Word of Mouth Bias
and
Optimal Communication Strategies

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Word of Mouth Bias and Optimal Communication Strategies

Abstract

We analyze a firm’s optimal communication strategy when dissipative advertising can be used as a signal of unobserved quality for an experience good, consumers share experiences via word of mouth, and word of mouth can be biased. We study the impact of two distinct empirically documented behavioral biases in word of mouth: negativity and positivity. In terms of the first of these biases, a priori, one might expect that with more negative opinions being shared, it should be easier for a low quality firm to be exposed and hence a high quality firm may need a smaller investment to separate itself in the eyes of rational consumers. Surprisingly, we show that with more negativity bias, a high quality firm becomes more aggressive in signaling its quality. This is because when negative word of mouth is prevalent and consumers hear about a negative experience, they are more likely to be forgiving while updating their quality beliefs. This yields important benefits to a low quality firm, and as a consequence, to effectively achieve separation and prevent the low type from mimicking, a high quality firm needs to increase its advertising spending. Such firm behavior crucially relies on followers being aware of the existence and magnitude of this bias; and is reversed otherwise. Similar results hold for positivity bias, when biases arise due to under-reporting, and when a firm can rely on prices to signal quality to consumers along with advertising. Overall, our analysis suggests that as bias in word of mouth increases, it is optimal for a high quality firm to shift to a more aggressive communication strategy.

Keywords: managing expectations, experience goods, word of mouth, bias, game theory, signaling, behavioral industrial organization.
1 Introduction

In many situations, consumers are uncertain about the quality of products or services offered by a firm: for example, when a new product or service is being introduced in the market. In the presence of such uncertainty, a firm has some leeway in strategically influencing consumer perceptions, and hence expectations, regarding its quality. Past research has extensively analyzed the strategic role of a firm’s communication strategies such as advertising in the context of shaping such expectations. Since the early works of Nelson, it is well recognized theoretically that advertising can serve as a credible signal for product or service quality for experience goods (e.g., Nelson 1970, 1974, 1978; Schmalensee 1978; Kihlstrom and Riordan 1984; Milgrom and Roberts 1986; Hertzendorf 1993; Zhao 2000; Orzach et al. 2002).

Firm communications (e.g., advertising), however, are not the only means by which consumers can learn about a product’s quality, since consumers often also rely on the opinions of peers (word of mouth) who have already experienced the product or service (e.g., Godes and Mayzlin 2004; Mayzlin 2006; Godes 2012; Kuksov et al. 2012). With the rise of information technologies and social media, it is becoming easier to record, store and share such peer opinions, and consequently they are playing a more prominent role in the consumer decision process for trying and adopting new products. This is consistent with the emergence of companies such as yelp.com, epinions.com and the competitive advantage enjoyed by amazon.com through its product reviews system. A critical aspect of these opinions, however, is that they are not always unbiased sources of information to potential customers.

Relying on past literature, it is possible to identify and postulate a number of potential biases. For example, prospect theory suggests that losses have a stronger impact than gains (Kahneman and Tversky 1979). Such bias has been postulated in the context of a consumer processing information about alternatives. This may also have implications for word of mouth: when a consumer reacts more strongly to a negative rather than a positive experience, she may be more likely to share negative experiences rather than positive ones as suggested in prior work (e.g., Richins 1983, Anderson and Sullivan 1993, Anderson
Table 1: Airline Delays and Punctuality Opinions.

<table>
<thead>
<tr>
<th>Airline</th>
<th>BTS Delays (%)</th>
<th>Negative Opinions About Punctuality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>JetBlue</td>
<td>23.6</td>
<td>57.9</td>
</tr>
<tr>
<td>United Airlines</td>
<td>19.5</td>
<td>81.8</td>
</tr>
</tbody>
</table>

1998, Bolton 1998, Harrison-Walker 2001, Rozin and Royzman 2001, Ahluwalia 2002, Dixon et al. 2010). Such biases might also arise, for example, when considering attributes that consumers regard as minimum requirements, such as airline punctuality (Brandt 1988). In such contexts, consumers may primarily talk about negative experiences (e.g., “my flight left one hour late”), rather than about positive ones (e.g., "the flight departed on time") which consumers may not deem as being interesting enough to be shared. For example, Table 1 illustrates the discrepancy between the fraction of delayed flights according to the Bureau of Transportation Statistics and the proportion of punctuality-related comments on Epinions.com that are negative, during the January 2009 and December 2012 period. For instance, in the case of United Airlines, the fraction of negative opinions is more than 4 times the actual fraction of delayed flights.

For very different reasons, an opposite bias might be observed in other contexts such as in the acquisition of big ticket items (e.g., car or house purchases), where a buyer might prefer to abstain from complaining to peers about a recent purchase, for example consistent with a self-presentation motivation or to protect the resale value of the good. This suggests that while in some contexts, consumers might be more likely to encounter negative opinions, in others consumers might be more likely to encounter positive opinions (e.g., Chevalier and Mayzlin 2006).

Given the increasingly important role of word of mouth in shaping consumer beliefs, and that word of mouth is not always an unbiased reflection of a product’s true quality, a firm faces the critical challenge of determining how to optimally adjust its communication strategy, which ultimately impacts consumers’ quality beliefs and therefore their purchase decisions. 

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decisions. Analyzing this firm decision is the central research goal of this paper. To the best of our knowledge, we are the first to theoretically investigate how a firm should optimally adjust its communication strategy in the presence of word of mouth biases.

To do so, we model a signaling game where ex ante a firm’s quality is equally likely to be high or low. The firm decides whether and how much to invest in advertising (and what prices to charge). Rational consumers belong to one of two segments: influentials and followers (as is common in the diffusion literature, e.g., Katz and Lazarsfeld 1955, Coleman et al. 1957, Rogers 1962; and more recently Valente 1995, Watts and Dodds 2007, Van den Bulte and Joshi 2007). In the first stage, influentials update their beliefs about the firm’s type based on observed advertising (and prices), and given these beliefs decide whether to engage in consumption. Followers then interact with influentials, and during these interactions, influentials share their experiences, if any, with followers via word of mouth communication (Ellison and Fudenberg 1995, Dellarocas 2003). To study the impact of potential bias in word of mouth, we consider two distinct cases:

- prevalence of negative word of mouth: influentials might be more likely to share negative experiences with followers than positive ones
- prevalence of positive word of mouth: influentials might be more likely to share positive experiences with followers than negative ones

Our analysis first reveals that, consistent with prior research, only a high quality firm is willing to invest in advertising. This investment allows the firm to effectively communicate to the influentials its high type. How much the high type is willing to invest in advertising determines how aggressive its signaling efforts are, and also how much is needed to effectively separate from a low type.

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2It is also possible to perform an analogous analysis allowing firm quality to belong to a continuum of types. This analysis leads to qualitatively similar conclusions, and is available from the authors upon request.
3We investigate the pricing decision as a model extension, with our initial model focusing only on the advertising decision. We show that similar qualitative results can be observed, when prices are a signal of quality along with advertising.
We then turn to our central objective of analyzing the impact of the behavioral word of mouth biases on a firm’s communication strategy. Considering first the negativity bias, one might a priori expect that with more negative opinions being shared, it should be easier for a low quality firm to be exposed and hence a high quality firm may need a smaller investment to separate itself in the eyes of rational consumers. Surprisingly we find that the more consumers share negative experiences, the more aggressive a high quality firm needs to become in its advertising efforts. Intuitively, when negative word of mouth is prevalent and consumers hear about a negative experience, they are more likely to be forgiving while updating their beliefs. This yields important benefits to a low quality firm, by relatively raising its returns. Consequently, as negative word of mouth becomes more prevalent, the high quality firm needs to become more aggressive in its advertising to prevent a low type from mimicking, and to effectively achieve separation.

This counterintuitive firm behavior can only be explained by explicitly analyzing the impact of biases on the rational formation of beliefs. In fact, we show that if followers were not aware of the existence of biases in word of mouth, they would not be as forgiving when updating their beliefs. More importantly, the firm would shift to a more conservative rather than a more aggressive strategy as word of mouth becomes more negatively biased, yielding a complete reversal of the normative recommendations previously obtained for the case when consumers are aware of word of mouth biases. Therefore, rational belief formation and follower awareness of biases is key towards understanding and explaining the optimal communication strategy adopted by firms in the presence of such word of mouth biases.

