Abstract

We develop a model of positive and negative word of mouth (WOM) about a new product. WOM is costly, but early adopters, who have tried the product, experience utility if they had a good (bad) experience with the product and can influence followers to buy (not buy) it. Early adopters talk if they believe they can affect the buying behavior of the followers. Whether a follower’s action can be affected by a positive or negative signal depends on her prior. Whether an early adopter thinks that he can affect the follower’s action, in turn depends on the distribution of priors. We distinguish between two cases: With homogeneous priors, the adopter knows exactly what the prior of the follower is. With heterogeneous priors, the adopter believes that priors are uniformly distributed. The price set by the firm determines the default action of the follower absent WOM. We show that with homogeneous priors, only adopters with a negative experience talk in equilibrium. With heterogeneous priors both positive WOM and negative WOM can occur depending on the type of the product. We examine the consistency of our theoretical results with review data from Yelp.com where we argue that new chain restaurants constitute homogeneous priors while independent restaurants constitute heterogeneous priors.

1 Introduction

Chain restaurants on Yelp.com have 40% negative reviews (1 or 2 star ratings) on average whereas independent restaurants serving the same cuisines have only 20% 1 or 2 star ratings. Let’s take the example of the well-known pizza joint Pizza Hut that has 7000+ stores across US and is one of the largest fast food chains by revenue (Quick Service Magazine Report)\(^1\). Pizza Hut has an average rating of only 2.2 on a five point scale on Yelp.com and the average rating of Pizza Hut stores has
been falling by 5.33 percentage points from 2010 to 2017. However, they rank relatively highly in the American Consumer Survey Index (ACSI) with an average of 79 points in the recent years from 2013-2018, 78-81 being the average satisfaction of restaurants. Further, the satisfaction ratings for Pizza Hut increased by 4 points in the year 2018 though reviews continue to decline. Also for other large established chains, such as Subway, there seems to be a similar gap between customer satisfaction and customer reviews. In contrast, independent restaurants in similar categories have on average very high ratings of 3.7 on Yelp.com. This indicates that the average valence of reviews and word-of-mouth is not necessarily an indication of consumer satisfaction or future profits of a firm, and suggests that there is selection in the types of reviews, potentially based on the product characteristics and consumer expectations about quality.

In this paper we propose a game-theoretic model with endogenous word-of-mouth and examine the consistency of our results with restaurant review data from Yelp.com. The key premise of the model is that consumers only want to talk or write reviews if it affects the action of the person who is listening or is reading the review, whom we refer to as a follower. If the follower was likely to buy to start with, then there is no reason to engage in positive word-of-mouth. If an early adopter had a negative experience, however, this might affect the follower’s action and hence, we expect to observe negative WoM. Thus, even if there were more people with positive experience, only consumers with negative experience speak up. Note that whether the follower is likely to buy to start with can be affected by the firm, for example through its pricing. In particular, a follower is more likely to buy as a default if the firm sets a relatively low price. Thus, the firm can affect the type of word-of-mouth through the price. Whether it is optimal for the firm to induce positive and/or negative word-of-mouth depends on the type of the product or service.

We show that the heterogeneity of priors about the quality of the restaurant plays an important role for the selection of positive versus negative word-of-mouth. For established chain restaurants such as Pizza Hut, for example, most people have similar beliefs about the quality of a newly opened restaurant. If it was, however, an independent restaurant, priors are likely to be dispersed. Thus, an early adopter cannot be sure whether the follower who is reading or hearing her review is likely to buy or not. Our model predicts that for new restaurants of established chains all word-of-mouth is negative because adopters with positive experience do not bother talking. In contrast, for new independent restaurants, where consumers might not share the same prior about the quality, we expect positive and/or negative word-of-mouth depending on whether it is a specialty product or a consistency product, respectively. A specialty product is one for which a positive review is a strong signal for good quality of the product, while a consistency product is one where a mistake is a strong signal for bad quality, i.e. if cleanliness, freshness, basic service are important.

The reason for this asymmetry between positive and negative word-of-mouth stems from the way “no news” is interpreted. If potential adopters expect only negative experiences to be shared, then “no news” can be interpreted as good news. In this case, if only few people have tried a restaurant
so far – which is the case for new restaurants – then it is likely to observe “no news” which increases the belief about the quality of the product. This is why it is always beneficial for a firm to induce negative word-of-mouth in equilibrium.

Our model is based on the assumption that talking bears some opportunity cost and that early adopters derive some benefits if the follower’s action matches his recommendation. This can be due to social spill-overs, actual usage externalities, pleasure of giving useful information to a friend, or benefits from a relational contract with friends where giving useful information guarantees useful information from the friend in return. One could interpret the positive externalities in our model also as a reduced form of a “self-enhancement motive.”

We solve the firm’s pricing problem when the number of early adopters is low, as is the case for new products or restaurants. This makes the problem technically tractable and we are less concerned about the assumption as in the Yelp.com data we can see that 24% of total reviews are written in the first year and there is a sharp drop of 64% in the number of reviews written in the second month over the first month after which the decline is much more gradual.

We test these propositions using data from Yelp.com which is one of the largest online review platforms for restaurants. Consistent with the model predictions, we find that new chain restaurants on Yelp.com have 1 point lower average rating (2.7) than new independent restaurants (3.7). We also find that among chain restaurants, the established national chains e.g, Subway, Pizza Hut have the largest number of 1-star reviews (both new and old stores); the new and more local chains e.g., Culver’s, Whataburger, IHop etc. have a mix of positive and negative reviews whereas the independent restaurants have the most 4 and 5-star reviews. Similarly, we observe a decreasing trend in average ratings of new stores of chains as time passes and the chain brands become more well-known. These differences can be attributed to the differences in the level of heterogeneity of priors (chain restaurants are more homogenous) and different product types. Most independent restaurants are specialty products i.e., they create some positive surprises for customers (great ambiance or unique recipes) and hence combined with heterogeneous priors that people have for these restaurants, positive word of mouth equilibrium is optimal. On the other hand, established chains as well as new and lesser known chains are mostly evaluated for their consistency of offerings and hence irrespective of the degree of heterogeneity in priors, negative word of mouth is induced.

The paper is structured as follows. Section 2 reviews the relevant literature and discusses how our work complements previous research. Section 3 introduces the model and the equilibrium notion. Section 4 contains the equilibrium characterization and all theoretical results. Section 5 discusses some empirical facts and how they are consistent with the theoretical findings.

\footnote{This is in contrast to word-of-mouth that brings pleasure in itself. For example, Gilchrist and Sands (2016) detect strong social spillovers of consumption for movies.}
2 Literature Review

Word-of-mouth is an important marketing tool - in particular for new products – and researchers have studied diffusion of information through word-of-mouth pioneered by Bass (1969). Three measures of online user reviews - volume, valence, and variance – are of particular interest. In this paper we are concerned with valence. In particular, we are interested in the drivers of valence, as the existing theoretical and empirical literature on word of mouth has shown that valence has a strong impact on profit-relevant outcome variables. For example Chevalier and Mayzlin (2006) find that an improvement in ratings impacts sales and that negative reviews have larger impact than positive. Likewise, more recently, Luca (2016) finds that a 1-star increase in Yelp reviews can increase revenue by 5-9 %. The type of Word of mouth can even affect the types of products we see in the market: Godes (2016) studies how the type of word of mouth affects the incentives of firms to invest in product quality.

This paper identifies two main drivers of valence - distribution of priors or past beliefs and product characteristics, namely consistency versus specialty product. We highlight that these drivers impact valence even controlling for product quality and complement existing empirical findings by looking at heterogeneity in valence rather than focusing on overall average valence on a platform. Our data is in line with the existing literature that has found that the overall average distribution of online reviews is right skewed — additionally we show that there are interesting differences by product type. For example, on eBay about 99% of reviews are positive (Resnick and Zeckhauser (2002), Nosko and Tadelis (2015)) or for books an average rating of 4.14–4.45 out of 5 has been documented (Chevalier and Mayzlin (2006)). Hotels average ratings range from 3.49 to 3.95 (Ghose, Ipeirotis and Li (2012), Mayzlin, Dover and Chevalier (2014)). Fradkin, Grewal, Holtz and Pearson (2015) also notes that most reviews on the popular home-sharing website Airbnb.com are positive. Though past literature has documented that there is difference in valence by industry type, this paper is the first to focus on heterogeneity in valence due to heterogeneity in prior beliefs about products. This might also be one explanations for why movies Chintagunta, Gopinath and Venkataraman (2010) report a relatively low average rating 9.9 out of 13 as priors about the quality of a movie are likely to be quite heterogeneous.³

Our paper also contributes to the literature on managing word-of-mouth more broadly by theorizing one of the possible reasons for adopters to engage in WOM. Most of the early papers on WOM treat it as mechanical, cost-less process and focuses on WOM as a mechanism to generate awareness about the existence of a product.⁴ The incentive for adopters talk only if they can affect the follower’s action is similar to the incentive to search in Mayzlin and Shin (2011). The value of additional information must be sufficiently large in order to engage in costly information

³See Bramoullé, Galeotti, Rogers and Mayzlin (n.d.) for a nice survey.
⁴See also Godes, Mayzlin, Chen, Das, Dellarocas, Pfeiffer, Libai, Sen, Shi and Verlegh (2005) for a survey of the literature.
diffusion or acquisition, respectively. Kamada and Öry (2017) consider a contracting problem in which the incentive to talk is driven by externalities of using a product together, similar to our model. Thus, offering a free contract can make WOM more attractive since receivers are more likely to start using the product, conditional on knowing about it. In Biyalogorsky, Gerstner and Libai (2001) a firm can encourage WOM through the price or a referral programs. Unlike in our model, a reduced price induces senders to talk because it “delights” them, whereas in our paper the sender cares about the receiver’s action. Depending on the delight threshold, the price reductions become more or less attractive relative to the referral program. Another rationale for WOM is provided in Campbell, Mayzlin and Shin (2015). They assume that senders talk in order to be perceived as a knowledgeable type by the receiver. Thus, our paper is closer to these papers that recognize that talking is costly and hence model a specific source of utility that governs the decision to talk.

