

## THE DYNAMICS OF ONLINE CONSUMER REVIEWS

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### 1. Introduction

The significance of online consumer reviews has been increasingly acknowledged by both practitioners and researchers. These reviews are commonly used by consumers as a proxy for product quality in making purchase decisions. An implicit assumption behind their use is that the review ratings reflect consumers' private evaluations of product quality. In this paper, we question this underlying assumption. Specifically, we examine the formation of consumer ratings, and how a consumer rating is influenced by public opinions such as consensus ratings, recent consumer ratings and professional ratings. We develop a statistical model that allows consumer reviews to be influenced by both private evaluation and public opinion. We empirically test the model using data from CNET.com and find that consumer reviews are heavily influenced by public opinions. Our study is one of the first to examine the dynamics of online consumer reviews and show that online consumer reviews exhibits remarkable community features.

Given the importance of online consumer reviews, there has been an emerging group of studies to examine the association between online consumer reviews and sales (e.g., Godes and Mayzlin 2003, Dellarocas, Awad and Zhang 2004; Li and Hitt 2004; Clemons, Gao and Hitt 2006). These papers largely consider consumer reviews as given and focus on understanding how they influence product sales. Up until now, we have a very limited understanding on how online consumer reviews are generated in the first place and what factors influence the ratings (Dellarocas and Narayan 2006, Hu and Zhang 2006). This lack of understanding has prevented us from constructing better metrics to associate reviews to sales, designing websites to better facilitate knowledge sharing among consumers, and helping firms benefit from online consumer reviews (Chen and Xie 2004).

This research intends to fill the void by examining the dynamics of online consumer review itself. One noticeable characteristic is that online consumer reviews are an extension of word-of-mouth phenomenon where consumers influence each other in forming and disseminating their opinions. As such, a consumer's online review is influenced by not only his own opinions, but public opinions as well. In this study, we examine the following two questions:

- (1) How do public opinions such as consensus ratings, existing consumer reviews and professional reviews influence consumer reviews?
- (2) Do public opinions crowd out consumers' use of their private information?

Our contribution to the IS literature is three-folded. First, we develop a statistical model that allows us to identify the impact of various public opinions on consumer reviews. Second, we offer a way to measure the impact of public opinions on consumers' use of their private information. Third, we highlight the importance of studying the dynamic structure of online consumer reviews.

### 2. Literature

Because of its economic importance (Avery, Resnick and Zeckhauser, 1999), there has been an emerging literature on online consumer reviews, and most focus on the relationship between consumer ratings and sales. Chen and Xie (2004) construct an analytical model on how this new information channel influences a monopoly's sales. Godes and Mayzline (2004) use newsgroups as a measure of word-of-mouth to study TV show ratings. Dellarocas, Awad and Zhang (2004) find that online reviews of movies can be a good proxy for word-of-mouth and can be useful in revenue forecasting. Chevalier and Mayzlin (2006) find that improvement in a book's average ratings leads to an increase in relative sales at that site. In contrast, Chen and Wu (2004) and Duan et al (2005) do not find average ratings to be significantly related to sales, but that the recommendations

and number of ratings have significant impact on sales. Dellarocas (2003) provides an overview of different kinds of online feedback mechanisms.

Recently, scholars are paying more attention to the nature of online consumer review itself. Li and Hitt (2004) find that online ratings for a product decrease over time, suggesting self-selection of reviewers. Dellarocas and Narayan (2006) examine what motivates consumers to post reviews for different kinds of movies. They found that most consumers rate movies very high or very low, resulting in a bimodal, U-shaped histogram. By contrast, critic ratings are distributed as uni-modal. Hu and Zhang (2006) find that most online reviews on Amazon.com are distributed bimodally and provide conditions under which these ratings will converge to the real product quality. Overall above findings based on movie, books and CD are consistent with the findings of Anderson (Anderson, 1998), who developed a utility-based model for the relationship between customer satisfaction and their engagement in word-of-mouth activities, and suggested a U-curve distribution function of consumer opinions.

