

ONLINE DISCUSSION GROUPS AS SOCIAL NETWORKS: AN EMPIRICAL INVESTIGATION OF WORD-OF-MOUTH ON THE INTERNET

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ABSTRACT: While consumer behavior researchers have long studied word-of-mouth and diffusion of information among reference groups, the emergence of the internet has recently provided the means to empirically establish just how this process takes place, as well as who contributes to it. In this study, the way information was shared among consumers in relation to two product categories was described as following a power law. Implications for marketing and research are provided.

Social networks play an important part in the diffusion of information among consumers, a process widely referred to as 'word-of-mouth'. How individuals relate to each other within a given market will influence whether information is shared and diffused, often ultimately determining the adoption of innovations by consumers (Goldenberg, Libai, and Muller 2001). The key role played by opinion leaders in this process has been well established (Burt 1999), and prolific empirical research has been spawned from seminal work by Rogers (1962), Milgram (1967), and Valente (1995). However, its application to consumers has been limited by the 'open' nature of most relationship networks, making it impossible to identify clear and stable boundaries (Brown and Reingen 1987). Furthermore, the difficulties associated with the collection and analysis of data on such a large scale has prevented the use of traditional measures.

Underpinning the modeling of most consumer networks, and hence innovation diffusion or word-of-mouth, is the assumption that interactions between individuals are random or that the probability of contact between any two individuals is uniformly distributed (Bass 1969; Frenzen and Nakamoto 1993). This, and a given distribution of innovators and opinion leaders in the overall population, leads to the notion of critical mass, a threshold beyond which diffusion or word-of-mouth becomes self-sustaining. Thus, success, in terms of product adoption or information diffusion, depends directly on the initial number of innovators or opinion leaders.

However, recent research in statistical physics would appear to place this assumption into question, suggesting that social networks, when considered on a larger scale, differ from random networks and are, therefore, inadequately described by exponential laws. Indeed, it makes intuitive sense that consumers should be in contact - and direct communication - with others who share similar interests, work in similar jobs, live in similar areas, or engage in similar hobbies, more so

than they do with strangers they might randomly meet in the street. As a result, the distribution of contacts between network members has been more recently described as a power law, of which the coefficient varies between one and three (Barabási and Bonabeau 2003). If this is true, then the notion of critical mass, and the importance of both the numbers of opinion leaders and innovators in the market, or the critical importance of reaching them, should be called into question. This, in turn, has direct implications for marketers and may shed some light on the usefulness and effectiveness of 'viral marketing' techniques.

The emergence of the Internet offers a welcome and timely opportunity to investigate how information travels among members of social networks (Goldenberg, Libai, and Muller 2001). The Internet allows unprecedented records of consumers' online behavior, which may usefully inform our understanding of the underlying process of information acquisition and consumers' ultimate choice behaviors (Bucklin et al. 2002). More specifically, by directly observing the manner in which information is shared and diffused in the natural setting of online discussion groups, we believe it is possible to track down and measure the paths undertaken by information between individuals interacting in this particular type of social online network. We argue that it is possible to draw inferences from such online 'word-of-mouth' phenomenon to what happens in word-of-mouth more generally. Hence, we examined consumers' online discussion groups in relation to two product categories where word-of-mouth would be expected to be intense, namely mobile phones and movies.

This paper is structured as follows. After a brief review of the relevant literature on power laws and their relevance to Internet-based social networks, we present empirical evidence concerning the distribution of messages among consumers involved in group discussion about two product categories,

and demonstrate that it follows a power law. Based on these findings, we then argue mathematically that the notion of critical mass, so important in networks based on random interactions, simply does not apply for consumer groups characterized by non-random interaction. Implications for marketing and discussion of several avenues for future research conclude this paper.

Power Laws on the Internet: A Literature Review

Research on social networks has long grappled with the difficulties of describing large-scale populations. In such instances, where N individuals are involved in p contacts with other individuals, the distribution of contacts has predominantly been hypothesized as a Poisson law (Erdos and Renyi 1960). Furthermore, most social networks empirically studied have been characterized by few degrees of separation between individuals. For example, Milgram (1967) demonstrated that a letter distributed by relatives from a random initial point would always reach its target after a limited number of contacts. Watts and Strogatz (1998) labeled networks characterized by intense interactivity between numerous nodes as "small worlds". Supported by much empirical evidence, the existence of smaller degrees of separation between some individuals would appear to cast doubt on the random model initially proposed by Erdos and Renyi (1960).