Another reason for these differences in valence could be arising from the type of people who chose to be early adopters. Angelis, Bonezzi, Peluso, Rucker and Costabile (2012) show that consumers with a strong self-enhancement motive generate a lot of positive WOM, while transmitting more negative WOM about other peoples’ experiences. Our model is agnostic to user type.

3 Model

Basics. Consider a firm with a new product or service. The marginal cost of production is normalized to zero. The production technology is of high ($H$) or low quality ($L$). The quality of the production technology $\theta \in \{H, L\}$ is the firm’s private information. The firm faces a continuum of consumers of measure 1. Ex-ante, each consumer believes that the technology is $H$ with probability $\phi \in [0, 1]$. Consumers’ priors $\phi$ are distributed according to a cdf $F$ on $[0, 1]$. In the analysis we consider two cases:

- With homogeneous priors, $F = \delta_a$, where $\delta_a$ represents the Dirac distribution with mass on $a \in [0, 1]$, i.e., all consumers believe that the technology is high quality ($\theta = H$) with probability $a \in [0, 1]$.

- With heterogeneous priors, we assume that $F = U[0, 1]$, i.e., prior beliefs $\phi$ are uniformly distributed among consumers.

Intuitively, a homogeneous prior distribution implies that consumers all agree on the likelihood that the product technology is good. For example, for franchised restaurants like Starbucks, it is reasonable to assume that consumers agree on the expected quality of a new Starbucks location. However, there would be more heterogeneity in beliefs in case of a new independent coffee shop. Some consumers might think it is good with probability $\phi_1$, while others might think it is good with a higher probability $\phi_2$. 

5
A fraction $\beta$ of consumers has tried the product with a realized quality $q \in \{h, \ell\}$. We call such a consumer **early adopter** (he). Given $\theta$, the realized quality is drawn independently such that $Pr(q = h|\theta = H) = \pi_H$ and $Pr(q = h|\theta = L) = \pi_L$ where $1 \geq \pi_H > \pi_L \geq 0$. Thus, every early adopter receives a signal about the type of production technology $\theta$. The remaining fraction $1 - \beta$ of consumers is called **follower** (she).

**Timing and payoffs.** The game proceeds as follows:

1. At the start, early adopters try the product and the firm commits to a publicly observable price $p$ for future followers.

2. Consumers are randomly matched in pairs. Consequently, a consumer is matched to a early adopter with probability $\beta$ and to another adopter with probability $1 - \beta$. Consumers do not know the type of the consumer they are matched with.

3. Every early adopter decides whether to engage in word-of-mouth (WoM) communication by sending a message about his realized quality of the product to the consumer he is matched with. Thus, the message space of a early adopter with realized quality $q \in \{h, \ell\}$ is given by

\[ M_q \equiv \{q, \emptyset\}, \]

where $\emptyset$ indicates that he does not engage in WoM. Let $M = M_h \cup M_\ell$. We assume that communication is verifiable, i.e., early adopters can either make a truthful report or stay silent. Engaging in WoM (i.e., sending a message $q$) entails a cost $c > 0$. The benefit of engaging in WoM communication stems from receiving an additional utility $r$ whenever the adopter buys (does not buy) and $q = h$ ($q = \ell$).\(^5\) This positive utility could be attributed to positive externalities in the product market, or to consumers enjoying the fact that others are making the same choices as them. One can also think of $r$ as a benefit from a good reputation in the relationship with the adopter. We assume

\[ r > c. \tag{1} \]

Otherwise early purchasers never talk. In order to simplify notation, let

\[ \xi \equiv \frac{c}{r} \in (0, 1). \]

4. Finally, followers update their belief about the type of the firm, observing the price and the message, and then decide whether to purchase the product or not. If an adopter does not buy,

\[^5\text{We can think of two alternative models: In the first, the early adopter derives utility from the adopter taking the recommended action, i.e., buys the product after a message } \tilde{m} = h \text{ and not buys the product after a message } \tilde{m} = \ell. \text{ In the other, the early adopter gets utility only if the adopter keeps the product (i.e., also gets the same realization of quality). This makes the model technically more messy but we do not expect the results to change.}\]
she stays with an outside option which gives her utility 0. If she buys a high (low) quality product, she gets payoff $\bar{v} - p (v - p)$. We normalize $\bar{v} = 1$ and $v = 0$. This is without loss.\(^6\)

We assume that

$$p \in [\pi_L, \pi_H].$$

This is the only interesting case because whenever $p > \pi_H$ no one buys for any posterior and whenever $p < \pi_L$, everyone buys for any posterior.

**Histories, strategies, and equilibrium.** A firm’s history is trivial as it does not observe anything but its type. Thus, a type-$\theta$ firm’s strategy simply consists of a price $p_\theta \in [\pi_L, \pi_H]$. A early adopter observes the price set by the firm and his quality realization $q \in \{h, \ell\}$, i.e., his set of histories is given by $H_{\text{early adopter}} = [\pi_L, \pi_H] \times \{h, \ell\}$. Each adopter, observes the price set by the firm, the message received $m \in M$, and her prior $\phi$. Thus, her history is in $H_{\text{follower}} = [\pi_L, \pi_H] \times M \times [0, 1]$.

We are interested in perfect Bayesian equilibria (PBE) in pure strategies. A PBE comprises a tuple $\{p_L, p_H, \mu, \alpha, \hat{\phi}\}$ such that

1. a firm of type $\theta$ sets price $p_\theta$ to maximize its profit given other players’ strategies and beliefs,

2. $\mu : H_{\text{early adopter}} \to \Delta M$ is the optimal WOM strategy of a early adopter that maps the observed price and the observed $q \in \{h, \ell\}$ to a messaging strategy (possibly mixed), such that the message is feasible, i.e., $\text{supp}(\mu(p, h)) \in \{h, \emptyset\}$ and $\text{supp}(\mu(p, \ell)) \in \{\ell, \emptyset\}$ for all $p \in [\pi_L, \pi_H]$.

3. $\hat{\phi} : H_{\text{follower}} \times M \to [0, 1]$ maps the observed price, prior $\phi$ and observed message $m \in M$ to the posterior belief of an adopter about the type of the firm using Bayes’ rule whenever possible,

4. $\alpha : H_{\text{follower}} \to \{\text{buy, not buy}\}$ is a purchasing strategy of followers that maps the observed price, the prior belief $\phi$ and message $m \in M$ to a purchasing decision, and maximizes the adopter’s payoff given the beliefs.

With a slight abuse of notation, let $\mu_q(p) \in [0, 1]$ denote the probability with which a early adopter who sees quality $q$ and price $p$ engages in WoM in equilibrium. We omit the $p$ and write $\mu_q$ if there is no ambiguity about the price considered.

In order to characterize equilibria, we proceed by backwards induction. Hence we will need to analyze the sub-game which starts with the early adopter’s WoM decision, given a price. We call this the “WoM subgame” and the equilibria of this subgame, “WoM equilibria.”

\(^6\)It turns out that $\bar{v}$ enters the analysis only as the ratio $\frac{\bar{v}}{v}$.\]
4 Characterization of the equilibrium

Given that firms set prices at the start of the game, followers may infer information from the observed price and update their beliefs about the firm’s type. The lemma below shows that such signaling via prices cannot arise in a (pure-strategy) equilibrium.