We also study the consequences of positivity bias in word of mouth, and show that as positivity bias increases, a high type still finds it optimal to shift to a more aggressive communication strategy. This is because consumers being forgiving in updating beliefs in this case works against the high type, requiring more communication efforts on its part to separate from the low type. We test the robustness of our results by analyzing an alternative mechanism for modeling biases, where biases arise due to some consumers choosing not to
report certain types of experiences (i.e., under-reporting). We finally consider a case where a firm not only relies on advertising, but also on prices to signal its quality. In this case as well, we show that we can reach qualitatively similar conclusions regarding the impact of negativity bias on optimal advertising spend.

The rest of this paper is organized as follows. In Section 2 we review the related literature. We outline our basic modeling framework in Section 3 and show that advertising can serve as a credible device for high types to signal quality even in the presence of word of mouth. Section 4 incorporates specific behavioral biases associated with word of mouth (negativity, positivity, and under-reporting) into our modeling framework, and analyzes their effects on a firm’s equilibrium communication strategy. Section 5 explores the robustness of our results when a firm can signal quality using advertising as well as prices. Finally, Section 6 concludes by summarizing our findings and discussing avenues for future research.

2 Related Literature

Past research has provided different perspectives on the issue of consumer uncertainty regarding firm quality and the related firm communication decisions. A positive relationship between advertising and product quality has been proposed since Nelson’s early works (Nelson 1970, 1974, 1978), notably for experience goods. A core argument in favor of this positive relation was of signaling efficiency, in that demand expansion via signaling high quality would be most attractive to efficient firms (Nelson 1974; Bagwell 2007). In addition to signaling efficiency, past research has also proposed that such a positive relation may be explained by repeat sales, i.e., advertising might be more appealing to a high quality firm since it is more likely to earn repeat sales (Schmalensee 1978; Kihlstrom and Riordan 1984; Milgrom and Roberts 1986; Bagwell 2007). Hertzendorf (1993) extends the work of Milgrom and Roberts (1986) to situations where advertising may be noisy, and shows that advertising is a credible signal only when price is not correlated with quality. Kennedy (1994) studies a setting where
firm quality types are extreme (i.e., the firm either always or never provides a good quality product) and consumers can rely on prices and word of mouth (rather than advertising) to learn about the firm’s quality. If there is no cost for consumers to communicate with peers, he finds that word of mouth would not be observed in equilibrium and only serves as a threat that prevents a low quality firm from mimicking a high quality firm. Zhao (2000) extends earlier research to consider the informative role of advertising along with its role as a quality signal. Given its informative role, advertising is no longer purely dissipative; consequently in equilibrium one could observe a negative correlation between advertising and quality.\footnote{For an excellent review of this stream of research, see Bagwell (2007).} In this paper, we extend previous research by explicitly modeling the effects of word of mouth and its biases. Our main contribution over existing findings is gaining an understanding of how a firm should adjust its quality signaling strategy in the presence of word of mouth biases.

Along with advertising, price often plays an important and sometimes complementary signaling role, as has been suggested and analyzed in previous research (e.g., Milgrom and Roberts 1986, Moorthy and Srinivasan 1995, Simester 1995, Desai 2000, Bhardwaj et al. 2008). Accordingly, we will explicitly model the role of prices as a tool that the firm can employ to signal its quality. For ease of exposition, we first analyze the simpler case with exogenous prices, and later extend the model such that the pricing decisions are endogenized.

In terms of the recent literature on word of mouth, over the last decade research has begun explicitly incorporating the role of social interactions in consumer and firm communications. Mayzlin (2006) showed that even when a firm mimics consumer word of mouth, overall word of mouth can still be a credible signal of quality, since good products are likely to generate adequate legitimate word of mouth. Mayzlin and Shin (2011) analyze the joint role of search and advertising content in signaling quality, and show that uninformative advertising along with search can serve as a credible signal of quality. Godes (2012) analyzes the impact of reference programs in business-to-business markets, and shows that when a firm’s information
is noisy, offering reference programs can serve as a credible signal of its quality. Our research focuses instead on consumer markets, where consumers always have a ready reference to go to, and in this context we focus on whether different biases in the availability of these references makes a firm more or less aggressive in signaling quality.

Recent research has also looked at the impact of observational learning on quality and attribute inference. Miklos-Thal and Zhang (2013) analyze the signaling implications of engaging in marketing activities where marketing expands demand, and show that de-marketing can be a credible signal of quality when consumers have moderate prior perceptions regarding firm quality. The intuition behind this result is that when the early demand is small relative to later demand, late consumers are likely to attribute low sales in the early market to a lack of marketing, thus enhancing their perceptions of firm quality. Yoganarasimhan (2012) analyzes fashion products providing consumption and social utility, and proposes that at times a firm might actively refrain from advertising to restrict access to its products only to sophisticated consumers, who might then use these as exclusive signals to interact with other similar types. Alongside regular product features, Kuksov and Xie (2010) analyze the role of unexpected frills in boosting experiences of early customers and the impact of their ratings on behavior of subsequent customers. In this research, we focus instead on quality learning via word of mouth shared between consumers, and furthermore, incorporate biases observed in word of mouth to determine their impact on a firm’s signaling strategy. Our focus is consistent with prior research modeling rational agents reacting to biased information (e.g., Mayzlin 2006; Xiang and Sarvary 2007).

Finally, many experimental and empirical studies have investigated the role of advertising, pricing and other marketing decisions as signals of quality (see Kirmani and Rao 2000 for a review) and how expectations drive satisfaction and updated beliefs (e.g., Anderson and Sullivan 1993, Boulding et al. 1993, DeSarbo et al. 1994, Rust et al. 1995, Rust et al. 1999). In particular, the work of Kopalle and Assunção (2000) and Kopalle and Lehmann (2006) considers consumers with adaptive expectations to determine how a firm might set expecta-
tions in order to optimally influence demand generation, when repeat sales are important.

In this paper, our primary focus will not be on repeat sales, but on the effects of word of mouth on a firm’s signaling strategy.\textsuperscript{5} We adopt the view that consumer biases are akin to biases in processing information received or experienced, whereas word of mouth biases are akin to biases in sharing information between one another. In addition, in interpreting a firm’s communications, consumers often \textit{anticipate} that a firm might set prior expectations not just to communicate what quality they should expect, but also to influence their buying behavior and the resulting word of mouth in the firm’s best interest. To account for this strategic consumer behavior, we use signaling theory to examine when a firm should become more conservative or more aggressive in its advertising spending when rational consumers anticipate its intentions before making consumption decisions.

3 Quality Signaling with Word of Mouth

We first present a model for signaling quality in the presence of unbiased word of mouth, and characterize its equilibrium properties. Consistent with the main goal of this paper, in the next section we extend this model to incorporate word of mouth biases, and study the consequences on firm strategy. Finally, in section 5, we further extend this model by endogenizing the firm’s pricing decisions.

Our setup is motivated by standard advertising signaling models (e.g., Milgrom and Roberts 1986, Hertzendorf 1993, Kennedy 1994, Zhao 2000, among others). Consider a monopolistic firm providing an experience good. The firm is characterized by its quality type ($q_0$), which is an exogenously specified likelihood of the firm providing its consumers with a good experience upon consumption of its product. Examples of such goods include services, where the consumer experience may be impacted by human and contextual factors; or experiential products where whether consumers like the product may only be determined

\textsuperscript{5}We have tested the robustness our results by considering model extensions with repeat sales. This analysis is available from the authors upon request.
ex post, upon consumption (Nelson 1970), thus leading to stochasticity in consumer experiences. Let \( q_0 \) be high (H) or low (L) with equal likelihood, where \( 0 < L < H < 1 \). Assume consumers are unaware of the firm’s true quality \( (q_0) \), but aware of its distribution (i.e., \( p(q_0 = H) = p(q_0 = L) = \frac{1}{2} \)).

We model consumers as belonging to one of two segments: influentials and followers (following the diffusion literature, e.g., Katz and Lazarsfeld 1955, Coleman et al. 1957, Rogers 1962, Watts and Dodds 2007, Van den Bulte and Joshi 2007, also see Miklos-Thal and Zhang 2013). Let the relative size of the influentials segment be \( \alpha > 0 \). In the first stage, influentials update their prior beliefs about the firm’s quality based on the firm’s observed advertising, and then decide whether to engage in consumption. Influentials that purchase the good gain an experience \( e \in \{0, 1\} \), where this experience can be either positive \( (e = 1) \) or negative \( (e = 0) \).\(^6\) Followers then interact with influentials, and during these interactions, influentials share their experiences, if any, with followers via word of mouth communication. Relying on these shared experiences, followers update beliefs about the firm’s quality and decide whether to purchase.

Thus, a consumer in either segment deciding whether to purchase anticipates a utility, \( EU(\text{purchase}) = E_c[q_0] \), where \( E_c \) denotes the expected value operator given the beliefs of the consumer about the firm’s quality. If she chooses not to buy, her utility is given by \( U(\text{no purchase}) = \epsilon \), where \( \epsilon \sim U[0, 1] \). Consumption takes place if the expected utility from purchasing surpasses the utility from not making a purchase.