However, only since the advent of the Internet have researchers been able to collect the data necessary to empirically test this assertion. As early as 1999, Barabási and Albert argued that the Internet differed from more randomly structured networks based on two observations. First, the growth of the Internet since 1969, from a few sites to billions of sites; whereas Erdos and Renyi (1960) had assumed stable and established networks. Second, the simple fact that links between web pages could not possibly be described as equiprobable, given the purposeful 'preferential link' between websites (Barabási and Albert 1999). Barabási and colleagues proceeded to build a search engine enabling them to scan the Internet and to collect information on the links between web pages, allowing them to measure the number of links separating any two pages. They further refined their measure by taking into account the number of links leading to a specific web page as well as the number of links leading away from that web page to others. As reported by Barabási, Albert, and Jeong (2000), the distribution of contacts observed in these networks followed a power law of which the coefficient is less than 3 (2.45 for contacts towards the page and 2.1 for contacts away

from it). Clearly, therefore, these networks cannot be adequately described as resulting from random interaction. Furthermore, there is evidence of 'small worlds' on the Internet: Any 2 pages randomly selected among the billions currently existing, are only separated, on average, by 19 links.

These early results have been generalized more widely by subsequent research in the field of statistical physics. For example, Borgs et al. (2004) and Ebel, Mielsch, and Bornholdt (2002) examined the contacts between groups registered with Usenet, or other e-mail networks. Importantly, these networks comprised people (as opposed to web pages) and the results supported the notion that a power law describes the distribution of contacts between individuals better. In recent studies of Internet-based behaviors, researchers have advocated that consumer networks be further described as either 'dense' or 'loose' (Shi 2003), depending on whether they encompass predominantly 'strong' or 'weaker ties' between individuals (Goldenberg, Libai, and Muller 2001).

In their latest study, Barabási and Bonabeau (2003) reported that similar network structures could be observed in non-internet contexts, be it in relation to the chemistry between proteins in the human body, the relationships between firms operating in a given market, or even the appearance together of certain actors in Hollywood blockbusters. Clearly, therefore, these types of networks may well characterize consumer interaction and in particular, the process by which consumers share information about products or services.

An Empirical Examination of Two Product Categories

In order to examine the relevance of these findings to marketing, we set out to examine the distribution of messages between consumers engaged in online discussion groups. Given the ability of such discussions to be recorded in real time, and the availability of information about sequence as well as sources of these messages, the observation of discussion groups has the potential to enable data collection for much larger social networks than have been previously studied in the marketing literature. In order to ensure that our observations were not strictly product category specific, we selected two categories of products, one tangible, innovative, and functional (mobile phones), and the other intangible, familiar, and experiential (movies), in order to provide some contrast between the two research contexts and, a priori, consumer communities involved in them.

Given the technical difficulty that arises when trying to establish that a consumer has read any given piece of

information, we focused on the provision of information, or message contribution, to the group discussion. A number of indicators are presented in Table 1 to quantify the type of information available for both discussion groups under scrutiny.

Table 1. General Profile and Indicators for both Online Discussion Groups

Group	Mobile phone provider	Movies
Number of days of observations	244	245
Number of message contributors	1257	1952
Number of messages	8036	19964
Number of threads initiated	1597	3025
Number of responses	6439	16939
Ratio responses/messages	.801	.848
Ratio unanswered messages/messages	.046	.045
Number of lines	183213	666388

As can be seen from Table 1, the group discussing movies exhibited a large volume of communication. With just 50% more participants, it produced over twice the number of messages and threads of discussion. Longer messages also tended to be posted in relation to movies than in relation to mobile phones. However, both groups were similar in relation to the ratio of messages left unanswered, suggesting that participants sought to support and reward contributions, as described elsewhere in the literature (e.g. Fisher, Bristor, and Gainer 1996; Galegher, Sproull, and Kiesler 1998), with messages seldom left unanswered.

Choice of Measures for this Study

Traditional measures of social interaction in discussion groups have included relationships, strength of links, or centrality (Granitz and Ward 1996; Wellman and Gulia 1999), typically self-reported by means of surveys or interviews. The ability to measure the contribution and place of any individual within a discussion group is one of the useful benefits offered by the direct observation of online discussion groups. According to Granitz and Ward (1996), individuals can be ranked depending on their centrality and membership to different subgroups, experts being more active, connected, and enjoying more social capital. Of the different indicators available to us, therefore, we selected to focus on the number of messages contributed by an individual as a surrogate indicator of his or her place in the network; a network being defined here as the total of all contributors. The exclusion of all passive message readers, while an obvious limitation to this research, is nevertheless consistent with previous research, and in particular reflects:

- that group membership is expressed by contribution to the discussion, be it in volume or quality (McKenna and Bargh 1998),

- that contribution is encouraged by group recognition and linked to legitimacy by participants (Moore, Mazvancheryl, and Rego 1996),
- that participation over time fosters greater contribution (Galegher, Sproull and Kiesler 1998), and
- that the volume of messages is correlated with the value of the information they contain (Fiore, Tiernan, and Smith 2003).

In summary, therefore, the use of the number of messages contributed by any individual involved in a discussion group would appear to provide an objective, observable, and reliable measure of an individual's contribution to word-of-mouth within the social network represented by the discussion group.