Lemma 1 There is no fully separating equilibrium.\(^7\)

Proof. In a fully separating equilibrium, all buyers are willing to buy at any price \(p \leq \pi_H\). Thus, if \(p_H > p_L\), then the \(L\)-firm wishes to deviate to offering \(p_H\). If \(p_L > p_H \geq \pi_L\), then no one buys at the price \(p_L\) and the \(L\)-firm can increase profits by deviating to offering \(p_H\). ■

Given this lemma, any pure-strategy equilibrium must be pooling, that is both firm types choose the same price. In such an equilibrium posterior belief is independent of the observed price. In what follows, we prove the existence of a pooling equilibrium by construction. First, we assume that both firm types set the same price \(p\) and solve the subgame using a backwards induction argument. Then, we verify that that there is a continuum of pricing decisions in the first stage that constitute an equilibrium. We characterize the pooling equilibrium in which the \(H\)-type maximizes profits.

4.1 Purchase decision of an adopter

Let us assume firms in the pricing stage have set the same price \(p\). An adopter with posterior belief \(\hat{\phi}(p, \phi, m)\) purchases at a price \(p\) if and only if her expected utility from purchasing is greater than her outside option of 0, i.e., if

\[
v(p, \phi, m) = \left(\hat{\phi}(p, \phi, m)\pi_H + (1 - \hat{\phi}(p, \phi, m))\pi_L\right) \cdot \bar{v} - p \geq 0.
\]

Let us denote the posterior that makes an adopter indifferent between buying and not buying given a price \(p\) by

\[
\Phi(p) = \frac{\bar{v} - \pi_L}{\pi_H - \pi_L}.
\]

Then, the adopter buys if and only if \(\hat{\phi}(p, \phi, m) \geq \Phi(p)\). Note that \(\Phi(p)\) is increasing in \(p\).

On equilibrium path, posteriors are formed according to Bayes’ rule given the equilibrium strategies, i.e., \(\hat{\phi}(p^*, \phi, h) = \frac{\phi \pi_H}{\phi \pi_H + (1 - \phi)\pi_L}, \hat{\phi}(p^*, \phi, \ell) = \frac{\phi (1 - \pi_H)}{(1 - \pi_H) + (1 - \phi)(1 - \pi_L)}\) and

\[
\hat{\phi}(p^*, \emptyset) = \frac{\phi \cdot [1 - \beta + \beta \left(\pi_H (1 - \mu_h) + (1 - \pi_H)(1 - \mu_\ell)\right)]}{1 - \beta + \phi \beta \left(\pi_H (1 - \mu_h) + (1 - \pi_H)(1 - \mu_\ell)\right) + (1 - \phi)\beta \left(\pi_L (1 - \mu_h) + (1 - \pi_L)(1 - \mu_\ell)\right)}.
\]

Note that \(\hat{\phi}(p^*, \emptyset)\) is a function of \(\mu_h\) and \(\mu_\ell\) which are determined by the equilibrium strategies being played and \(\hat{\phi}(p^*, \phi, h) \geq \hat{\phi}(p^*, \phi, \emptyset) \geq \hat{\phi}(p^*, \phi, \ell)\). Off-path we specify posteriors to be the

\(^7\)We conjecture that a semi-separating may exist if we allowed for mixed strategies.
most pessimistic, i.e., we assume that \( \bar{\phi}(p, \phi, m) = 0 \) if the observed price \( p \) is not equal to the equilibrium price. Any pooling equilibrium of the game can be sustained by these off-path beliefs.

All in all, an adopter’s equilibrium purchasing strategy is given by:

\[
\alpha(p, \phi, m) = \begin{cases} 
\text{buy} & \text{if } \bar{\phi}(p, \phi, m) \geq \Phi(p) \\
\text{not buy} & \text{otherwise}
\end{cases}
\] (3)

Using the expressions for \( \hat{\phi}(p^*, \phi, h) \) and \( \hat{\phi}(p^*, \phi, \ell) \), which do not depend on the equilibrium played, we can define the following cutoffs for the prior belief \( \phi \). Let \( \bar{\phi}(p) \) be the threshold prior belief such that followers with priors \( \phi > \bar{\phi}(p^*) \) buy regardless of the signal they receive, i.e., even if \( m = \ell \). It is given by

\[
\bar{\phi}(p^*) = \frac{1}{1 - \frac{\pi_H}{\pi_L} \cdot \frac{1 - \Phi(p^*)}{\Phi(p^*)}}.
\]

Similarly, let \( \check{\phi}(p^*) \) be the threshold belief such that followers with priors \( \phi < \check{\phi}(p^*) \) do not buy regardless of the signal they receive:

\[
\check{\phi}(p^*) = \frac{1}{\frac{\pi_H}{\pi_L} \cdot \frac{1 - \Phi(p^*)}{\Phi(p^*)} + 1}.
\]

Note that \( \check{\phi}(p^*) > \Phi(p^*) > \bar{\phi}(p^*) \). Finally, given a message strategy of early adopters resulting in \( (\mu_h, \mu_\ell) \), let \( \tilde{\phi}(p^*; (\mu_h, \mu_\ell)) \in [\check{\phi}(p^*), \bar{\phi}(p^*)] \) be the threshold such that followers with prior belief \( \phi \in (\tilde{\phi}(p^*; (\mu_h, \mu_\ell)), \check{\phi}(p^*)) \) do not buy if and only if they receive an \( \ell \) signal, and followers with prior \( \phi \in (\check{\phi}(p^*), \tilde{\phi}(p^*; (\mu_h, \mu_\ell))) \) buy if and only if they receive a \( h \) signal. Figure 1 summarizes these thresholds.

These thresholds allow us to categorize prior distributions, which turns out to be useful for the characterization of the equilibrium behavior in the WoM stage.

**Definition 1** Given an equilibrium price \( p^* \), we call a distribution of priors \( F \)

- **pessimistic**, whenever \( F(\Phi(p^*)) - F(\bar{\phi}(p^*)) > \xi > F(\check{\phi}(p^*)) - F(\Phi(p^*)) \),
- **optimistic**, whenever \( F(\check{\phi}(p^*)) - F(\Phi(p^*)) > \xi > F(\Phi(p^*)) - F(\bar{\phi}(p^*)) \).

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Figure 1: Followers’ decisions for given prior beliefs
• uninformed whenever \(F(\Phi(p^*)) - F(\tilde{\phi}(p^*))\), \(F(\tilde{\phi}(p^*)) - F(\Phi(p^*)) > \xi\)

• well-informed whenever \(F(\Phi(p^*)) - F(\tilde{\phi}(p^*))\), \(F(\tilde{\phi}(p^*)) - F(\Phi(p^*)) < \xi\).

Pessimistic priors require that many consumers have low priors between \(\phi(p^*)\) and \(\Phi(p^*)\), while optimistic beliefs require that many consumers have high priors between \(\Phi(p^*)\) and \(\bar{\phi}(p^*)\). If priors are uninformed, most consumers have priors that are intermediate. In contrast, if priors are informed most consumers have very extreme priors.

4.2 Word-of-mouth subgame

Given the adopter's equilibrium purchasing behavior (3), we can infer the early adopters’ communication decision, given the observed price, signal, and equilibrium played. Since WoM is costly, a early adopter talks only if he can affect the adopter’s decision. A early adopter who observes a quality \(q = h\) receives a utility of 
\[r(1 - F(\tilde{\phi}(p)))\] if he sends the message \(m = h\) and a utility of
\[r(1 - F(\tilde{\phi}(p; (\mu_h, \mu_\ell))))\] if he does not send a message. Thus, he weakly prefers to engage in WOM whenever
\[
(F(\tilde{\phi}(p; (\mu_h, \mu_\ell))) - F(\tilde{\phi}(\bar{p}))) \cdot r \geq c,
\]

Similarly, a early adopter who observes a quality \(q = \ell\) weakly prefers to engage in WoM whenever
\[
(F(\tilde{\phi}(p)) - F(\tilde{\phi}(p; (\mu_h, \mu_\ell)))) \cdot r \geq c.
\]

There are four types of WoM equilibria.\(^8\)

1. Full WoM (\(\mu_h = \mu_\ell = 1\)): If all early adopters talk, then \(\hat{\phi}(p, \phi, \emptyset) = \phi\) and
\[
\bar{\phi}(p) < \hat{\phi}(p; (1, 1)) = \Phi(p) < \phi(p).
\]

2. No WoM (\(\mu_h = \mu_\ell = 0\)): Without any WoM, \(\hat{\phi}(p, \phi, \emptyset) = \phi\) and \(\tilde{\phi}(p; (0, 0)) = \Phi(p)\).

3. Negative WoM (\(\mu_h = 0, \mu_\ell = 1\)): If only early adopters with \(q = \ell\) engage in WoM, then
\[
\phi(p) > \Phi(p) \geq \tilde{\phi}(p; (0, 1)) = \frac{1}{\frac{1}{1-\beta+\beta\pi_L} - \Phi(p)} \geq \phi(p).
\]

4. Positive WoM (\(\mu_h = 1, \mu_\ell = 0\)): If only early adopters with \(q = \ell\) engage in WoM, then
\[
\bar{\phi}(p) < \Phi(p) \leq \tilde{\phi}(p; (1, 0)) = \frac{1}{\frac{1}{1-\beta+\beta(1-\pi_H)} - \Phi(p)} \leq \phi(p).
\]

\(^8\)Recall that we restrict attention to pure strategy equilibria.
Intuitively, these equilibria differ in how the followers interpret the absence of WOM, that is if the early adopters choose message $\emptyset$. In the negative WOM equilibrium, $\emptyset$ means a weak positive signal about quality, while in a positive WOM equilibrium, $\emptyset$ means a weak negative signal. The number of early adopters in the market $\beta$ determines the strength of this signal. In particular, the signal $\emptyset$ is weaker the smaller $\beta$, while more followers receive it.