While these studies focus on consumers' motivation to provide product reviews, they often assume that the reviews provided reflect consumers' private evaluation of products. In contrast, this paper shows that the reviews provided do not necessarily reflect consumers' private information. They are heavily influenced by public opinions.

### 3. Methodology

We propose a statistical model to describe consumer reviews influenced by both private evaluation and public opinions. We assume that the private evaluation of product  $j$  for consumer who arrives at time  $t$  is uncertain and follows a normal distribution of  $N(a_j, \sigma_j)$ . The mean of the distribution  $a_j$  represents the inherent quality of product  $j$  and  $\sigma_j$  captures uncertainty in the consumer's assessment of product quality. The private evaluation can be expressed as  $a_j + \varepsilon_{jt}$ . Prior literature generally assumes that consumers report their private observation in product reviews. We extend this approach by explicitly modeling the formation process of consumer reviews. We assume that consumer reviews are determined not only by a consumer's private observation of product quality, but also by reviews from other sources. We consider three outside sources in our model: community consensus, immediate prior reviews and professional reviews.

1. Community Consensus. Community consensus reflects the overall consumer rating for a product. Consensuses are prominently highlighted in product pages and are typically calculated as the arithmetic average of total consumer ratings for the product. Community consensus changes over time as individual consumer reviews influence the arithmetic average and thus the community consensus. We denote the most recent consumer consensus for product  $j$  observed by a consumer arriving at time  $t$  as  $cc_{jt-1}$ .

2. Prior Consumer Ratings. Consumers pay attention not only to the community consensus, but also to other consumers' rating as well. While a consumer rarely has opportunity to read substantial number of reviews from other consumers, they often pay attention to the most recent reviews that are listed at the top of the review page. To model the influence of reviews from fellow consumers, we denote the most recent review for product  $j$  observed by a consumer arriving at time  $t$  as  $cr_{jt-1}$ .

3. Professional Reviews. Finally, consumers are influenced by professional reviews. The professional reviews are provided by experts who have substantial knowledge in evaluating products. Professional reviews are not provided for every product. Only a selective group of products are evaluated by professionals. We denote the professional review of product  $j$  as  $er_j$ .

To model the influence of these factors on reported consumer ratings, we assume that each consumer is Bayesian rational and uses a weighted average approach to aggregate private information and public opinions. Specifically, when there is no professional rating for the product, the reported consumer rating for product  $j$  by a consumer who arrives at time  $t$  takes the following form:

$$cr_{jt} = \chi_1(a_j + \varepsilon_t) + \chi_2 cc_{jt-1} + \chi_3 cr_{jt-1} \quad (1)$$

$\chi_1$  in the above equation represents the weight of private evaluation on consumer reviews.  $\chi_2$ , and  $\chi_3$  stand for the influence of public opinions. On the other hand, if there is professional review for the product, the reported consumer rating takes the following form:

$$cr_{jt} = \beta_1(a_j + \varepsilon_t) + \beta_2 cc_{j,t-1} + \beta_3 cr_{j,t-1} + \beta_4 er_j \quad (2)$$

where  $\beta_s$  represents the influence of various information sources. Estimation of equations (1) and (2) however presents two challenges. First, we do not observe consumer private evaluations or the inherent product quality  $a_j$ . To address this problem, we introduce product fixed effects into the equation. Second, the use of fixed effects makes it impossible to identify the influence of professional reviews because professional reviews are time-invariant for each product. Therefore, the effect of professional rating will be captured by the fixed effect. One innovation of the paper is that we solve the identification problem by noting that professional reviews generally lag consumer reviews. On average, professional reviews are provided 6 months after product introductions. This lag creates a variability in the influenced of professional reviews that makes equation (2) identifiable. Specifically, we introduce a dummy variable  $p_t$  for the introduction of professional review and combine (1) and (2) into the following model:

$$cr_{jt} = \chi_1 a_j + (\beta_1 - \chi_1) a_j^* p_t + \chi_2 cc_{j,t-1} + (\beta_2 - \chi_2) cc_{j,t-1}^* p_t + \chi_3 cr_{j,t-1} + (\beta_3 - \chi_3) cr_{j,t-1}^* p_t + \beta_4 er_j^* p_t + \xi_{jt} \quad (3)$$