A firm can rely on promotional efforts \((A)\) to signal quality to consumers and influence their beliefs.\(^7\) Real world examples of such promotional efforts include product launch events, the premiere of a movie, press releases and the publication of new product release advertisements in specialized magazines and websites. Many of these efforts are mainly directed towards influentials, who form beliefs about the firm’s quality based on these efforts and

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\(^6\)Our model is agnostic about how experiences turn out to be positive or negative for a consumer, as long as in the end, the proportion of buying consumers receiving positive experiences equals \( q_0 \).

\(^7\)We analyze the impact of price as a signal, along with advertising, in Section 5.
decide upon consumption. Followers primarily rely on word of mouth to update their beliefs about the firm's quality, which in turn determine their consumption. Thus, an important aspect of our model is that the firm signal is observable only (i.e., private) to the influentials. It is perfectly possible to allow for the signal to be public - i.e., observable to both influentials and followers. However, such a formulation could lead to unrealistic equilibrium outcomes where consumers would not be able to learn from actual word of mouth. This is because if the followers observed the signal along with influentials, when a separating equilibrium exists, all consumers would be fully informed about the firm’s type, and word of mouth would play no direct role in the belief formation process for consumers. The only potential indirect role for word of mouth in this case would be as a threat that prevents a low quality firm from mimicking a high type (e.g., as shown in Kennedy 1994). We believe that this property is not a good reflection of how consumers actually benefit from word of mouth information; hence we choose to model signals as being available only to a subset of consumers.

The timeline of the game is summarized in Figure 1. The play begins with a draw from nature on the quality type \( q_0 \in \{L, H\} \) of the firm. The firm learns its quality, and chooses its promotional efforts. Let \( A_{q_0} \) denote the amount that a firm of quality \( q_0 \) allocates to its promotional efforts. In stage 1, influentials observe the firm’s choice, update their beliefs about firm quality, and decide whether to buy from the firm. Each influential who buys from the firm gains an experience, \( e \in \{0, 1\} \), which is positive with probability \( q_0 \), the true quality of the firm. In stage 2, followers enter the market, and each follower engages in
a conversation with an influential. If the influential had an experience with the firm, this experience is shared via word of mouth with the follower. The follower then updates her belief about quality, and decides on consumption. In each segment, consumers rationally update their beliefs based on all available information using Bayes’ rule. We now elaborate on the updating process, starting with the influentials.

### 3.1 Influentials Beliefs

For influentials, the prior beliefs about a firm’s quality are $p(q_0 = H) = p(q_0 = L) = \frac{1}{2}$. When a separating equilibrium exists, if influentials observe a private signal (non-zero advertising), they update their beliefs such that $p(q_0 = H) = 1$; and if they do not observe any signal (zero advertising), then $p(q_0 = L) = 1$. When a pooling equilibrium exists, on the equilibrium path, influentials do not observe any signal.

Since the size of influentials segment is $\alpha$, demand in this segment is given by:

$$d_i = \alpha(E[q_0|A] > \epsilon) \quad (1)$$

Thus, when a separating equilibrium exists, the demand from the influential segment is $\alpha H$ if influentials observe a private signal, and $\alpha L$ if otherwise. When a pooling equilibrium exists, the demand from influentials on the equilibrium path is $\alpha \frac{H+L}{2}$.

Next, we elaborate on the belief updating process for followers.

### 3.2 Followers Beliefs

Followers do not observe the firm’s private signal. However, they can interact with influentials from stage 1 to learn about their actual product experiences, and use this information in updating their beliefs. We model this process as follows. Every follower interacts with an influential. If the influential had not engaged in consumption, which happens with proba-
bility $\frac{a-d_i}{a}$, then she has no experience with the firm and the follower does not receive any experience information from the influential. Followers do not know $d_i$, but have rational beliefs given each possible scenario (i.e., $q_0 = L$ and $q_0 = H$), which we denote as $\tilde{d}_{eq_0}$. Now, if the influential had gained an experience ($e$) with the firm, then during the interaction she shares either a positive ($e = 1$) or negative ($e = 0$) experience with the follower. Let $f_{e\emptyset}$, $f_{e1}$ and $f_{e0}$ denote the follower’s updated quality belief given the follower did not hear about an experience, heard about a positive experience, and heard about a negative experience, respectively. First, consider the case where the follower does not hear about an experience. Here, beliefs are updated as follows:

$$f_{e\emptyset}(q_0) \equiv f(q_0 \mid e = \emptyset) = \frac{P(e = \emptyset | q_0) f(q_0)}{\sum_{q \in \{L, H\}} P(e = \emptyset | q) f(q)} = \frac{(\alpha - \tilde{d}_{eq_0})^\frac{1}{2}}{d_{eL} (1 - L) + d_{eH} (1 - H)}$$

$$E_{e\emptyset} \equiv E[q_0 \mid e = \emptyset] = \sum_{q_0 \in \{L, H\}} q_0 f_{e\emptyset}(q_0) = \frac{(\alpha - \tilde{d}_{eq_0}) L + (\alpha - \tilde{d}_{eq_0}) H}{2\alpha - d_{eL} - d_{eH}}$$

(2)

Thus, not hearing about an experience because an influential did not buy may actually provide valuable information to the follower. If followers believe that influentials are more likely to buy if the firm’s quality is high instead of low (i.e., if $\tilde{d}_{eH} > \tilde{d}_{eL}$), then a no purchase would lead follower beliefs $E_{e\emptyset}$ about the firm’s quality to be closer to $L$ than to $H$.

When followers hear about an experience, and this experience is negative, they update their beliefs as follows:

$$f_{e0}(q_0) \equiv f(q_0 \mid e = 0) = \frac{P(e = 0 | q_0) f(q_0)}{\sum_{q \in \{L, H\}} P(e = 0 | q) f(q)} = \frac{\tilde{d}_{eq_0} (1 - q_0)^\frac{1}{2}}{\tilde{d}_{eL} (1 - L) + \tilde{d}_{eH} (1 - H)}$$

$$E_{e0} \equiv E[q_0 \mid e = 0] = \sum_{q_0 \in \{L, H\}} q_0 f_{e0}(q_0) = \frac{\tilde{d}_{eL} (1 - L) + \tilde{d}_{eH} (1 - H) H}{d_{eL} (1 - L) + d_{eH} (1 - H)}$$

(3)

Similarly, when followers hear about an experience, and this experience is positive, they
update their beliefs as follows:

\[ E_{e1} \equiv E[q_0 | e = 1] = \sum_{q_0 \in \{L, H\}} q_0 f_{e1}(q_0) = \frac{\tilde{d}_i L^2 + \tilde{d}_i H^2}{d_i L + d_i H} \quad (4) \]

Thus, a shared negative experience leads to beliefs about the firm’s quality closer to \( L \) than if the shared experience were to be positive (i.e., \( E_{e0} < E_{e1} \)). Finally, demand in the follower segment (whose size is \( 1 - \alpha \)) can be written as:

\[ d_f = (1 - \alpha)(\frac{\alpha - d_i}{\alpha} E_{e0} + \frac{d_i (1 - q_0)}{\alpha} E_{e0} + \frac{d_i}{\alpha} q_0 E_{e1}) \quad (5) \]

### 3.3 Perfect Bayesian Equilibrium

We now analyze a firm’s equilibrium signaling policy. We derive a perfect Bayesian equilibrium (PBE) in this signaling game such that the beliefs of all consumers are consistent with the firm’s optimal signaling strategy, and the firm’s signaling strategy is consistent with the equilibrium beliefs held by all consumers.

We begin by studying whether a high quality firm can credibly separate itself in the eyes of rational influentials from a low quality firm by spending a sufficient amount of resources (\( A \)) in promotions aimed at influentials. Under a separating equilibrium, if influentials observe the firm spend \( A > 0 \) on advertising, then they learn that the firm is of a high quality, leading to a demand from influentials of \( d_{iA} = \alpha H \). Otherwise, if they see no spending, they will infer that the quality must be low leading to a demand of \( d_{i0} = \alpha L \).