The following lemma describes the WOM equilibria for each type prior distributions specified in Definition 1.

**Lemma 2 (WOM sub-game)** Suppose that the firm sets price $p$. There exist thresholds $\beta^{pos}(p)$, $\beta^{neg}(p)$ such that

1. With uninformed priors, a full WoM equilibrium always exists. A negative WoM equilibrium exists if and only if $\beta > \beta^{neg}(p)$ and a positive WoM equilibrium exists if and only if $\beta > \beta^{pos}(p)$. An equilibrium without WoM can never exist.

2. With optimistic priors, a negative WoM equilibrium always exists and a positive WoM equilibrium exists if and only if $\beta > \beta^{pos}(p)$. An equilibrium with full or without WoM can never exist.

3. With pessimistic priors, a positive WoM equilibrium always exists and a negative WoM equilibrium exists if and only if $\beta > \beta^{neg}(p)$. An equilibrium with full or without WoM can never exist.

4. With well-informed priors, an equilibrium without WoM always exists. A negative WoM equilibrium exists if and only if $\beta > \beta^{neg}(p)$ and a positive WoM equilibrium exists if and only if $\beta > \beta^{pos}(p)$. An equilibrium with full WoM can never exist.

The reader can refer to the Appendix for the proof. To see the intuition, recall that the early adopter wants to pay the cost of WOM only if he can affect the followers’ decision with a sufficiently high probability. Thus, with pessimistic priors, early adopters with a positive signal have a higher incentive to talk. Indeed, in that case, a positive WOM equilibrium always exists. Similarly, with optimistic priors a negative WOM equilibrium always exists. With well-informed priors, where a large proportion of followers cannot be influenced, an equilibrium without WOM always exists. Analogously, with uninformed priors, where a large proportion of followers can be convinced, a full WOM equilibrium always exists.

The intuition for the multiplicity of WOM equilibria for large $\beta$ is more subtle. With large $\beta$, in a positive WOM equilibrium, no WOM is a relatively strong negative signal about quality as discussed above. Thus, for instance, even with optimistic priors, early adopters who have received a negative signal can convey the negative information even without talking. A similar intuition applies to other prior distributions.
4.3 The firm’s pricing decision

Finally, we step back and consider the firm’s price setting decision. In the following, we characterize the pooling equilibrium in which the $H$-type firm maximizes its profits. Now, given any price $p$, Lemma 2 allows us to write down the induced demand functions faced by the firm. Let $\hat{\beta}^{\text{pos}}(\pi, \xi, \beta, p; \theta)$, $\hat{\beta}^{\text{neg}}(\pi, \xi, \beta, p; \theta)$, $\hat{\beta}^{\text{full}}(\pi, \xi, \beta, p; \theta)$, $\hat{\beta}^{\text{no}}(\pi, \xi, \beta, p; \theta)$ denote the demands faced by a firm of type $\theta \in \{L, H\}$ in an equilibrium with positive, negative, full, and no WoM, respectively:

$$
\hat{\beta}^{\text{pos}}(\pi_H, \pi_L, \xi, \beta, p; \theta) = (1 - \beta + \beta \cdot (1 - \pi_\theta)) (1 - F(\hat{\phi}(p; (1,0)))) + \beta \pi_\theta (1 - F(\phi(p))),
$$

$$
\hat{\beta}^{\text{neg}}(\pi_H, \pi_L, \xi, \beta, p; \theta) = (1 - \beta + \beta \pi_\theta) \cdot (1 - F(\hat{\phi}(p; (0,1)))) + \beta (1 - \pi_\theta) (1 - F(\hat{\phi}(p))),
$$

$$
\hat{\beta}^{\text{full}}(\pi_H, \pi_L, \xi, \beta, p; \theta) = \beta \cdot (\pi_\theta (1 - F(\phi(p))) + (1 - \pi_\theta) \cdot (1 - F(\hat{\phi}(p)))) + (1 - \beta) \cdot (1 - F(\Phi(p)))
$$

$$
\hat{\beta}^{\text{no}}(\pi_H, \pi_L, \xi, \beta, p; \theta) = 1 - F(\Phi(p)).
$$

(6)

A $H$-firm can affect with his pricing in which region the buyers’ beliefs fall, and thus which equilibria are being played in the WOM subgame according to Lemma 2. In the following, we consider two types of markets - one with homogeneous priors, and one with heterogeneous priors.

In what follows, we focus on the case of small $\beta$, i.e., a setting in which there is a small number of early adopters, as we are interested in thinking about word-of-mouth about new products. Moreover, the analysis in the limit for small $\beta$ yields a cleaner and intuitive equilibrium characterization.

4.3.1 Homogeneous priors among followers

First, we assume that all followers have the same prior belief $\gamma \in [0, 1]$, i.e., $F(\phi) = 1_{\{\phi \geq \gamma\}}$.

**Proposition 1** For a sufficiently small $\beta$, it is optimal for the $H$-type firm to induce a negative WOM equilibrium. If the prior $\gamma$ is in $\left[\frac{\pi_L}{\pi_L + \pi_H}, \frac{1}{2}\right]$, then the optimal price is given by $p^*(\beta) = p^{\text{pess}} = \frac{\gamma \pi_H^2 + (1 - \gamma) \pi_L^2}{\gamma \pi_H + (1 - \gamma) \pi_L}$, and negative WoM is induced with pessimistic priors. Otherwise, the optimal price is $p^*(\beta) = p^{\text{opt}} = \gamma \pi_H + (1 - \gamma) \pi_L < p^{\text{pess}}$.

The detailed proof can be found in the appendix. The intuition is as follows. Note that if all followers have the same belief, the $H$-type firm can always set a price such that all followers buy in the absence of any information. Can the firm improve upon this outcome? An $H$-firm would want to signal its quality to be able to charge a higher price: Note that this is possible only if followers can learn something about quality, specifically, they buy after “good news” and do not buy otherwise. So the $H$-type firm may want to induce some WoM.

In any equilibrium agents who have not tried the product end up sending a “no-news signal.” When $\beta$ is small, there are many agents who will send this no-news signal. However, the way the no-news signal is interpreted depends on the WoM equilibrium being played. In a positive WoM equilibrium, the no-news signal is “bad news” and so many people would end up receiving “bad news.” On the contrary, in a negative WoM equilibrium, the no-news signal is “good news” and
moreover, the $H$-type firm knows that it will generate little negative WoM. This allows the $H$-type firm to charge a higher price to a large fraction of followers and improve profits in a negative WoM equilibrium.

### 4.3.2 Heterogeneous priors among followers

Next, we consider the case of heterogeneous priors among followers. We assume that the prior beliefs of followers are uniformly distributed. The following result characterizes the profit maximizing price for the firm.

**Proposition 2** There exist thresholds $\xi$ and $\bar{\xi}$

$$\xi := \frac{\pi_H(\pi_H - 2\pi_L)}{2(\pi_H - \pi_L)(2 - \pi_H - 2\pi_L)}, \quad \bar{\xi} := \frac{\pi_H(\pi_H - 2\pi_L)}{2(\pi_H - \pi_L)(\pi_H + 2\pi_L)},$$

such that, for sufficiently small $\beta$, a $H$-firm sets a price $p^*(\beta)$ with $\lim_{\beta \to 0} p^*(\beta)$ such that a full WOM arises iff $\xi \leq \min\{\xi, \bar{\xi}\}$ and no WOM arises iff $\xi \geq \max\{\xi, \bar{\xi}\}$. Moreover,

- if $2\pi_L \geq 1 - \pi_H$, then $\bar{\xi} \geq \xi$ and for $\xi \in [\xi, \bar{\xi}]$ a negative WOM equilibrium is played,
- if $2\pi_L \leq 1 - \pi_H$, then $\bar{\xi} \leq \xi$ and for $\xi \in [\xi, \bar{\xi}]$ a positive WOM equilibrium is played.

The proof is the appendix. First notice that with heterogeneous priors, it is no longer the case that the $H$-type firm will always induce negative WoM. The type of WoM equilibria that arise now crucially depend on the information structure.

The intuition is as follows. Note that if all followers have the same belief, the $H$-type firm can always set a price such that all followers buy in the absence of any information. Can the firm improve upon this outcome? An $H$-firm would want to signal its quality to be able to charge a higher price. Note that this is possible only if followers can learn something about quality, specifically, they buy after “good news” and do not buy otherwise. So the $H$-type firm may want to induce some WoM.

