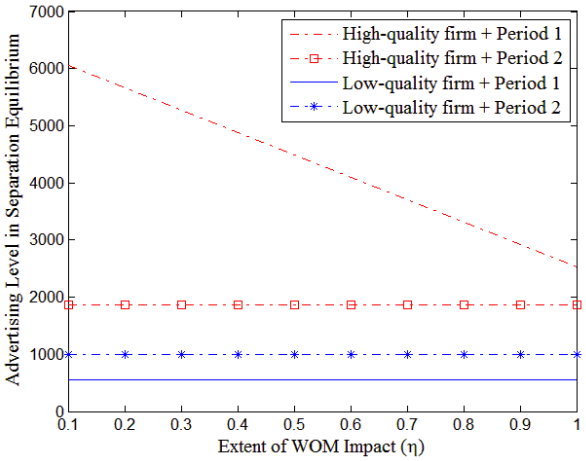
a. Herding effect & Separating equilibrium



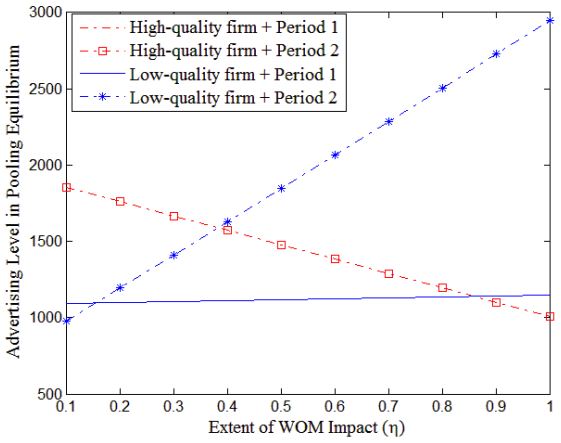
b. Herding effect & Pooling equilibrium

Figure 2. Impact of the herding effect on the advertising decision in different equilibria

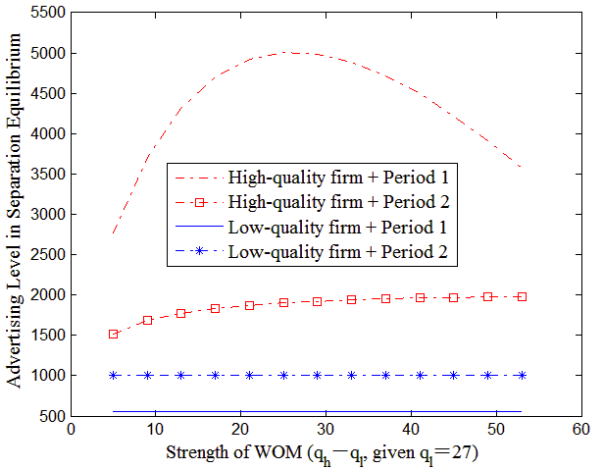
Figure 2 shows that the advertising level in Period 1 increases in the herding effect, but the advertising level in Period 2 decreases as the herding effect increases. This result implies that the herding effect is an important factor that results in the firm's overinvestment in Period 1. Especially, Figure 2(a) shows that the advertising level in Period 1 increases in the herding effect, indicating that a higher herding effect will result in a higher signaling cost.



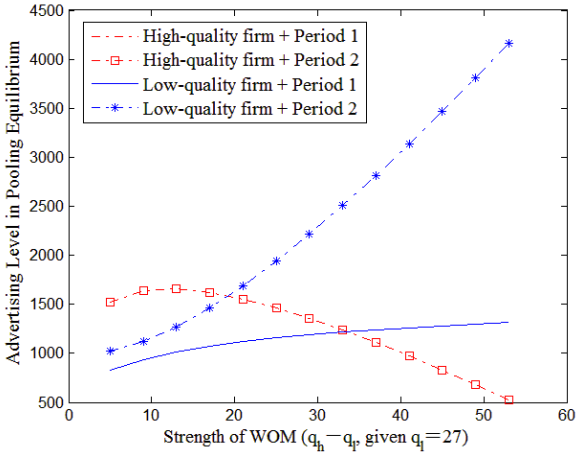
a. Extent of the WOM impact & Separating equilibrium



b. Extent of the WOM impact & Pooling equilibrium



c. Strength of WOM & Separating equilibrium



d. Strength of WOM & Pooling equilibrium

Figure 3. Impact of WOM on the advertising decision in different equilibria

Figure 3(a) shows that the advertising level in Period 1 dramatically decreases as the extent of the WOM impact increases in the separating equilibrium, which leads to a slight increase in the advertising level in Period 2. This result implies that WOM can help the firm reduce its signaling cost. Although WOM does not exist in the separating equilibrium, it affects the firm's advertising decision in the stable separating equilibrium.