Rational followers, even though they don’t observe this spending, will be aware of the existence of a separating equilibrium. Hence, they will expect the demand from influentials to be \( \tilde{d}_i H = d_{iA} = \alpha H \) if the firm is of a high quality and \( \tilde{d}_i L = d_{i0} = \alpha L \) if the firm’s quality is low. Considering now follower beliefs, recall that there are three possible scenarios. Followers could have a conversation with an influential who did not buy the firm’s product,
an influential who purchased and had a negative experience or one that purchased and had a positive experience. Accordingly, follower beliefs under these three cases become:

\[ E_{e0} = \frac{(1-L)H+H}{2-L-H}, \quad E_{e1} = \frac{L^2(1-L)+H^2}{L(1-L)+H(1-H)} \quad \text{and} \quad E_{e1} = \frac{L^3+H^3}{L^2+H^2}. \]

Under a separating equilibrium, demand can be computed using these expressions in Equations (1) and (5) for each quality type:

\[
\begin{align*}
d_L &= d_{e0} + d_f(q_0 = L) \\
&= \alpha L + (1 - \alpha)((1 - L)\frac{L+(L^2+H^3)}{2-L-H} + L(1 - L)\frac{L^2+H^2}{L(1-L)+H(1-H)} + L^2\frac{L^3+H^3}{L^2+H^2}) \\
d_H &= d_{e1} + d_f(q_0 = H) \\
&= \alpha H + (1 - \alpha)((1 - H)\frac{L+(L^2+H^3)}{2-L-H} + H(1 - H)\frac{L^2+H^2}{L(1-L)+H(1-H)} + H^2\frac{L^3+H^3}{L^2+H^2}).
\end{align*}
\]

For a separating equilibrium to exist, the low type firm should not find it profitable to mimic the actions of the high type. It is the advertising investment \(A\) that enables a high type to separate itself from the low quality firm. Therefore, this investment should be sufficiently expensive so that the returns for a low type are lower from mimicking than what it obtains from separating. Hence, the following condition needs to be satisfied:

\[
\alpha L + (1 - \alpha)((1 - L)\frac{L+(L^2+H^3)}{2-L-H} + L(1 - L)\frac{L^2+H^2}{L(1-L)+H(1-H)} + L^2\frac{L^3+H^3}{L^2+H^2}) \\
> \alpha H - A + (1 - \alpha)((1 - H)\frac{L+(L^2+H^3)}{2-L-H} + H(1 - H)\frac{L^2+H^2}{L(1-L)+H(1-H)} + H^2\frac{L^3+H^3}{L^2+H^2}).
\]

To maximize its profit, the high quality firm chooses the lowest amount of advertising spending such that the above constraint is satisfied.\(^8\) We can now define the properties of a separating equilibrium in this signaling game.

**Proposition 1.** “Credible Signal”: There exists a separating equilibrium in the signaling game with word of mouth, where a high type spends \(A^* > 0\) on advertising such that \(A^* = (H - L)(\alpha + (1 - \alpha)((1 - L)\frac{L+(L^2+H^3)}{2-L-H} + (1 - L)\frac{L^2+H^2}{L(1-L)+H(1-H)} + L\frac{L^3+H^3}{L^2+H^2}))\). Further, if \(H^3 - H^2(1+L) + H(2-L)L + (1-L)L^2 > 0\), this separating equilibrium is unique.

The above proposition states that the high type is able to credibly separate itself from the low type using communication with influentials as a signal, as long as certain conditions

\(^8\)Via a simple elimination of dominated strategies, a la Milgrom and Roberts (1986).
Figure 2: A unique separating equilibrium exists in the shaded region.

are satisfied. These conditions are plotted in Figure 2. For $L < H$ in the unshaded region, a pooling equilibrium also exists, since the low type has much to gain from mimicking a high type and not much to earn if influentials realize its true identity. In the shaded region, as the quality of the low type becomes higher, its profit becomes higher even when its identity is revealed to influentials. Here, a high type is willing to invest in costly signaling, whereas a low type is not. While this outcome is consistent with earlier findings (e.g., Milgrom and Roberts, 1986), the rationale behind why a high type has more to gain from signaling a high quality is somewhat different. While the gains to the high type in Milgrom and Roberts (1986) arise from higher repeat sales, in our case, these gains are driven by the demand realized in the follower segment, which . This demand is in turn depends on the mix of positive and negative word of mouth. Such a mix is more favorable for a high quality firm, as it delivers more positive experiences to influentials than a low type. Hence, a high quality firm has more to gain from signaling its high quality, and this allows the high type to find an advertising spending that prevents a low type from mimicking it. Further, this investment in communication by the high type is strictly increasing in the proportion of influentials in the market (i.e., $\partial A^*/\partial \alpha > 0$). With more influentials, the early market becomes more attractive, thus increasing the benefits from mimicking, making it more expensive for the high type to separate.
4 Signaling in Presence of Word of Mouth Biases

Having established the basic modeling framework, we now analyze the impact of biases in word of mouth between influentials and followers on a firm’s optimal communication strategy. We focus on two distinct biases identified in the behavioral literature - negativity and positivity - and determine whether the optimal communication strategy becomes more aggressive or more conservative in the presence of these biases. Finally, we also discuss the implications of followers not being aware of biases on the optimal communication strategy.

4.1 Prevalence of Negative Word of Mouth

If word of mouth opinions were unbiased, then the fraction of positive experiences shared via word of mouth should be equal to the fraction of positive experiences delivered by the firm (i.e., \( q_0 \)). Past research suggests that in some cases, negative experiences might be discussed more often and hence might be more likely to be encountered (e.g., Richins 1983, Harrison-Walker 2001, Rozin and Royzman 2001, Dixon et al. 2010). This might also be observed for products and services with basic features that consumers often take for granted and hence consumers don’t talk about them unless there is a problem (Brandt 1988). In such cases, we expect word of mouth to be skewed towards negative experiences.

We model this potential prevalence of negative word-of-mouth by discounting the likelihood of a follower encountering an influential who had a positive experience. Let \( \beta \in [0, 1) \) be this discount factor, such that the likelihood of a follower hearing about a positive experience from an influential who made a purchase is given by \( q_0(1 - \beta) \) instead of \( q_0 \) (for \( q_0 < 1 \)). Thus, when \( \beta = 0 \), the likelihood of a follower hearing about a positive experience is simply equal to the fraction of influentials that had a positive experience (\( q_0 \)), while higher values of \( \beta \) allow for negative word of mouth to be encountered disproportionately more frequently than positive word of mouth. At the other extreme, \( \beta \rightarrow 1 \) represents the situation where an influential almost never shares a positive experience, and hence followers almost always
hear about negative experiences. Thus, an increase in $\beta$ symbolizes an increasing prevalence of negative word of mouth.

A priori, one might expect that with more negative opinions being shared, it should be easier for a low quality firm to be exposed and hence a high quality firm may need a smaller investment to separate itself in the eyes of rational consumers. Surprisingly, we find that this may not be the case. Given rational beliefs about the firm’s strategy, influential beliefs retain the same formulation described in Subsection 3.1. However, since rational followers are aware of the existence of a bias in the market, their beliefs are revised to account for prevalence of negative word of mouth. This is a key distinction between the model presented here versus that in the previous section. Analogous to Section 3.2, here the updated follower beliefs after hearing about a negative experience can be written as follows:

$$f_{e0}^n(q_0) \equiv f(q_0 \mid e = 0) = \sum_{q \in \{L, H\}} \frac{P(e=0|q_0)f(q_0)}{P(e=0|q)} = \frac{\tilde{d}_{iL}(1-q_0(1-\beta))^{1/2}}{\alpha} \frac{\tilde{d}_{iL}(1-L(1-\beta))^{1/2} + \tilde{d}_{iH}(1-H(1-\beta))^{1/2}}{d_{iL}(1-L(1-\beta)) + d_{iH}(1-H(1-\beta))} \quad (6)$$

$$E_{e0}^n \equiv E[q_0 \mid e = 0] = \sum_{q_0 \in \{L, H\}} q_0 f_{e0}^n(q_0) = \frac{\tilde{d}_{iL}(1-L(1-\beta))L + \tilde{d}_{iH}(1-H(1-\beta))H}{d_{iL}(1-L(1-\beta)) + d_{iH}(1-H(1-\beta))} \quad (7)$$

Thus, even though followers are aware of the existence and magnitude of negativity bias, in updating their beliefs they are unable to fully disentangle the effects of this bias. This is primarily due to uncertainty: since opinions are biased, the learning process is “contaminated”. Similarly, when followers hear about a positive experience, their updated beliefs are:

$$E_{e1}^n \equiv E[q_0 \mid e = 1] = \sum_{q_0 \in \{L, H\}} q_0 f_{e1}^n(q_0) = \frac{\tilde{d}_{iL}L^2(1-\beta) + \tilde{d}_{iH}H^2(1-\beta)}{d_{iL}L(1-\beta) + d_{iH}H(1-\beta)} = \frac{\tilde{d}_{iL}L^2 + \tilde{d}_{iH}H^2}{d_{iL}L + d_{iH}H} \quad (8)$$

Finally, demand in the follower segment in presence of negativity bias can then be written as:

$$d^n_j = (1-\alpha)[(\alpha - d_i)E_{e0} + \frac{d_i}{\alpha}(1-q_0(1-\beta))E_{e0}^n + \frac{d_i}{\alpha}q_0(1-\beta)E_{e1}^n] \quad (8)$$
Given this demand specification, we now characterize the equilibrium spending that a high quality firm needs in order to separate itself from a low quality firm.