In any equilibrium agents who have not tried the product end up sending a “no-news signal.” When $\beta$ is small, there are many agents who will send this no-news signal. However, the way the no-news signal is interpreted depends on the WoM equilibrium being played. In a positive WoM equilibrium, the no-news signal is “bad news” and so many people would end up receiving “bad news.” On the contrary, in a negative WoM equilibrium, the no-news signal is “good news” and moreover, the $H$-type firm knows that it will generate little negative WoM. This allows the $H$-type firm to charge a higher price to a large fraction of followers and improve profits in a negative WoM equilibrium.

To gain some intuition, let us consider two limiting cases.

Suppose that $\pi_L \approx 0$. This means that most consumers have a mediocre experience with the product, but if the firm is a high type, some consumers will have an exceptional experience. Put
differently, a positive signal is particularly informative since it fully reveals that the firm is a high type. This can be the case for books where the experience can be optimal only if one has the knowledge or mindset to fully appreciate it. In general, the case of $\pi_L \approx 0$ would apply to products where only a small fraction of people can fully appreciate the product, and bad quality is never valued. In such situations, negative WOM is never optimally induced by the firm, but positive WOM is induced for an intermediate range of costs of talking. Note that for $\pi_L = 0$ we have $\zeta = \frac{\pi_H}{2(2-\pi_H)} < \xi = \frac{1}{2}$ and $\xi$ is increasing in $\pi_H$. Thus, positive WOM is optimal for a wider range of costs if $\pi_H$ is also small.

Next, suppose that $\pi_H \approx 1$. This means that most consumers have a positive experience. Here, a negative signal is particularly informative. Hotels might fall into this category, in the sense that customers are happy as long as no major quality flaws such as cleanliness or bad service occur. In general, the case of $\pi_H \approx 1$ would apply to product categories where high quality is defined by consistency. In this case, we have $\zeta = \frac{1}{2(1-\pi_L)} > \xi = \frac{1-2\pi_L}{2(1+\pi_L-2\pi_L^2)}$ and $\bar{\xi} - \xi$ is increasing in $\pi_L$. Thus, negative WOM is optimal for a wider range of costs if $\pi_L$ is also large. In fact, it is optimal for any $\xi \in (0,1)$ if $\pi_L > 0.5$.

Also, note, that if $\pi_H < 2\pi_L$, then the firm induces no WOM independent of the cost of talking. Put differently, if the strength of the signal is not too strong it is not worth it for the firm to incentivize WOM. Furthermore, if the signal is close to symmetric, i.e., $\pi_L \approx 1 - \pi_H$, then the firm never implements positive WOM.

If followers have heterogeneous beliefs, then the signal structure determines whether more or fewer people see positive versus negative signals (levels of $\pi_H$ and $\pi_L$) and whether a good or a bad signal are a stronger news. For example, with $\pi_L \approx 0$, a positive signal is fully revealing and hence very informative, so an $H$-firm prefers a positive WoM equilibrium. In that case, only an $H$-firm can receive good signals and the higher $\pi_H$ the more WoM we should observe.

Similarly, with $\pi_H \approx 1$, a negative signal is fully revealing and informative, so an $H$-firm prefers a negative WoM equilibrium. At the same time it knows that all its early adopters will have a good experience and hence won't talk.

5 Empirical Evidence

5.1 Industry Background

Restaurants and hotels are experience goods and it is hard to ascertain their quality prior to trial (Nelson, 1970; Luca, 2016). Hence, many restaurant goers read online reviews prior to visiting a new restaurant. Several crowd-sourced review forums have become popular in recent times; most notably Yelp, OpenTable, Foursquare, Google and Facebook reviews. Yelp.com is one of the oldest

94 % of US diners are influenced by online reviews as per the Trip Advisor “Influences in Diner Decision-Making” survey 2018. BrightLocal’s 2017 Local Consumer Review Survey estimated this number at 97 %
platforms, established in 2005 that is now present in 31 countries with 177 million reviews and over 5 million unique businesses listed (Yelp Investor Relations Q4 2018). This platform contains reviews from a variety of local businesses like restaurants, shopping centers, hair stylists and salons. We use a stratified sample of Yelp.com restaurant reviews for empirically illustrating some of the propositions in this paper.

Restaurants are an ideal setting to study different types of word of mouth equilibria due to the wide variety of restaurant types and corresponding signal structures. Another characteristic of restaurants is that consistent with our model, in the early days, each restaurant has a small number of followers (small $\beta$) who try the product following which they can decide to either engage or not engage in word of mouth. The decision of followers to talk is a function of how good or bad their experience was as well as the price set by the restaurant. Many restaurant reviewers mention that one of the key reasons for writing a review is to simplify decision-making for people who want to visit a restaurant for the first time \(^{10}\) which is in line with our assumption that people get utility by convincing new adopters to try (not try) a restaurant if their experience was good (bad).

5.2 Restaurant Types and Prior Distributions

Restaurants can be mainly classified as chain and independent restaurants by ownership structure. National chain restaurants are franchisees that are affiliated to a large corporate chain (the franchiser). In such a franchiser-franchisee arrangement, typically the franchiser is responsible for high-level decisions like menu, pricing, branding and marketing whereas the franchisee handles day to day operations like procurement, staffing and customer management. Thus, other than employee service, such chains can ensure fairly uniform customer experience across stores. This results in extremely homogeneous priors or beliefs among customers for a new store from the same brand. Many of these restaurant chains have been established several decades ago (McDonald’s, Burger King and Pizza Hut are one of the oldest) and enjoy strong brand recognition due to the presence of large number of stores across the country and huge advertising spends. For instance, McDonald’s is known for fast service and good prices, Subway for reasonably-priced healthy food options and Starbucks for a great work atmosphere and consistent coffee blends. Table 1 summarizes the characteristics of these national chains.

We specifically look at the top 15 national chains by either sales volume or per store profitability(Statista.com). Chipotle Mexican Grill and Jimmy John’s are the only large chains established post 1980 and they also have the smallest store presence. Thus, these two brands are likely to have less homogeneous priors and majority of customers might be uninformed. There also exist some lesser-known chain restaurants whose national presence is limited and they have fewer stores. In spite of being chain restaurants, people may not have a very strong or homogeneous belief about

\(^{10}\)https://www.theverge.com/2018/4/10/17215784/whyd-you-push-that-button-yelp-tripadvisor-reviews-restaurant
Table 1: US national restaurant chains

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>N (stores in US)</th>
<th>Year of Est</th>
<th>Revenue (USD 1bn)</th>
<th>Ad Spend (USD mn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subway</td>
<td>Sandwich</td>
<td>25908</td>
<td>1965</td>
<td>11.3</td>
<td>486</td>
</tr>
<tr>
<td>McDonald’s</td>
<td>Sandwich</td>
<td>14027</td>
<td>1955</td>
<td>37.64</td>
<td>687</td>
</tr>
<tr>
<td>Starbucks</td>
<td>Coffee</td>
<td>13930</td>
<td>1971</td>
<td>17.65</td>
<td>NA</td>
</tr>
<tr>
<td>Dunkin’ Donuts</td>
<td>Coffee</td>
<td>12538</td>
<td>1950</td>
<td>8.46</td>
<td>143</td>
</tr>
<tr>
<td>Pizza Hut</td>
<td>Pizza</td>
<td>7522</td>
<td>1958</td>
<td>5.51</td>
<td>204</td>
</tr>
<tr>
<td>Burger King</td>
<td>Burger</td>
<td>7226</td>
<td>1953</td>
<td>9.65</td>
<td>341</td>
</tr>
<tr>
<td>Taco Bell</td>
<td>Tex-Mex</td>
<td>6446</td>
<td>1962</td>
<td>9.79</td>
<td>422</td>
</tr>
<tr>
<td>Wendy’s</td>
<td>Sandwich</td>
<td>5769</td>
<td>1969</td>
<td>9.31</td>
<td>258</td>
</tr>
<tr>
<td>Domino’s Pizza</td>
<td>Pizza</td>
<td>5587</td>
<td>1960</td>
<td>5.93</td>
<td>363</td>
</tr>
<tr>
<td>KFC</td>
<td>Chicken</td>
<td>4109</td>
<td>1952</td>
<td>NA</td>
<td>0</td>
</tr>
<tr>
<td>Arby’s</td>
<td>Sandwich</td>
<td>3415</td>
<td>1964</td>
<td>3.63</td>
<td>NA</td>
</tr>
<tr>
<td>Papa John’s Pizza</td>
<td>Pizza</td>
<td>3314</td>
<td>1984</td>
<td>1.78</td>
<td>72</td>
</tr>
<tr>
<td>Chipotle Mexican Grill</td>
<td>Tex-Mex</td>
<td>2364</td>
<td>1993</td>
<td>4.48</td>
<td>106.35</td>
</tr>
<tr>
<td>Chick-fil-A</td>
<td>Chicken</td>
<td>2100</td>
<td>1967</td>
<td>9</td>
<td>72</td>
</tr>
<tr>
<td>Jimmy John’s</td>
<td>Sandwich</td>
<td>2800</td>
<td>1983</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

The quality of these restaurants. Waffle House, Whataburger, Culver’s etc. are some examples for these lesser known chains. However, irrespective of these differences in the degree of heterogeneity in the priors, most chains are evaluated on consistently delivering brand promises. Also, due to extreme standardisation of products and services, there is high probability that a good chain store will meet expectations and deliver what is promised ($\pi_H \approx 1$).