From Figure 3(b), we find that in the pooling equilibrium, the high-quality firm's advertising level in Period 2 decreases as the extent of the WOM impact increases, but the low-quality firm's increases. This is because the high-quality firm receives positive WOM, whereas the low-quality firm receives negative WOM. A higher positive WOM saves more in advertising costs in Period 2. However, the low-quality firm may have to advertise more to offset the impact of negative WOM on the demand in Period 2.

Figure 3(c) shows that in the separating equilibrium, the high-quality firm's advertising level in Period 1 first increases and then decreases as the high-quality firm's product quality increases. That is, the increase in the quality gap does not always increase the high-quality firm's signaling cost. When the firm's quality is sufficiently high, the signaling cost will reduce. This case exists when two products have different market positioning strategies based on the product quality, such as high-grade and low-grade products. When the quality gap is not very high, the firm must balance the benefit of a quality increase (e.g., a high level of positive WOM) and the increase in signaling cost. Figure 3(c) also shows that the high-quality firm's advertising level in Period 2 increases as its product quality increases, which indicates that the impact of quality on the demand in Period 2 is greater than the impact of the herding effect. This is because the advertising level in Period 2 is affected by the increase in quality and the herding effect, which depends on the demand in Period 1.

As Figure 3(d) illustrates, in the pooling equilibrium, the high-quality firm's advertising level in Period 2 first increases and then decreases as the firm's product quality increases. The high-quality firm's advertising level in Period 2 depends on two factors: the quality (which has a positive impact on advertising) and the strength of WOM (which has a negative impact on advertising). If the impact of quality outweighs that of the strength of WOM, then the advertising level of the high-quality firm in Period 2 increases as its product quality increases; otherwise, it decreases. Figure 3(d) also indicates that the low-quality firm's advertising level in Period 2 increases as the strength of WOM increases. This result is similar to that shown in Figure 3(b).

6.2. The firm's strategy preference

Recall that we define $\Delta\prod^{Q} = \pi^{Q,Q}(A_{1,s}^{*}(q_Q)) - \pi^{Q,m}(A_1^{m*})$. The type Q firm chooses the separating (pooling) equilibrium if $\Delta\prod^{Q} > 0$ (< 0). We theoretically discussed the firm's strategy preference in Section 5 (the main results are summarized in Proposition 6). For intuitive understanding, in this section, we present numerical results to gain further insight into the choice between stable separating and stable pooling equilibria.

Figures 4 and 5 show that if the unit advertising cost is very small or the price is very high, the impact of WOM on the firm's strategy preference is virtually non-existent and the separating equilibrium is the best strategy. In other words, the extent of WOM plays an important role in the firm's choice of pooling equilibrium. In practice, when the firm faces a scenario in which advertising is costly, WOM is huge and the product price is low; consequently, the pooling equilibrium may become the firm's best strategy. That is, the firm reveals nothing through advertising before releasing the product.

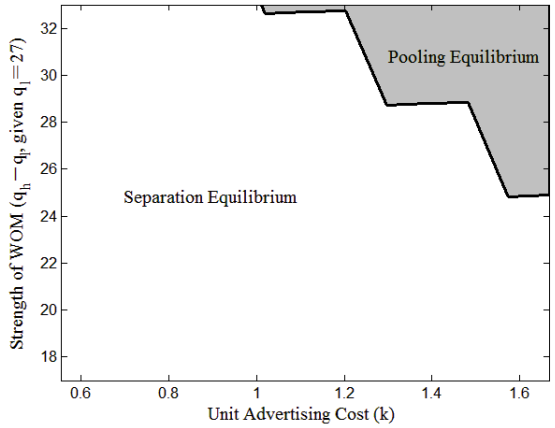


Figure 4. Impact of unit advertising cost and the strength of WOM on strategy preference

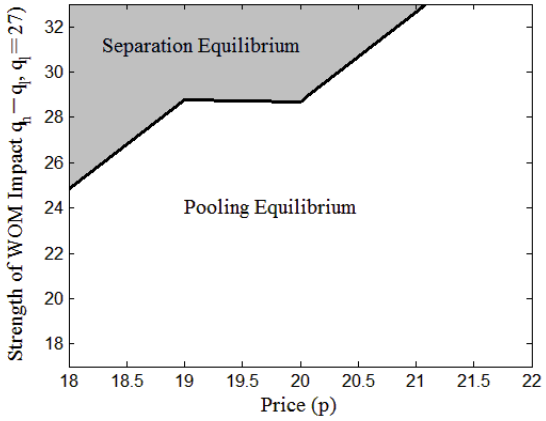


Figure 5. Impact of the strength of WOM and price on strategy preference

As Figure 4 indicates, the firm is more likely to adopt the separating equilibrium if the unit advertising cost (k) is low. This is because a lower advertising cost means a lower cost of signaling. Figure 5 shows that the separating equilibrium is more likely to occur as the market price increases. Although the market price may be the same because of market competition, the unit cost is usually different. Thus, the increasing market price can be regarded as the decreasing unit cost or the increasing profit margin. As the profit margin increases, the loss that comes from consumers' wrong perception increases. Thus, the firm prefers the separating equilibrium.