**Proposition 2.** “Prevalence of Negative Word of Mouth.” There exists a separating equilibrium in the signaling game with word of mouth and negativity bias ($\beta > 0$), such that a high type spends $A^{n*} > 0$ on advertising, where

$$A^{n*} = (H - L)(\alpha + (1 - \alpha)\left(-\frac{(1-L)L+(1-H)H}{2-L-H}\right) + (1-L(1-\beta))L^2(1-L(1-\beta))H^2(1-H(1-\beta)) + L(1-\beta)\left(\frac{L^3+H^3}{L^2+H^2}\right) + H(2-L(1-\beta))L + (1-L(1-\beta))L^2 > 0$$

If $H^3(1-\beta) - H^2(1+L(1-\beta)) + H(2-L(1-\beta))L + (1-L(1-\beta))L^2 > 0$, this separating equilibrium is unique.

Given Proposition 1, not surprisingly, we see that a separating equilibrium can indeed exist in a signaling game where word of mouth is negatively biased. A priori, one might expect that as word of mouth becomes more negatively biased, a high quality firm may have an easier time separating itself from a low quality firm since negative experiences are shared more, and hence require a smaller advertising spending. However, surprisingly we find that this is not the case:

**Corollary 1.** When a separating equilibrium exists, an increase in the prevalence of negative word of mouth ($\beta$) leads the high quality firm to spend more on advertising ($A^{n*}$).

Corollary 1 argues that as the prevalence of negative word of mouth increases, the equilibrium advertising spending increases, and the high quality firm needs to become more aggressive in signaling. The intuition behind why this is the case is that when negative word of mouth is prevalent, rational followers realize that the word of mouth they hear is biased. In other words, they are likely to be hearing more negative experiences in this market. Consequently, when negativity is higher followers are skeptical, and hence more likely to be forgiving in updating their quality beliefs upon hearing a negative experience from an influential (in our analysis, we find that $\frac{\partial E_{n0}}{\partial \beta} > 0$). At the same time, their beliefs upon hearing a positive experience, or no experience at all, do not vary with the extent of bias. This benefits a low quality type firm, as it provides fewer positive experiences and more
negative experiences. To elaborate, profits for the low type are higher with more bias in a separating equilibrium, and also when it mimics the high type. This profit increase is higher when mimicking as compared to when separating, because followers are more likely to hear about experiences via word of mouth in the former case. This makes it harder for a high type to separate. Consequently, as negative word of mouth becomes more prevalent, a high quality type firm needs to become more aggressive in its advertising spending, to prevent a low quality firm from mimicking its actions.\footnote{To test the robustness of this result, we also analyze a separate case where word of mouth is biased only if the firm advertises. We find that this result can also hold under such a case. This analysis is available from the authors upon request.}

\section*{4.2 Prevalence of Positive Word of Mouth}

Complementary to our analysis in the previous sub-section, researchers have also argued that in some instances an opposite bias might be observed: consumers might encounter positive opinions more often than negative ones (e.g., Chevalier and Mayzlin 2006). This could happen, for example, because the shared experience can have an impact on how a consumer is perceived by others, thus motivating consumers to share positive experiences more. Analogous to the previous analysis, we model the potential prevalence of positive word-of-mouth by discounting the likelihood of a follower encountering an influential who had a negative experience. Thus, if $\beta^p \in [0, 1)$ is this discount factor, then the likelihood of a follower hearing about a negative experience from an influential who made a purchase is given by $(1 - q_0)(1 - \beta^p)$ instead of $1 - q_0$ (for $q_0 < 1$); and consequently the likelihood of a follower hearing about a positive experience is $1 - (1 - q_0)(1 - \beta^p)$ instead of $q_0$. Thus, higher values of $\beta^p$ allow for positive word of mouth to be encountered disproportionally more frequently than negative word of mouth. The rest of the analysis proceeds along the same lines as earlier.\footnote{Additional details regarding this analysis are provided in the Appendix.}

We show that a separating equilibrium exists in this game as well, and parallel to Corollary 1, we find that:
Corollary 2. When a separating equilibrium exists, an increase in the prevalence of positive word of mouth ($\beta^p$) leads the high quality firm to spend more on advertising ($A^p*$).

Corollary 2 argues that as the prevalence of positive word of mouth increases, the equilibrium advertising spending increases, and the high quality firm needs to become more aggressive in its signaling approach. Compared to Corollary 1, the intuition here is that when positive word of mouth is prevalent, rational followers realize that they are likely to be hearing more positive experiences in this market. Consequently, when positivity bias is higher followers once again become more skeptical, and hence more likely to be punishing in updating their quality beliefs upon hearing a positive experience from an influential (in our analysis, we find that $\frac{\partial E_{p1}}{\partial \beta^p} < 0$). At the same time, their beliefs upon hearing a negative experience, or no experience at all, do not vary with the extent of positivity bias. This once again benefits a low type firm, as it provides fewer positive experiences and more negative experiences; making it harder for a high type to separate. Consequently, as positive word of mouth becomes more prevalent, a high quality type firm needs to become more aggressive in its communication.

Overall, comparing the impact of both positivity and negativity bias in word of mouth on a firm’s equilibrium communication strategy, we find that both types of biases lead a high type firm to become more aggressive in its communication efforts. The primary driver behind this outcome is consumer skepticism, although skepticism manifests itself differently in the two cases: as forgiveness for shared negative experiences in the presence of a negativity bias, and punishment for shared positive experiences in the presence of a positivity bias. Thus, a firm’s communication spending is at its most conservative (i.e., lowest) level in the absence of either of these two biases; i.e., a firm under either kind of word of mouth bias (positive or negative) is forced to employ a more aggressive communication approach to signal its type.
4.3 Considerations about information and beliefs

So far we have assumed that if word of mouth opinions are biased (either negatively or positively), followers are aware of these biases, and take them into account while updating their beliefs. However, in several settings, it might be unreasonable to expect followers to indeed be aware of these biases, as well as their magnitudes. To explore the implications of relaxing this assumption on our results, here we discuss how a firm’s equilibrium strategy changes in the presence of negativity bias, when followers mistakenly believe that word of mouth is unbiased.

Relaxing this assumption has direct implications on how followers update their beliefs, i.e., if they are unaware of the bias, they are no longer forgiving in updating their beliefs. We find that the firm’s optimal strategy is remarkably different in this case. In Section 4.1, we found that as the negative bias increases, a high type becomes aggressive in communication spending in a separating equilibrium (i.e., \( \frac{dA^u}{d\beta} > 0 \)). In contrast, here when followers are unaware of the negativity bias, as the negative bias increases, a high type reduces its equilibrium advertising spending, thus becoming more conservative in its signaling strategy.

This result is in line with the a priori intuition discussed before: followers that are not aware of any bias are not forgiving in updating their beliefs. Consequently, the more they hear about a negative experience, more likely they are to update beliefs towards a low type. This makes it easier for the high type to separate, and become conservative in its communication spending. Thus, this comparison of results when followers are aware versus unaware of word of mouth bias highlights the importance of considering and explicitly accounting for consumer sophistication and available information when formulating a firm’s optimal communication strategy.
4.4 Word of mouth bias due to under-reporting

Our model formulation in Section 4.1 models biases as shifting the mix of shared experiences in the market, by making negative opinions more likely to be encountered than positive ones. Such a formulation implies that the total fraction of followers exposed to word of mouth, regardless of its valence, is invariant to the magnitude of bias, therefore that bias only affects the mix of positive and negative opinions shared with followers.

An alternative way in which word of mouth might become biased is due to the phenomenon of under-reporting. If a proportion of influentials who gain an experience refrain from sharing their experiences with followers, and if this proportion varies with the valence of the experience (i.e., positive versus negative), then this will also give rise to a bias in shared word of mouth.\footnote{We thank an anonymous reviewer for suggesting this modeling approach.} To illustrate, in the most extreme case of negativity bias, all influentials who have a positive experience with the firm refrain from sharing their experiences, whereas all who have a negative experience share it with followers. In such a case, the only type of word of mouth that followers will be exposed to, if any, is negative, irrespective of the firm’s quality.