Independent restaurants are single retailer set-ups or local chains that might have multiple branches within a focal city but no national presence. It is hard for newer and smaller establishments to create a consistent perception both due to lack of marketing budget and highly human-driven processes. Unlike chain restaurants, independent restaurants have more variations in the menu items served as well as pricing and service. As a result, consumers have a fairly heterogeneous prior distribution of beliefs with respect to the quality of these restaurants. When a new independent store opens, there will be a large population that is uninformed about these restaurants. Among independent restaurants, there are extremely high end pizza joints and Italian dinner places ($\pi_L \approx 0$) where it is unlikely that a bad restaurant can lead to a good experience. There are also relatively cheaper diners, delis and cafes that thrive mainly due to some unique food recipes (e.g. the town of New Haven in Connecticut has several family-owned pizzerias that are each known for a very special type of pizza). Table 2 graphically illustrates the prior beliefs and product types for different types of restaurants. To summarize, we would be looking at four types of restaurants—large chains with a national presence, newer national chains, lesser known local chains and completely independent restaurants.
Table 2: Types of Restaurants and distribution of Priors

<table>
<thead>
<tr>
<th>Consistency Product</th>
<th>Homogeneous Priors</th>
<th>Heterogeneous Priors</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi_H = 1$</td>
<td>Established Chains</td>
<td>Lesser Known Chains</td>
</tr>
<tr>
<td></td>
<td>$F = 1$</td>
<td>Waffle House, IHOP</td>
</tr>
<tr>
<td></td>
<td>Negative WOM</td>
<td>Negative WOM</td>
</tr>
<tr>
<td>Specialty Product</td>
<td>Established Chain</td>
<td>Independent Restaurants</td>
</tr>
<tr>
<td>$\pi_L = 0$</td>
<td>ruths cotswold</td>
<td>2018 Michelin Guide</td>
</tr>
<tr>
<td></td>
<td>Negative WOM</td>
<td>Positive WOM</td>
</tr>
</tbody>
</table>

5.3 Summary Statistics

We use the dataset from Yelp Dataset Challenge 2017 that has business, review and reviewer information for several US and some international cities between the years 2008-2017. We focus on cities in US and Canada — majorly Pittsburgh, Cleveland, Las Vegas, Phoenix and Charlotte since these were some of the early cities in which the platform was launched and hence have a high Yelp coverage. By name matching the top 15 chain restaurants in US, we get a sample of 3408 national chain stores and 2548 local/lesser known chain stores in these 5 cities. Most of the big chains are sandwich, pizza, burger joints and coffee houses. To ensure fair comparison, we chose independent restaurants serving cuisine similar to chains again by name-matching on “sandwich”, “pizza”, “burger”, “deli” and “coffee” categories. This gives us a list of 6299 independent restaurants in the same neighborhoods as the bigger chains. Among the independent restaurants, we have a mix of both low-end establishments like delis as well as some high-end pizza and sandwich stores. Table 3 summarizes the stratified data sample that we use for this analysis.

Table 3: Stratified Sample from Yelp.com

<table>
<thead>
<tr>
<th>Type of Restaurant</th>
<th>Example Business</th>
<th>Reviews(Yr1)</th>
<th>Reviews(All)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Independent Restaurants</td>
<td>Independent Stores</td>
<td>6299</td>
<td>609032</td>
</tr>
<tr>
<td>Established National Chains</td>
<td>Subway, Pizza Hut</td>
<td>3408</td>
<td>8512</td>
</tr>
<tr>
<td>New National Chains</td>
<td>Chipotle, Jimmy John’s</td>
<td>205</td>
<td>1623</td>
</tr>
<tr>
<td>Lesser Known Chains</td>
<td>iHop, Culver’s</td>
<td>2548</td>
<td>12347</td>
</tr>
<tr>
<td>N</td>
<td>12460</td>
<td>91514</td>
<td>426425</td>
</tr>
</tbody>
</table>

Since we are mainly interested in studying word of mouth evolution for new products, we analyze

---

11 Yelp.com does not classify restaurants as chains versus independent restaurants. We identify the national chains by name matching. Other chains get identified due to the fact that a chain typically has multiple stores in different cities.
the two cases separately—word of mouth generated in the first year of a restaurant’s launch and that generated over its entire lifetime. The lifetime of a restaurant is the time period since its first review on Yelp.com till the date of the last review or the year 2017 as our review dataset is from 2005-2017. The left graph in Fig 2 shows the trend of restaurant launch, exit and survival. In the earlier years of platform growth (2006-2011), many new restaurants are listed on Yelp.com. Few restaurants exit or stop receiving reviews but this number is small compared to the restaurants that continue to remain active. In order to understand how word of mouth evolves over the lifetime of restaurants, we segregate restaurants by cohort (based on year of listing), i.e., every cohort has restaurants listed in the same year. The left graph in Fig 2 shows the declining trend of reviews as time passes from restaurant start date aggregated over 1311 restaurants from the cohort of 2013.

We can see that the first few months from a restaurant’s launch date are a period of intense word of mouth activity after which there is a sudden drop. This drop is not merely due to the exit of bad restaurants — 101(8%) restaurants stop receiving reviews after the first year, 108 of surviving restaurants after the second year and 205(17%) after three years of platform existence.

5.4 Supporting Evidence from Data

Fact 1: Chain restaurants of all types (established, new or lesser known) on an average receive more negative reviews as compared to independent restaurants serving the same cuisine. This is also true for chain restaurants who have had repeatedly ranked higher on customer satisfaction by American Customer Satisfaction Index Survey (ACSI). Also, many of these chains have continued to show

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12 We do not observe restaurant launch and exit directly but observe the date of the first last review posted. The graphs are similar for other cohorts (e.g., restaurants starting in 2011,12,14 but we use 2013 as an illustration).

13 The American Customer Satisfaction Index (ACSI) measures the satisfaction of U.S. household consumers with the quality of products and services by surveying roughly 300,000 consumers—https://www.theacsi.org/about-acsi
Figure 3: Chains versus Independent Restaurants

Figure 3 shows the distribution of reviews for chain and independent restaurants in the dataset. Independent restaurants have overwhelmingly positive reviews (mostly four or five stars) whereas chain restaurants have a large number of negative reviews. Table 4 show the differences in average review rating, total reviews written per restaurant, survival (for how many months restaurants continue to receive reviews), share of positive and negative reviews for different types of chains and independent restaurants. The mean average rating for established chains is 1 point lower than independent restaurants in the first year of existence. Also, they receive much lesser reviews. These trends continue over time and the reviews for chains become more and more negative over their lifetime. This can be attributed to the homogeneous and mostly optimistic priors of customers for established chain restaurants. In such a situation, people by default chose to purchase unless they receive bad news. Hence, a small group of early adopters with negative experience chose to talk (as they care about influencing followers). However, followers know that there are many other adopters who have tried the product but remain silent when expectations are met. In other words, in a negative word of mouth equilibrium, this absence of signal is interpreted as "good news".

Fact 2: Prominent surveys like American Consumer Survey Index (ACSI) have reported an increasing customer satisfaction with respect to fast-food restaurant chains. Many of them have made sizeable investments in technology and human resources for e.g. Pizza Hut. These efforts get reflected in ACSI surveys (Pizza Hut gains 5 percentage points in 2017). However, review websites continue to see lower ratings for new stores from these brands over time. Figure 4 graphically illustrates this trend.