In the above equation,  $\chi_1$ ,  $\chi_2$ , and  $\chi_3$  measure the weights that consumers assign to private evaluations and public opinions prior to the introduction of professional reviews.  $(\beta_1 - \chi_1)$ ,  $(\beta_2 - \chi_2)$  and  $(\beta_3 - \chi_3)$  measure how consumers change their weights after the introduction of professional reviews.  $\beta_4$  capture the weight consumers assign to professional reviews once it is available. We also note that  $\xi_{jt}$  follows a normal distribution of  $N(0, \chi_1 \sigma_j)$  before the introduction of professional reviews and  $N(0, \beta_1 \sigma_j)$  afterwards. This indicates heteroscedacity in the model.

#### 4. Hypotheses

The objective of the paper is to assess two questions: 1) how public opinions affect online consumer reviews and 2) how does the introduction of one type of public opinion affect consumer use of his private information and other public options. A number of theories have been proposed with regard to factors influencing consumer opinions. In general, whenever a consumer has uncertain private information, she is likely to be influenced by others because their opinions contain new information. For example, Bikhchandani, Hirshleifer and Welch (1992) proposed an economic model of informational cascading and show that in some cases individuals may discard their own private signals to follow others, which produces conformity and herding behavior. Similar phenomena are also studied by social psychologists, the most famous of which is the experiment conducted by Asch (1951), where it was shown that group pressure can and did affect the judgment of individuals.

Given the extensive studies showing the influence of public opinions, we propose the following hypotheses:

*H1: Consumer reviews are influenced by public opinions. Specifically, consumer reviews are influenced by community consensus, recent consumer reviews and professional reviews.*

H1 suggests that consumers put positive weights on the three types of public opinions studied in this paper. Empirically, the hypothesis indicates that the coefficients  $\chi_2$ ,  $\chi_3$  and  $\beta_4$  are positive and significant.

Now we consider the impact of introducing a new source of public opinions. Clearly, public opinions are substitutes for other public opinions, although they are not necessarily perfect substitutes. Moreover, a new source of public opinions carries new information. As a result, it reduces the value of private information for rational consumers. We therefore propose

*H2: The introduction of a new source of public opinions influences a consumer's use of his private information and the impact of other public opinions. Specifically, the introduction of professional review reduces the impact of a consumer's private information, community consensus and recent consumer reviews.*

This hypothesis indicates that after the introduction of professional reviews, consumers will reduce their weights on private information, community consensus and other consumer reviews. That is, the coefficients  $(\beta_1 - \chi_1)$ ,  $(\beta_2 - \chi_2)$  and  $(\beta_3 - \chi_3)$  will all be negative.

## 5. Data

We used CNET.com as our context for analyzing online product reviews. CNET was established in the mid-1990s, and it provides editor and user opinions to help consumers make informed decisions about technology products. Being one of the most popular online review websites, CNET has a huge audience. In March 2006 alone, CNET has 28.9 million unique US visitors. In addition to its influence, CNET has some features that make it a neat data source for testing our hypotheses.

First, CNET has a vast scope of products thus providing a different setting than what was done in prior research. Altogether there are over 173 categories. Table 1 provides a sample of major categories. Earlier studies on consumer reviews have concentrated on TV shows, movies, books and CDs. Our dataset includes all products listed on CNET, which cover automobiles, computer software, hardware, personal technology products such as digital cameras, MP3 players and video games, and services including broadband access. Such a broad range of products offers an opportunity to examine reviews and their dynamics in different categories.

Second, CNET.com has both professional reviews (Editor's Ratings and Editor's Reviews) and customer reviews, which enables us to examine the authority effect specified in hypothesis 3.

Third, unlike websites like Amazon.com, CNET is a pure information intermediary, not a retailer. Thus CNET is less likely to engage in deliberately censoring consumer ratings, which might interfere in our empirical analysis. (Kawakami, 2005)

We collected our data from CNET in March 2006 using web crawlers. The complete dataset includes all products that were found on CNET, as of March 6<sup>th</sup>, 2006 that had both Consumer Ratings (CRs) and Editor Ratings (ERs). Prices of products are also retrieved if they are available on the webpage. This contains 3317 unique products with 149459 consumer ratings. On average we have 45 consumer reviews for each product.