To formulate a model with under-reporting, denote by $r_1$ and $r_0$ the probabilities that an influential shares her experience, given this experience was positive ($e = 1$) or negative ($e = 0$), respectively. Given rational beliefs about the firm’s strategy, the updated influential beliefs are the same as described in Section 3.1. The beliefs of followers aware of the under-reporting bias are updated as follows. When a follower does not hear about an experience from an influential, she has three competing hypotheses about why this might be the case: (i) the influential may not have made a purchase; (ii) the influential had a positive experience but chose not to share it; and (iii) the influential had a negative experience but chose not to share it. Thus, in the case of a separating equilibrium, when no experience is shared with
towards a firm after a follower has been exposed to negative as opposed to no word of mouth reveals that these conditions crucially depend on whether follower beliefs are more favorable to negative 

It is helpful to define 

We now identify conditions under which a separating equilibrium exists, and a stronger negativity bias arises when it becomes disproportionately more likely for a follower to encounter negative rather than positive word of mouth: i.e., when \( r_0 > r_1 \). It is helpful to define \( r_1 = r \) and \( r_0 = r\lambda \), such that \( 0 \leq r \leq 1 \) and \( 0 \leq \lambda \leq \frac{1}{r} \). Thus, \( \lambda > 1 \) implies a negativity bias, while \( \lambda < 1 \) implies a positivity bias. Interestingly, \( r \) reflects the extent to which experiences are reported in this market.

We now identify conditions under which a separating equilibrium exists, and a stronger negativity bias \( (\lambda) \) leads to a more aggressive communication by a high type. Our analysis reveals that these conditions crucially depend on whether follower beliefs are more favorable towards a firm after a follower has been exposed to negative as opposed to no word of mouth.
(i.e., whether negative WOM is better than no WOM):

**Lemma 1.** “When Bad News Is Better Than No News” Follower beliefs about a firm’s quality \( q_0 \) after hearing a negative experience are higher than those after hearing no experience if and only if the following signal-to-noise condition holds:

\[
\frac{1 - H + H^2 (1 - r) + H (1 - H) (1 - r\lambda)}{H (1 - H)} < \frac{1 - L + L^2 (1 - r) + L (1 - L) (1 - r\lambda)}{L (1 - L)}.
\]

In the above expression, the denominators on each side correspond to the variance of experiences for a given type (i.e., \( q_0(1 - q_0) \)). Therefore, they can be interpreted as a measure of how noisy experiences are as a reflection of the firm’s quality. The numerators, in turn, correspond to the probability that no experience is shared under each type. Thus, they can be interpreted as how strongly the absence of a shared experience can be used as a signal of each type. When this signal to noise ratio is greater for a low quality type, then no news is more detrimental than negative news in terms of its impact on follower beliefs since the absence of a shared experience can be more strongly linked to a low quality type. This ratio plays a key role in determining how negativity bias impacts equilibrium communication strategy:

**Proposition 3.** “Asymmetric Under-Reporting:” When a unique separating equilibrium exists in the under-reporting game, and when “bad news is better than no news,” the equilibrium advertising spending \( A_{ur^*} \) by the high quality type increases as the under-reporting bias becomes relatively less severe for negative experiences (i.e., as the negativity bias \( \lambda \) increases).

To understand the intuition behind Proposition 3, recall that in a separating equilibrium a high type chooses the smallest advertising spending required to prevent a low type from mimicking it. This spending thus depends on the difference between the profit obtained by a low type when it mimics the high type and the profit obtained by the low type when it separates from the high type. Consider how these profits change when under-reporting
becomes less severe for negative experiences (i.e., when \( \lambda \) increases). With more negativity, consumers that would have otherwise received no information are instead exposed to a negative experience. Under Lemma 1, if bad news is better than no news, profits for a low type under both mimicking and separating case increase. More importantly, the increase is greater in the mimicking case. This is because the number of followers switching from hearing no news to bad news is greater in the mimicking case (where it is proportional to \( H(1 - L) \)) than in the separating case (where it is proportional to \( L(1 - L) \)). This imposes an additional burden on the high type, to exert greater effort to effectively separate itself from a low type. Consequently, as word of mouth becomes more negatively biased due to more skewed under-reporting, the high quality firm resorts to a more aggressive advertising spending strategy to achieve separation.

Finally, when according to Lemma 1 bad news is indeed worse than no news, then the above result is fully reversed; and we observe less aggressive spending by the high type in response to a stronger negativity bias in word of mouth due to asymmetric under-reporting.

5 Advertising, Prices and Word of Mouth Biases

Past research has shown that a firm may use multiple signals, such as price and advertising, to signal its quality. We now investigate the implications of expanding a firm’s strategy space to incorporate price as a second signal, along with advertising, and examine how advertising and prices are affected by word of mouth. In particular, we investigate whether there exist situations when a high quality type engages in a more aggressive advertising and pricing approach under stronger word of mouth biases (e.g., negativity).

To do so, we modify the model from Section 4.1 and our specification of consumer utility to incorporate price, as follows: \( EU(\text{purchase}) = E_c[q_0] - p \), where \( p \) denotes price. As before, if a consumer chooses not to buy, her utility is given by \( U(\text{no purchase}) = \epsilon \), where \( \epsilon \sim U[0, 1] \) and consumption takes place if the expected utility from purchasing surpasses
the utility from not making a purchase.

In terms of a firm’s decisions, in addition to advertising spending, it now also chooses the prices charged to influentials and followers. It is easy to see that the price charged to followers cannot be a viable separating device, since this price can be mimicked at no cost by the low type. Consequently, a high type can employ advertising and the price charged to influentials as tools to separate itself in the eyes of influentials. Denote by $p_{iH}$ and $p_{iL}$ the price charged to influentials by a high and low type, respectively; and by $p_f$ the price charged to followers.

Given the complexity of this expanded model, we conduct a numerical analysis with the primary objective of illustrating that our main results derived earlier continue to hold, at least under certain realistic conditions, in this expanded setting. First, we specify conditions under which a separating equilibrium exists and is unique. Then, we choose the following model parameters. Let the size of the influential segment be $\alpha = 0.15$. Let quality types be $H = 0.80$ and $L = 0.35$. Let the negativity bias $\beta$ vary between $[0, 0.9]$, in increments of 0.1. The steps involved in this numerical analysis are outlined in the Appendix. Figure 3 plots the equilibrium advertising and prices as a function of the negativity bias.

Consistent with our previous findings, these results show that as negativity bias in word of mouth increases, a high quality firm shifts to a more aggressive advertising approach to effectively separate from the low type (see the top left panel in Figure 3). The top-right panel in Figure 3 shows that the price $p_f$ offered to followers (by both types) is slightly increasing with the extent of negativity bias.

In terms of the prices charged to influentials, the bottom-left panel in Figure 3 shows that the price by a high type ($p_{iH}$) decreases as shared experiences become more negatively biased. Since the high type uses a combination of advertising and price ($A$ and $p_{iH}$) to signal its type, as the extent of negativity bias increases, the high type adjusts this mix. A lower price helps the high type capture more demand in the influential segment, which leads to more experiences being shared with followers. When shared experiences become more
Figure 3: Equilibrium advertising ($A$) and prices ($p_i$, $p_{fH}$, $p_{fL}$) versus negativity bias.

Negatively biased, this is compensated by followers acting in a more forgiving fashion when updating their beliefs after hearing about this negative events. This leads the high type to become more aggressive in its signaling efforts.

Finally, the bottom-right panel in Figure 3 shows that the price by the low type to influencers ($p_{iL}$) decreases as shared experiences become more negatively biased. Intuitively, as this bias increases, followers become more forgiving after hearing about a negative experience. This generates greater incentives for the low quality type to lower prices and capture more influential demand, since any negative word of mouth spread from influencers to followers will be less effective at reducing followers’ beliefs about the firm’s quality.

Thus, we have shown that our central result - that an increase in negativity bias can make a firm more aggressive in its communication strategy - can hold even when price is a viable signal along with advertising; and intuitively for similar reasons as those observed when price is not being considered by a firm as a potential signal for quality.
6 Conclusions

Using communication tools such as advertising for alleviating consumer uncertainty has always been a well recognized and challenging strategic problem. This problem is particularly acute for experience goods, for many of which a simple search, a sample trial, or under certain circumstances even an entire consumption episode might not entirely reveal the true underlying quality. Shared consumption experiences are an important input in helping consumers reduce uncertainty, but at the same time these opinions can sometimes be severely affected by different communication biases. For example, in certain contexts consumers may primarily talk about negative experiences, rather than about positive ones, as in the case of punctuality and other attributes perceived as minimum requirements (Brandt 1988). While past research has extensively analyzed the role of advertising communication in signaling quality, the role of consumer word of mouth and particularly its biases has not been explicitly analyzed. Given the increasing importance of this input in consumers’ decision making, it is imperative for a firm to adjust its communication strategies optimally taking explicitly into account the effects that word of mouth biases have on consumer inferences regarding firm quality. In this paper, we provide insights on how a firm might strategically respond when faced with consumers engaging in potentially biased word of mouth to learn about firm quality.