Fact 3: Lesser known chains — that are new or have smaller number of stores (e.g. Chick-fil-A, El Pollo Loco, Famous Dave etc.) have a larger proportion of positive reviews (compared to}

14 These differences in the means of the two groups are statistically significant at a level of 5 percent (ANOVA)
Table 4: WOM equilibrium by Restaurant Type

<table>
<thead>
<tr>
<th>Time frame</th>
<th>Restaurant Type</th>
<th>Overall Rating</th>
<th>Total Reviews</th>
<th>Survival</th>
<th>Share PWOM</th>
<th>Share NWOM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Independent</td>
<td>3.7</td>
<td>11.3</td>
<td>0.6</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Year 1</td>
<td>(0.9)</td>
<td>(27.6)</td>
<td>(0.4)</td>
<td>(0.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Established Chains</td>
<td>2.7</td>
<td>2.7</td>
<td>0.3</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>(1.2)</td>
<td>(2.7)</td>
<td>(0.4)</td>
<td>(0.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lesser Known Chains</td>
<td>3.1</td>
<td>5.3</td>
<td>0.4</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>(1.0)</td>
<td>(18.6)</td>
<td>(0.4)</td>
<td>(0.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lifetime</td>
<td>Independent</td>
<td>3.6</td>
<td>54.1</td>
<td>52.0</td>
<td>0.6</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>(0.8)</td>
<td>(144.3)</td>
<td>(36.8)</td>
<td>(0.3)</td>
<td>(0.2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Established Chains</td>
<td>2.4</td>
<td>12.1</td>
<td>53.0</td>
<td>0.3</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>(0.8)</td>
<td>(11.9)</td>
<td>(29.2)</td>
<td>(0.3)</td>
<td>(0.3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lesser Known Chains</td>
<td>2.8</td>
<td>33.0</td>
<td>63.0</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>(0.7)</td>
<td>(57.1)</td>
<td>(34.7)</td>
<td>(0.2)</td>
<td>(0.2)</td>
<td></td>
</tr>
</tbody>
</table>

Figure 4: Ratings of new stores for chains over time
established chains) and the unknown, independent restaurants have the best ratings on Yelp.com
Fig 5 shows the distribution of rating for the four types of restaurants we study - established
national chains, lesser known chains, new national chains and independent restaurants. We can
see that the share of positive reviews increases as we move from established chains to lesser known
one’s and finally to independent restaurants. This can be attributed to the increasing heterogeneity
in prior beliefs. Further, the new chains as well as independent restaurants thrive mainly due to
some ”special offering” - great recipe, unique ambiance. In other words, people are delighted by
these restaurants resulting in more positive reviews. On the other hand, the main proposition of
large established brands is standardisation and consistency. This leads to more negative reviews.
Fig 6 shows some anecdotal evidence of how reviews for consistency restaurants differ from those
of delight restaurants. Fig 7(a) is a review from Pizza hut and the reviewer is disappointed because
there was a mistake in making the pizza. Clearly, reviewers for these restaurants only care about
getting a consistent product that meet expectations. Reviewers of independent restaurants, however,
care about positive surprises and specialty items and that is reflected in the reviews.

6 Conclusion

In this paper, we propose a game theoretic model to understand what leads to positive and negative
word of mouth in online reviews. We show that average reviews are misleading and do not always
reflect quality. Good restaurants can have bad reviews arising out of a combination of prior beliefs
(homogeneous or heterogeneous) and the type of product or service (consistency versus specialty
product). We check consistency of model predictions with Yelp.com restaurant reviews and find
that established chain restaurants receive overwhelmingly 1 or 2 star reviews whereas independent
restaurants receive mostly 4 or 5 stars. We also find significant differences by type of chain-
established or lesser known.
Figure 6: Consistency versus Delight Restaurant Reviews

(a) Established Chains

(b) Independent Restaurant

References


Bramoullé, Yann, Andrea Galeotti, Brian Rogers, and Dina Mayzlin, “Managing Social Interactions.”


A Appendix

Proof. (Lemma 2) Let $\beta_1^{\text{neg}}(p)$ be the smallest $\beta$ such that a follower with a positive signal does not want to talk in a negative WOM equilibrium

$$
\beta_1^{\text{neg}}(p) = \min\{1, \inf \left\{ \beta : F(\hat{\phi}(p; (0, 1))) - F(\hat{\phi}(p)) \leq \frac{c}{r} \right\} \}.
$$

and $\beta_2^{\text{neg}}(p)$ be the smallest $\beta$ such that a follower with a negative signal wants to talk in a negative WOM equilibrium

$$
\beta_2^{\text{neg}}(p) = \min\{1, \inf \left\{ \beta : F(\hat{\phi}(p)) - F(\hat{\phi}(p; (0, 1))) \geq \frac{c}{r} \right\} \}.
$$

Let $\beta^{\text{neg}}(p) = \max\{\beta_1^{\text{neg}}(p), \beta_2^{\text{neg}}(p)\}$, so that a negative WOM equilibrium can exist if and only if $\beta > \beta^{\text{neg}}(p)$. Similarly, let $\beta_1^{\text{pos}}(p)$ be the $\beta$ such that a follower with a negative signal does not want to talk in a positive WOM equilibrium

$$
\beta_1^{\text{pos}}(p) = \min\{1, \inf \left\{ \beta : F(\hat{\phi}(p)) - F(\hat{\phi}(p; (0, 1))) \leq \frac{c}{r} \right\} \}
$$

and let $\beta_2^{\text{pos}}$ be the smallest $\beta$ such that a follower with a positive signal wants to talk in a positive WOM equilibrium

$$
\beta_2^{\text{pos}}(p) = \min\{1, \inf \left\{ \beta : F(\hat{\phi}(p; (0, 1))) - F(\hat{\phi}(p)) \geq \frac{c}{r} \right\} \}.
$$

Let $\beta^{\text{pos}}(p) = \max\{\beta_1^{\text{pos}}(p), \beta_2^{\text{pos}}(p)\}$, so that a positive WOM equilibrium can exist if and only if $\beta > \beta^{\text{pos}}(p)$.

Note that $\hat{\phi}(0, 1)$ is decreasing in $\beta$ and $\hat{\phi}(1, 0)$ is increasing in $\beta$. Hence, the existence of different types of equilibria follows from the fact that in a negative WoM equilibrium $\Phi(p) \geq \hat{\phi}(p; (0, 1))$, in a positive WoM equilibrium $\Phi(p) \leq \hat{\phi}(p; (1, 0))$ and in full and no WoM equilibria $\Phi(p) = \hat{\phi}(p; (1, 1)) = \hat{\phi}(p; (0, 0))$.

Proof. (Proposition 1) Using Lemma 2 and the demand functions derived in (6) we know the following:

1. If $\gamma < \phi(p)$, then $F(\phi(p)) = F(\hat{\phi}(p)) = F(\Phi(p)) = 1$, i.e., adopters are well-informed. In the unique equilibrium, no one talks. Profits are zero.

2. If $\phi(p) < \gamma < \Phi(p)$, then $F(\phi(p)) = 0 < F(\Phi(p)) = F(\hat{\phi}(p)) = 1$, i.e., adopters have pessimistic priors. There exists a positive WoM equilibrium and profits are given by

$$
W(p, \pi_H, \pi_L, \xi, \beta; \theta) \equiv p \cdot \beta^{\text{pos}}(p, \pi_H, \pi_L, \xi, \beta; \theta) = p \cdot \beta \pi_0.
$$
A negative WoM equilibrium exists if and only if \( \beta > \frac{1-2\gamma}{(1-\gamma)(1-\pi_L) - \gamma(1-\pi_H)} \). Then, profits are given by
\[
W^u(\pi_H, \pi_L, \xi, \beta, p; \theta) \equiv p \cdot \hat{\beta}^{\text{neg}}(\pi_H, \pi_L, \xi, \beta, p; \theta) = p \cdot (1 - \beta + \beta \pi_\theta).
\]

3. If \( \Phi(p) < \gamma < \bar{\phi}(p) \), then \( F(\bar{\phi}(p)) = F(\Phi(p)) = 0 < F(\hat{\phi}(p)) = 1 \), i.e., adopters have optimistic priors. A negative WoM equilibrium exists and profits are given by
\[
W^u(\pi_H, \pi_L, \xi, \beta, p; \theta) \equiv p \cdot \hat{\beta}^{\text{neg}}(\pi_H, \pi_L, \xi, \beta, p; \theta) = p \cdot (1 - \beta + \beta \pi_\theta).
\]
A positive WoM equilibrium exists in addition if and only if \( \beta > \frac{1-2\gamma}{(1-\gamma)\pi_L - \gamma \pi_H} \). Then, profits are given by
\[
W^u(\pi_H, \pi_L, \xi, \beta, p; \theta) = p \cdot \beta \pi_\theta.
\]

4. If \( \gamma > \bar{\phi}(p) \), then \( F(\bar{\phi}(p)) = F(\Phi(p)) = F(\hat{\phi}(p)) = 0 \), i.e., adopters are well-informed and in the unique equilibrium no one talks. Profits are equal to \( p \).