In the following empirical analysis, we use a smaller, conservative sample of our dataset. First, since we are interested in the dynamics of consumer reviews, we want to make sure there are enough observations for each time series. Thus we include only products that have at least 20 consumer ratings. Second, we would like to test whether consumers are influenced by recent consumer reviews. By "recent consumer reviews", we mean the reviews that the consumer observes before he or she posts a rating. Before May 1<sup>st</sup>, 2005, CNET by default showed consumer ratings on its webpage in reverse chronological order. Sometime between then and March 2006, CNET changed the default order to show "Most Helpful" reviews first. Since we do not have a track of the measure of helpfulness, we could not determine which reviews a consumer read after May 1<sup>st</sup>, 2005. Thus we use only reviews up to May 1<sup>st</sup>, 2005 for our analysis. Finally, our second hypothesis examines the influence of editor reviews on consumer reviews. Thus we include only those products that have both editor reviews and consumer reviews. In this reduced dataset we have 82520 individual ratings covering 744 products from most categories.

## 6. Empirical analysis

We conducted a regression analysis using equation (3) to identify the weights of public opinions and how introduction of a new source of public opinions changes the influence of private information and other public opinions. Besides the independent variables considered in equation (3), we also add a control variable to capture self-selection among online consumers. Self-selection arises because early adopters of a product are more likely to be enthusiastic users and provide optimistic product reviews (Li and Hitt 2005). To control for this self-selection effect, we add log of number of days since product introduction into our regression model. A negative coefficient on the control variable captures the self-selection effect. The results of the regression analysis are reported in Table 1.

**Table 1: Factors Influencing Consumer Reviews**

Variables	Coefficients	Std err	p-value
Review * Private Information ( $\beta_1 - \chi_1$ )*a	0.66**	0.29	0.02
Community Consensus ( $\chi_2$ )	0.04**	0.02	0.03
Review * Community Consensus ( $\beta_2 - \chi_2$ )	-0.23***	0.02	<0.01
Recent Consumer Reviews ( $\chi_3$ )	0.05***	0.01	<0.01
Review * Recent Consumer Reviews ( $\beta_3 - \chi_3$ )	-0.01	0.01	0.36
Professional Reviews ( $\beta_4$ )	0.14***	0.04	<0.01
Log(DaysFromRelease)	0.41***	0.02	<0.01
Log(DaysFromRelease)*Log(DaysFromRelease)	-0.08***	0.00	<0.01

The results largely support the two hypotheses. We find that community consensus, recent consumer reviews and professional reviews all have positive and significant influence on consumer reviews. The weights on community consensus, recent consumer reviews and professional reviews are about 4%, 5% and 14% respectively. It shows that professional reviews have the most significant influence on consumer reviews. Recent consumer review and community consensus have similar weights on consumer ratings. We also find that the introduction of professional reviews significantly reduces consumers' weights on community consensus. But it has no influence on the impact of recent consumer reviews. This suggests that consumers largely view professional reviews as substitute to community consensus. But they do not necessarily view professional reviews as substitute to recent consumer reviews. Surprisingly, the introduction of professional reviews increases consumers' weights on private information. This results warrant further investigation.

## 7. Conclusions and discussions

This ongoing research contributes to the literature of online reviews by being one of the first to examine the dynamics of online consumer reviews. We show online consumer reviews are heavily influenced by public opinions. This helps researchers to develop a better understanding of the value online reviews. We also develop a parsimonious statistical model to isolate the influence various types of public opinions. We find that professional reviews have the most significant impact on consumer reviews.

We believe that this research has significance in practice as well. Given that more and more consumers turn to Internet for product information, online consumer reviews have become a significant force to influence consumer purchase decision. Firms have the urgency to better understand online reviewing behavior. Our finding should shed light on how firms can better manage the online information channel.