We study the impact of two distinct and opposite empirically documented behavioral biases in word of mouth: negativity and positivity. Considering the first of these two, we show that under such negativity bias, a firm becomes more aggressive in setting high expectations. This is because when negative word of mouth is prevalent and consumers hear about a negative experience, they are more likely to be forgiving while updating their beliefs. This yields important benefits to a low quality firm. Consequently, the high quality firm needs to become more aggressive in its advertising spending to prevent a low quality firm from mimicking a high quality firm’s actions. In addition, such firm behavior crucially relies on followers being aware of the existence and magnitude of this bias; and is reversed
otherwise.

In terms of extensions, there are several avenues for future research. In our analysis, we rely on a rational Bayesian updating process for modeling follower beliefs as a function of firm and influentials’ communications. One could anticipate that the learning process might potentially be more behaviorally nuanced. What this might suggest then is that the learning process for consumers might follow an alternative updating mechanism, not necessarily derived via Bayes’ rule and rational expectations. Incorporating such a behavioral updating mechanism into the consumers’ learning process might be an interesting direction for future research.

Our analysis has considered a signaling game between a firm and heterogenous influentials and followers. The model could be extended to consider multiple firms and the role of inter-firm competition (a la Villas-Boas 2006). In addition, we capture the essence of information sharing via word of mouth via a single interaction. Generalizations could include allowing followers to have multiple conversations, potentially with different influentials. Additionally, it might be interesting to more explicitly model the motivations of consumers to share information regarding own experiences with others. A related issue to consider would be an endogenous, rather than exogenous, assignment of consumers into influentials and followers, or early adopters versus late adopters. Notwithstanding these additional extensions, this paper suggests that biases in word of mouth might in fact lead a high quality firm to optimally shift to a more aggressive communication strategy to credibly signal its type.
References


Miklos-Thal, J., J. Zhang. 2013. (de)marketing to manage consumer quality inferences. *Journal of Marketing Research Forthcoming*.


Appendix

Proof for Proposition 1

To prove that the proposed separating equilibrium is unique, we determine conditions under which any potential pooling equilibrium does not survive the Intuitive Criterion (Cho and Kreps 1987). If a pooling equilibrium were to exist, profit for each type under such an outcome can be written as:

\[ \Pi_{pool}^H = (1 - \alpha) \left\{ \frac{(1-H)(H+L)(H(1-H)+L(1-L))}{2((1-H)+(1-L))} + \frac{H(H+L)(HH+LL)}{2(H+L)} + \frac{1}{2}(H + L) \left( 1 - \frac{H+L}{2} \right) \right\} + \frac{1}{2} \alpha(H + L) \]

\[ \Pi_{pool}^L = (1 - \alpha) \left\{ \frac{(H+L)(1-L)(H(1-H)+L(1-L))}{2((1-H)+(1-L))} + \frac{L(H+L)(HH+LL)}{2(H+L)} + \frac{1}{2}(H + L) \left( 1 - \frac{H+L}{2} \right) \right\} + \frac{1}{2} \alpha(H + L) \]

Either type can deviate by choosing \( A > 0 \). We assume off the equilibrium path beliefs such that if influentials observe a private signal, \( p(q_0 = H) = 1 \). Then, profits from deviating for each type are:

\[ \Pi_{pool-dev}^H = -A + \alpha H + (1 - \alpha) \left\{ \frac{H(1-H)(H(1-H)+LL(1-L))}{H(1-H)+L(1-L)} + \frac{HH(HHH+LLL)}{HH+LL} + \frac{(1-H)(1-H)(H+L)(1-L)}{(1-H)+(1-L)} \right\} \]

\[ \Pi_{pool-dev}^L = -A + \alpha L + (1 - \alpha) \left\{ \frac{H(1-L)(H(1-H)+LL(1-L))}{H(1-H)+L(1-L)} + \frac{HL(HHH+LLL)}{HH+LL} + \frac{(1-H)(1-H)(H+L)(1-L)}{(1-H)+(1-L)} \right\} \]

The maximum amount that a low type would be willing to spend on advertising and deviate is \( A_L = \alpha H + (1 - \alpha) \left\{ \frac{(H(1-L)(H(1-H)+LL(1-L))}{H(1-H)+L(1-L)} + \frac{HL(HHH+LLL)}{HH+LL} + \frac{(1-H)(1-H)(H+L)(1-L)}{(1-H)+(1-L)} \right\} - \left( (1 - \alpha) \left\{ \frac{(H+L)(1-L)(H(1-H)+L(1-L))}{2((1-H)+(1-L))} + \frac{L(H+L)(HH+LL)}{2(H+L)} + \frac{1}{2}(H + L) \left( 1 - \frac{H+L}{2} \right) \right\} + \frac{1}{2} \alpha(H + L) \right) \]

The maximum amount that a high type would be willing to spend on advertising and deviate is \( A_H = \alpha H + (1 - \alpha) \left\{ \frac{(H(1-L)(H(1-H)+LL(1-L))}{H(1-H)+L(1-L)} + \frac{HL(HHH+LLL)}{HH+LL} + \frac{(1-H)(1-H)(H+L)(1-L)}{(1-H)+(1-L)} \right\} - \left( (1 - \alpha) \left\{ \frac{(1-H)(H+L)(H(1-H)+L(1-L))}{2((1-H)+(1-L))} + \frac{H(H+L)(HH+LL)}{2(H+L)} + \frac{1}{2}(H + L) \left( 1 - \frac{H+L}{2} \right) \right\} + \frac{1}{2} \alpha(H + L) \right) \]

Thus, when \( A_H > A_L \), existence of a pooling equilibrium can be ruled out using the Intuitive Criterion (Cho and Kreps 1987), since there exists an \( A_{dev} > 0 \) such that the high type prefers to spend \( A_{dev} \) and deviate from the pooling outcome, whereas the low type prefers not to spend \( A_{dev} \) since doing so makes it worse off. Thus, simplifying \( A_H > A_L \), the separating equilibrium is unique when \( H^3 - H^2(1 + L) + H(2 - L)L + (1 - L)L^2 > 0 \).
Proof for Proposition 2

This proof proceeds along the same lines as the proof for Proposition 1. If a pooling equilibrium were to exist, profit for each type under such an outcome can be written as:

\[
\Pi_H^{pool} = \frac{1}{2} \alpha (H + L) + (1 - \alpha) \\
\frac{(1 - (1 - \beta) H (H + L) (1 - (1 - \beta) H + L (1 - (1 - \beta) L))}{2((1 - (1 - \beta) H) + (1 - (1 - \beta) L))} + \frac{(1 - \beta) H (H + L) (1 - \beta) HH + (1 - \beta) LL}{2((1 - \beta) H + (1 - \beta) L)} + \frac{1}{2} (H + L) \left( 1 - \frac{H + L}{2} \right)
\]

\[
\Pi_L^{pool} = \frac{1}{2} \alpha (H + L) + (1 - \alpha) \\
\frac{(H + L) (1 - (1 - \beta) L) (H (1 - (1 - \beta) H) + L (1 - (1 - \beta) L))}{2((1 - (1 - \beta) H) + (1 - (1 - \beta) L))} + \frac{(1 - \beta) L (H + L) (1 - \beta) HH + (1 - \beta) LL}{2((1 - \beta) H + (1 - \beta) L)} + \frac{1}{2} (H + L) \left( 1 - \frac{H + L}{2} \right)
\]

Either type can deviate by choosing \( A > 0 \). With the same assumption for the off the equilibrium path beliefs as earlier, profits from deviating for each type are:

\[
\Pi_H^{pool-dev} = -A + \alpha H + (1 - \alpha) \\
\frac{H (1 - (1 - \beta) H) (H (1 - (1 - \beta) H) + L (1 - (1 - \beta) L))}{H (1 - (1 - \beta) H) + L (1 - (1 - \beta) L)} + \frac{(1 - \beta) H HH (1 - \beta) HH + (1 - \beta) LL (1 - \beta) HH + (1 - \beta) LL}{(1 - \beta) H HH + (1 - \beta) LL} + \frac{(1 - H) (1 - H) H + (1 - L) L}{(1 - H) + (1 - L)}
\]

\[
\Pi_L^{pool-dev} = -A + \alpha H + (1 - \alpha) \\
\frac{H (1 - (1 - \beta) H) (H (1 - (1 - \beta) H) + L (1 - (1 - \beta) L))}{H (1 - (1 - \beta) H) + L (1 - (1 - \beta) L)} + \frac{(1 - \beta) H LL (1 - \beta) HH + (1 - \beta) LL (1 - \beta) HH + (1 - \beta) LL}{(1 - \beta) H HH + (1 - \beta) LL} + \frac{(1 - H) (1 - H) H + (1 - L) L}{(1 - H) + (1 - L)}
\]