Notice that for \( \beta \) close to 0 the profits under a positive WoM equilibria given by \( p \cdot \beta \pi_\theta \) are also close to zero, regardless of the price. Therefore, to maximize profit we need only compare negative WoM equilibria and no WoM equilibria which yield profits that are bounded away from zero. Negative WoM equilibria can arise under optimistic priors and under pessimistic if \( \beta > \frac{1-2\gamma}{(1-\gamma)\pi_L - \gamma \pi_H} \). Let \( p^{\text{pess}} \) denote the largest price that induces pessimistic priors. It is defined implicitly by \( \gamma = \bar{\phi}(p^{\text{pess}}) \) or
\[
p^{\text{pess}} = \frac{\gamma \pi_H^2 + (1-\gamma)\pi_L^2}{\gamma \pi_H + (1-\gamma)\pi_L}.
\]
Similarly, let \( p^{\text{opt}} \) be the largest price such that the prior is optimistic: \( \gamma = \Phi(p^{\text{opt}}) \) or
\[
p^{\text{opt}} = \gamma \pi_H + (1-\gamma)\pi_L
\]
and let \( p^{\text{well-informed}} \) be the largest price such that the prior is well-informed: \( \gamma = \hat{\phi}(p^{\text{well-informed}}) \) or
\[
p^{\text{well-informed}} = \frac{\gamma \pi_H (1 - \pi_H) + (1-\gamma)\pi_L (1-\pi_L)}{\gamma (1 - \pi_H) + (1-\gamma)(1 - \pi_L)}.
\]
Note that \( p^{\text{opt}} > p^{\text{well-informed}} \). For \( \beta \) sufficiently small, the profit under any no WoM equilibria is bounded above by \( p^{\text{well-informed}} \), which is lower than the profit under a negative WoM equilibrium with price \( p^{\text{opt}} \), given by \( p^{\text{opt}} \cdot (1 - \beta + \beta \pi_\theta) \). So, we need to consider two cases.

Case (i) \( \gamma \in \left[ \frac{\pi_L}{\pi_L + \pi_H}, \frac{1}{2} \right] \) (i.e., when \( \frac{1-2\gamma}{(1-\gamma)\pi_L - \gamma \pi_H} < 0 \)): Negative WoM can be sustained both under pessimistic and optimistic priors, for all \( \beta \). \( p^{\text{pess}} > p^{\text{opt}} \) because \( x \mapsto x^2 \) is convex. In
this case, the profit maximizing price is \( p^*(\beta) = p^{\text{pess}} = \frac{\gamma \pi_H^2 + (1-\gamma)\pi_L^2}{\gamma \pi_H + (1-\gamma)\pi_L} \), and negative WoM is induced with pessimistic priors.

Case (ii) \( \gamma \not\in \left[ \frac{\pi_L}{\pi_L + \pi_H}, \frac{1}{2} \right] \): Negative WoM can be sustained only under optimistic priors. In this case, the profit maximizing equilibrium involves setting price \( p^*(\beta) = p^{\text{opt}} = \gamma \pi_H + (1-\gamma)\pi_L \) and inducing negative WoM with optimistic priors.

**Proof.** Proposition 2 Recall the thresholds we used to categorize prior distributions in Definition 1. Note that for the uniform distribution, \( F \) is the identity function. Given \( \xi \), any price \( p \) determines whether a prior distribution is optimistic, pessimistic, uninformed or well-informed. It is useful to define the following price thresholds, given \( \xi \). Whenever solutions exist, \( p_1 \leq p_2 \) are solutions to the quadratic equality

\[
\Phi(p) - \Phi(p) = \xi
\]

and \( p_1 \leq p_2 \) are solutions to the quadratic equality

\[
\Phi(p) - \phi(p) = \xi.
\]

Then, we have \( \xi < \Phi(p) - \Phi(p) \) iff \( p \in (p_1, p_2) \) and \( \xi < \Phi(p) - \phi(p) \) iff \( p \in (p_1, p_2) \). We want to understand whether the profit maximizing price lies in \( (p_1, p_2) \) and / or in \( (p_1, p_2) \). As \( \beta \to 0 \), the profit of the \( H \)-type firm in all equilibria converges to \( p(1 - \Phi(p)) \) which is maximized at \( p^* = \frac{\pi_H}{2} \).

Consequently, it is sufficient to understand the sign of \( p_1 - \frac{\pi_H}{2}, p_2 - \frac{\pi_H}{2}, p_1 - \frac{\pi_H}{2}, p_2 - \frac{\pi_H}{2} \), which are given by

\[
\begin{align*}
\bar{p}_1 - \frac{\pi_H}{2} &= \frac{1}{2} \left( -\sqrt{\pi_H - \pi_L} (\xi^2 (\pi_H - \pi_L) + 2\xi (\pi_H + \pi_L - 2) + \pi_H - \pi_L) + \xi (\pi_L - \pi_H) + \pi_L \right) =: \bar{f}_1(\xi) \\
\bar{p}_2 - \frac{\pi_H}{2} &= \frac{1}{2} \left( \sqrt{\pi_H - \pi_L} (\xi^2 (\pi_H - \pi_L) + 2\xi (\pi_H + \pi_L - 2) + \pi_H - \pi_L) + \xi (\pi_L - \pi_H) + \pi_L \right) =: \bar{f}_2(\xi) \\
\underline{p}_1 - \frac{\pi_H}{2} &= \frac{1}{2} \left( -\sqrt{-2 (\xi^2 + 1) \pi_H \pi_L + (\xi - 1)^2 \pi_H^2 + (\xi + 1)^2 \pi_L^2 + c(\pi_L - \pi_H) + \pi_L} \right) =: \underline{f}_1(\xi) \\
\underline{p}_2 - \frac{\pi_H}{2} &= \frac{1}{2} \left( \sqrt{-2 (\xi^2 + 1) \pi_H \pi_L + (\xi - 1)^2 \pi_H^2 + (\xi + 1)^2 \pi_L^2 + c(\pi_L - \pi_H) + \pi_L} \right) =: \underline{f}_2(\xi).
\end{align*}
\]

Figure 7 depicts these four functions. \( \frac{\pi_H}{2} \) lies in the interval \( (\bar{p}_1, p_2) \) if and only if \( \bar{f}_1(\xi) \leq 0 \) and \( \bar{f}_2(\xi) \geq 0 \). Analogously, \( \frac{\pi_H}{2} \) lies in the interval \( (\underline{p}_1, p_2) \) if and only if \( \underline{f}_1(\xi) \leq 0 \) and \( \underline{f}_2(\xi) \geq 0 \). It is straightforward to show that \( \bar{f}_1 \) and \( \underline{f}_1 \) are increasing in \( \xi \) and \( \bar{f}_2 \) and \( \underline{f}_2 \) are decreasing in \( \xi \). It is
convenient to consider the following inverse functions.

\[ f_1^{-1}(y) = \frac{(2y - \pi_H)(2y + \pi_H - 2\pi_L)}{2(\pi_H - \pi_L)(\pi_H + 2\pi_L - 2 - 2y)} \]

\[ f_2^{-1}(y) = \frac{(2y - \pi_H)(2y + \pi_H - 2\pi_L)}{2(\pi_H - \pi_L)(\pi_H + 2\pi_L - 2 - 2y)} \]

\[ f_3^{-1}(y) = \frac{(2y - \pi_H)(2y + \pi_H - 2\pi_L)}{2(\pi_H - \pi_L)(2y - \pi_H - 2\pi_L)} \]

\[ f_4^{-1}(y) = \frac{(2y - \pi_H)(2y + \pi_H - 2\pi_L)}{2(\pi_H - \pi_L)(2y - \pi_H - 2\pi_L)} \]

Notice that \( f_1^{-1}(y) \) and \( f_2^{-1}(y) \) are exactly the same expression, though defined on non-overlapping domains, and similarly \( f_3^{-1}(y) \) and \( f_4^{-1}(y) \) are exactly the same expression, again on non-overlapping domains. Further, \( f_1^{-1}(y) \) is increasing in \( y \) in the relevant domain and \( f_2^{-1}(y) \) is decreasing. Similarly, \( f_3^{-1}(y) \) is increasing and \( f_4^{-1}(y) \) is decreasing on their respective domains. Hence, there exist thresholds \( \xi \) and \( \xi \) defined by

\[ \xi = \frac{\pi_H(\pi_H - 2\pi_L)}{2(\pi_H - \pi_L)(2 - \pi_H - 2\pi_L)}, \quad \xi = \frac{\pi_H(\pi_H - 2\pi_L)}{2(\pi_H - \pi_L)(\pi_H + 2\pi_L)} \]

such that \( \xi < \xi \) if and only if \( \frac{\pi_H}{2} \in (p_1, p_2) \) and \( \xi < \xi \) if and only if \( \frac{\pi_H}{2} \in (p_1, p_2) \). Furthermore, \( \xi > \xi \) if and only if \( 1 - \pi_H < 2\pi_L \). These thresholds are obtained by simply evaluating the relevant inverse functions at \( y = 0 \). Recall that \( \xi < \phi \left( \frac{\pi_H}{2} \right) - \Phi \left( \frac{\pi_H}{2} \right) \) iff \( \frac{\pi_H}{2} \in (p_1, p_2) \) and \( \xi < \Phi \left( \frac{\pi_H}{2} \right) - \phi \left( \frac{\pi_H}{2} \right) \) iff \( \frac{\pi_H}{2} \in (p_1, p_2) \). This observation and Lemma 2 concludes the proof.

\[ \square \]
Figure 8: Determination of belief regions for $\pi_L = 0.2$, $\pi_H = 0.8$