## Reference

- Anderson, E.W. "Customer Satisfaction and Word of Mouth," *Journal of Service* (1:1) 1998, pp 5-17.
- Asch, S. "Effects of group pressure upon the modification and distortion of judgments." In H. Guetzkow (Ed.), *Groups, leadership and men* (pp. 177–190). 1951, Pittsburgh, PA: Carnegie Press
- Avery, C.; Resnick, P.; and Zeckhauser, R. "The Market for Evaluations." *The American Economic Review*, (89) June 1999, pp. 564-484.
- Brown, J. and Reingen, P. "Social Ties and Word -of-mouth Referral Behavior," *Journal of Consumer Research*, 14, December, 1987, pp. 350-362.
- Bikhchandani, S., D. Hirshleifer, and I. Welch "A Theory of Fads, Fashions, Custom, and Cultural Change as Information Cascades." *Journal of Political Economy* (100), October 1992, pp. 992-1026.
- Blass, T. "The Milgram paradigm after 35 years", *Journal of Applied Social Psychology*, (29), 1999, pp. 955-978
- Butler, R. *Marketing and Merchandising*. New York,: Alexander Hamilton Institute. 1923.
- Chen, P., and Wu, S. "The Impact of Online Recommendations and Consumer Feedback on Sales." *Proceedings of the 24th International Conference on Information Systems*, Washington D.C., 2004.

- Chen, Y., and Xie, J. "Online Consumer Reviews: a New Marketing Communications Mix." Working paper, University of Florida, 2004.
- Chevalier, J. A., and Mayzlin, D. "The Effect of Word of Mouth Online: Online Book Reviews." Forthcoming, *Journal of Marketing Research*.
- Clemons, E.K., Gao, G. and Hitt, L. "When Online Review Meets Hyperdifferentiation: a Study of Craft Beer Industry." Forthcoming, *Journal of Management Information Systems*.
- Dellarocas, C. "The Digitization of Word-of-Mouth: Promise and Challenges of Online Feedback Mechanisms". *Management Science* (49:10), October 2003, pp. 1407–1424
- Dellarocas, C.; Awad, N.; and Zhang, X. "Exploring the Value of Online Reviews to Organizations: Implications for Revenue Forecasting and Planning." *Proceedings of the 24<sup>th</sup> International Conference on Information Systems*, Washington D.C., 2004
- Dellarocas, C., and Narayan, R. "A Statistical Measure of a Population's Propensity to Engage in Post-purchase Online Word-of-Mouth." *Statistical Science*, forthcoming.
- Duan, W.; Gu, B.; and Whinston, A. "Do Online Reviews Matter? - An Empirical Investigation of Panel Data", January 2005. Working paper. Available at SSRN: <http://ssrn.com/abstract=616262>.
- Godes, D., and Mayzlin, D. "Using Online Conversation to Study Word of Mouth Communication", *Marketing Science*, (23:4), Fall 2004, pp. 545-560
- Hornsey, M. J., & Jetten, J. "The individual within the group: Balancing the need to belong with the need to be different," *Personality and Social Psychology Review*, (8) 2004, pp. 248-264.
- Hu, N., and Zhang, J. Can Online Reviews Reveal a Product's True Quality? Empirical Findings and Analytical Modeling of Online Word-of-Mouth Communication, forthcoming, *Proceedings of the Seventh ACM Conference on Electronic Commerce (EC'06)*, Ann Arbor, Michigan, 2006
- Katz, E. and P. F. Lazarsfeld. *Personal Influence*. 1955. Glencoe, IL: Free Press.
- Kawakami, L. "Giving Reviews the Thumb Down", *The Wall Street Journal online*, 2005, August 4
- Kim, J. Y. and Ryu, K. "Yes-Men and No-Men: Does Defiance Signal Talent?" *Journal of Institutional and Theoretical Economics*, 159, 468-490.
- Li, X., and Hitt, L. "Self Selection and Information Role of Online Product Reviews." *Workshop on Information Systems and Economics*. Washington, DC. 2004
- Pendry, L. and Carrick, R. "Doing what the mob do: Priming effects on conformity," *European Journal of Social Psychology*, 2001, 31, 83-92.
- Welch, I. "Herding among security analysts," *Journal of Financial Economics*, 2000, 58, 369-396.