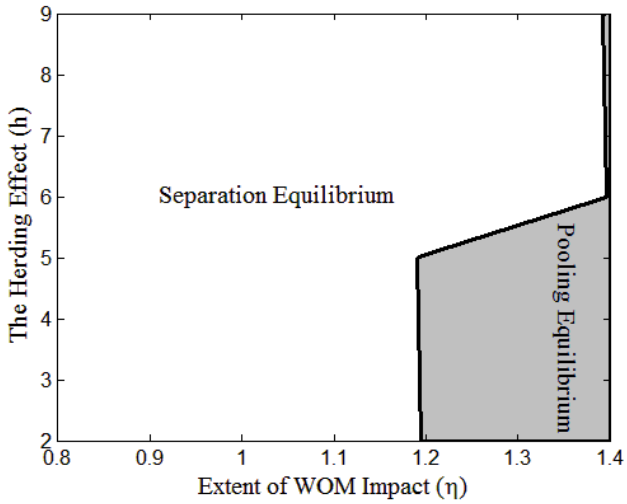


Figure 6. Impact of the herding effect and the extent of the WOM impact on strategy preference

Figure 6 shows that the pooling equilibrium is more likely to be the best strategy as the extent of the WOM impact increases or as the herding effect decreases. This implies that the herding effect and WOM have contrary effects on a firm's strategy preference. However, when the extent of the WOM impact is sufficiently high, the WOM's impact outweighs the herding effect's influence. In this case, the pooling equilibrium is

always the best strategy.

7. Conclusion

This paper has investigated how the effects of WOM and herding influence the role of advertising and a firm's preference for different advertising and signaling strategies when a product, for which there is no repeat purchase, is subsequently released in different markets. Consumers in Period 1 affect those in Period 2 by herding and WOM when the role of advertising—raising awareness and signaling quality—changes over time.

The results of our theoretical analyses reveal that the effects of WOM and herding play an important role in the advertising signaling strategy and leverage a firm's strategy preference, whereas the mass of potential consumers has no impact. In particular, as the strength of WOM increases or the herding effect decreases, the stable pooling equilibrium and stable separating equilibrium are more likely to coexist. Furthermore, the probability that the Pareto dominant stable pooling equilibrium is the best, and a win-win, strategy increases as the strength of WOM increases or as the herding effect decreases. As the strength of WOM increases, the firm must face a trade-off when it chooses the pooling strategy over the separating strategy: for the high-quality firm, demand in Period 1 decreases due to incomplete quality information (disadvantage), but the positive WOM in Period 2 increases (advantage); for the low-quality firm, demand in Period 1 increases (advantage), but the negative WOM in Period 2 increases (disadvantage). An increase in WOM leads to a larger advantage of the pooling equilibrium for the high-quality firm while increasing the disadvantage of the pooling equilibrium for the low-quality firm. This implies that for the high-quality firm, the advantage of the pooling equilibrium is more likely to outweigh the disadvantage as the strength of WOM increases. The advantage of the pooling equilibrium always outweighs the disadvantage for the low-quality firm. However, as the herding effect increases, the disadvantage of using the pooling equilibrium becomes overwhelming for the high-quality firm, whereas the advantage upsurges for the low-quality firm because of the increase in the first-period demand. Thus, the high-quality firm has a stronger incentive to reveal its product quality information if the herding effect is high.

Furthermore, this article finds that the cost of signaling decreases as the strength of WOM increases, but it increases with the herding effect or the mass of potential consumers in Period 1. The demand increases because being mistakenly regarded as a high-quality firm in Period 1 will enhance the demand in Period 2 owing to the herding effect. The potential, significant advantage of mimicry causes the high-quality firm to invest a large amount of its resources in preventing the low-quality firm from imitating its advertising strategy. However, the

negative WOM will reduce the advantage of imitation. Thus, the signaling cost has a negative relationship with the strength of WOM. A higher number of potential consumers in Period 1 leads to a higher advantage (more demand) for the low-quality firm via pretending to be a high-quality firm, which suggests that the high-quality firm must advertise more to separate itself from the low-quality firm.

This study can be extended in several directions. Although ours is a two-period model, in some cases, the time separation can be subtle, and a multi-period model, though intractable in our setting, might offer a more comprehensive analysis. Furthermore, with a focus on the advertising signaling effect, we assume that the retail price is exogenous for tractability, which is common in the extant literature (see, e.g., Schmalensee, 1978 and the references therein) and occurs in practice in the movie industry. An endogenous price, though computationally challenging, might better describe other industries with dynamic pricing.

Acknowledgments

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