The maximum amount that a low type would be willing to spend on advertising and deviate is \( A_L = \frac{(\alpha - 1)}{(\beta - 1) H^3 - (\beta - 1) H^2 (3 L - 2) + H (3 (\beta - 1) L^2 + 4 (\beta - 1) L + 2) + L (-(\beta - 1) L^2 + 2 (\beta - 1) L + 4)} + (1 - \alpha) \left( -\frac{H (H^2 - H + (L - 1) L)}{H + L - 2} + \frac{H ((\beta - 1) L + 1) ((\beta - 1) H^3 + H^3 + L^2 ((\beta - 1) L + 1))}{(\beta - 1) H^2 + H + L ((\beta - 1) L + 1)} - \frac{(\beta - 1) H (H^3 + L^3)}{H^2 + L^2} \right) + \alpha H - \frac{1}{2} \alpha (H + L)
\]

The maximum amount that a high type would be willing to spend on advertising and deviate is \( A_H = \frac{(\alpha - 1)}{(\beta - 1) H^3 - (\beta - 1) H^2 (3 L - 2) + H (3 (\beta - 1) L^2 + 4 (\beta - 1) L + 2) + L (-(\beta - 1) L^2 + 2 (\beta - 1) L + 4)} + (1 - \alpha) \left( -\frac{H (H^2 - H + (L - 1) L)}{H + L - 2} + \frac{H ((\beta - 1) L + 1) ((\beta - 1) H^3 + H^3 + L^2 ((\beta - 1) L + 1))}{(\beta - 1) H^2 + H + L ((\beta - 1) L + 1)} - \frac{(\beta - 1) H (H^3 + L^3)}{H^2 + L^2} \right) + \alpha H - \frac{1}{2} \alpha (H + L)
\]

Thus, when \( A_H > A_L \), existence of a pooling equilibrium can be ruled out using the Intuitive Criterion (Cho and Kreps 1987), since there exists an \( A_{dev} > 0 \) such that the high type prefers to spend \( A_{dev} \) and deviate from the pooling outcome, whereas the low type prefers not to spend \( A_{dev} \) since doing so makes it worse off. Thus, simplifying \( A_H > A_L \), the separating equilibrium is unique when \( H^3 (1 - \beta) - H^2 (1 + L (1 - \beta)) + H (2 - L (1 - \beta)) L + (1 - L (1 - \beta)) L^2 > 0 \).
Proof for Corollary 1

We have $A^n = (H - L)(\alpha + (1 - \alpha))(1 - L(L + \frac{1}{2} - (1 - L_H)(1 - H_H) + (1 - L(1 - \beta))L^2(1 - L(1 - \beta)) + (1 - H_H)H^2(1 - H(1 - \beta))) + L(1 - \beta))^{\frac{L^3 + H^3}{L^2 + H^2}}$. Hence, $\frac{\partial A^n}{\partial \beta} = \frac{(1 - \alpha)H^2L(H - L)^4}{(H^2 + L^2)(H(1 - H(1 - \beta)) + L(1 - L(1 - \beta))^2)} > 0$.

Proof for Corollary 2

Following a similar approach as adopted in the analysis for negativity bias, updated follower beliefs after hearing about a negative experience can be written as follows:

$$f_{e0}^p(q_0) = \frac{P(e = 0 | q_0)}{\sum_{q \in \{L, H\}} P(e = 0 | q)} = \frac{\tilde{d}_{i_L}(1 - q_0)(1 - \beta_L)}{\tilde{d}_{i_L}(1 - L) + \tilde{d}_{i_H}(1 - H)}$$

$$E_{e0}^p = E[q_0 | e = 0] = \sum_{q_0 \in \{L, H\}} q_0f_{e0}^p(q_0) = \frac{\tilde{d}_{i_L}(1 - L) + \tilde{d}_{i_H}(1 - H)H}{\tilde{d}_{i_L}(1 - L) + \tilde{d}_{i_H}(1 - H)}$$ \hspace{1cm} (12)

Similarly, when followers hear about a positive experience, their updated beliefs are:

$$E_{e1}^p = E[q_0 | e = 1] = \frac{\tilde{d}_{i_L}(1 - (1 - L)(1 - \beta_L))L + \tilde{d}_{i_H}(1 - (1 - H)(1 - \beta_L))H}{\tilde{d}_{i_L}(1 - (1 - L)(1 - \beta_L)) + \tilde{d}_{i_H}(1 - (1 - H)(1 - \beta_L))}$$ \hspace{1cm} (13)

Finally, demand in the follower segment in presence of positivity bias can then be written as:

$$d_f^p = (1 - \alpha)(\frac{\alpha - \tilde{d}_i}{\alpha})E_{e0}^p + \frac{\tilde{d}_i}{\alpha}(1 - q_0)(1 - \beta_L)E_{e0}^p + \frac{\tilde{d}_i}{\alpha}(1 - (1 - q_0)(1 - \beta_L))E_{e1}^p$$ \hspace{1cm} (14)

The remainder of the analysis follows along the same lines as that for the negativity bias: we find that a unique separating equilibrium exists, and that equilibrium advertising $A^p$ is increasing in $\beta^p$.\footnote{The details regarding these steps are available from the authors upon request.}
Proof for Lemma 1

When bad news is better than no news, $E_{e0}^{ur} > E_{e0}^{ur}$.

\[
\frac{H^3(1-H)+L^2(1-L)}{H(1-H)+L(1-L)} > \frac{H(1-H)+(1-H)(1-H)(1-r_L))+(L(1-L)+L^2(1-r_L))}{H(1-H)+(1-H)(1-r_L))+(1-L)L^2(1-r_L))}
\]

\[
\Rightarrow \frac{1-H+H^2(1-r)+H(1-H)(1-r_L))}{H(1-H)} < \frac{1-L+L^2(1-r)+L(1-L)(1-r_L))}{L(1-L)}.
\]

Proof for Proposition 3

The proof for this proposition follows the same steps as the proofs for Propositions 1 and 2. Following similar steps, in a unique separating equilibrium in this game, we obtain:

\[
A^{urs} = (H-L)\alpha + (H-L)(1-\alpha) \left( \frac{\lambda(1-L)r_3(1-H)L^2\lambda r_3+\lambda(1-L)L^2r_3}{(1-H)H\lambda r_3+\lambda(1-L)Lr_3} + \frac{Lr_3(H^3r_3+L^3r_3)}{H^4r_3+L^4r_3} \right)
\]

\[
-(H-L)(1-\alpha)\lambda r_3(H(1-H)H^2(1-H)+r_3H(1-L)(1-H)+L(L^2(1-r_3)+(1-L)L(1-L)-L+1))
\]

\[
\frac{\partial A^{urs}}{\partial \lambda} = \frac{(1-\alpha)r_3(H-L)^2(H^3r_3(Lr_3-1)+H^2r_3L^2r_3)+H(L-1)(3Lr_2-2)(L-1)^2}{(H^2-L(L-1)L)(H^2r_3L^2r_3-H\lambda r_3+\lambda L^2r_3-Lr_3+2)^2} > 0
\]

\[
\Rightarrow H^3r_3(1-Lr_3)+H^2r_3(1-L^2r_3)+H(L-1)(3Lr_2-2)+2(1-L)^2 > 0
\]

The above inequality always holds when $\frac{1-H+H^2(1-r)+H(1-H)(1-r_L))}{H(1-H)} < \frac{1-L+L^2(1-r)+L(1-L)(1-r_L))}{L(1-L)}$.

Steps in the Numerical Analysis for Section 5

For the signaling game specified in this section, we first analytically specify the conditions necessary for the existence and uniqueness of a separating equilibrium, following the same steps as outlined in the proofs for Propositions 1 and 2. For each numerical instance, we verify that these conditions are satisfied. Prices and advertising spending is chosen using backward induction: first the pooling price for followers, $p_f$, is chosen by a high type, given $A$, $p_H$ and $p_L$. In first stage, each type chooses advertising and price by anticipating the actions taken by the other type. Doing so allows us to numerically compute the equilibrium values of $p_f$, $A$, $p_H$ and $p_L$ for each numerical instance. We then plot these values against $\beta$ in Figure 3.