Mathematical Description of the Observed Distribution of the Number of Messages

For both groups under scrutiny, a few individuals contributed a large proportion of all the posted messages, whereas a large number contributed little. For example, in the mobile phone group, the 5 top contributors accounted for over 20% of the total volume of messages and 70% of all contributors posted less than 2 messages. For movies, 60% of contributors posted less than 2 messages and the top 5 contributors posted close to 20% of all messages. Clearly then, the distribution of messages is non-random and there is therefore a high degree of social heterogeneity. As shown in Figures 1 and 2, the probability for some individual to post k messages is proportional to $k^{-\alpha}$, where $\alpha=1$ for the movies group and $\alpha=1.12$ for the mobile phone group. This type of power law distribution follows a Pareto-Levy distribution and exhibits several mathematical characteristics. In particular, when α is between 1 and 2, the variance is infinite.

Figure 1. Logarithmic plot of the number of messages posted and the rank of the consumer in the cinema group (Straight line slope -1)

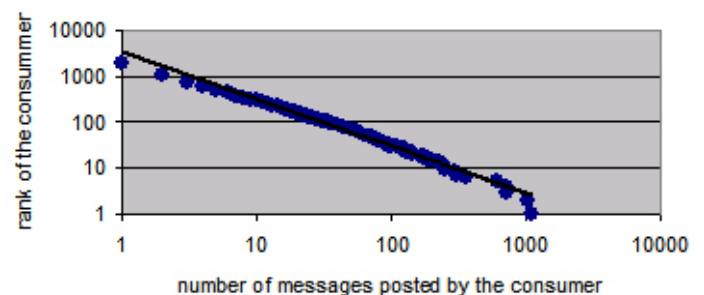
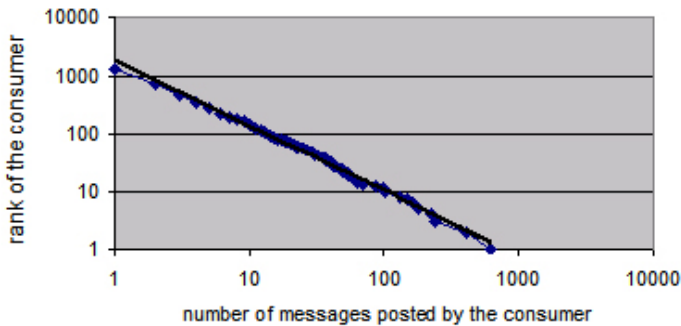


Figure 2. Logarithmic of the number of messages posted and the rank of the consumer in the mobile phone group (Straight line slope is -1.12)



As shown in Figures 1 and 2, the alpha empirically observed for both groups is between 1 and 2 and so the variance observed is infinite, supporting the notion of infinite heterogeneity among group participants and therefore, precluding the use of classic statistical inferences. The network of contributions must therefore be deemed non-random and therefore, the diffusion of information or word-of-mouth, cannot be aptly described by a traditional exponential law, leading to a number of important implications, first of which is the absence of critical mass in such networks.

Modeling Word-of-Mouth Mathematically

In order to model word-of-mouth in a social network of consumers, we examined the rate of diffusion of information over time, once it has been emitted at t=0. In this respect, our approach is similar to that advocated by Pastor-Satorras and Vespignani (2001) in relation to virus contamination.

As previously noted, each message contributor is characterized by the number of messages (s)he emits over time, k. Let p(k) be the proportion of consumers emitting k messages. Of these message contributors, only a proportion $\theta_k(t)$ already know the information. The rate of diffusion to the total consumers can therefore be written as:

(1)

$$\theta(t) = \sum_{k=1}^{\infty} \theta_k(t) p(k)$$

The number of messages contributed by all consumers who already know the information, therefore, is:

(2)

$$\mu(t) = \sum_{k=1}^{\infty} k \theta_k(t) p(k)$$

Furthermore, the persistence of the information in the discussion by the group can be deemed the result of two opposing forces. The first one involves information obsolescence or inertia resulting both from the nature of the information itself and consumers' propensity to forget it. This force is such that consumers will eventually forget the information. Hence, diffusion will exponentially decrease at the rate of δ . This force implies that:

(3)

$$\frac{d\theta(t)}{dt} = -\delta\theta(t)$$

This equation is true overall but also within each group of consumers contributing k messages in a given period of time, therefore:

(4)

$$\frac{d\theta_k(t)}{dt} = -\delta\theta_k(t)$$

The other force exercised on word-of-mouth is that which diffuses the information. As a result of it, a proportion of the individuals who do not yet know the information will eventually acquire it. This diffusion effect will be stronger:

- The more relevant the information, a constant λ .
- The more messages emitted by those individuals who already know the information, $\mu(t)$,
- The more the individuals receiving the information are active in the network, also measured by k, the number of messages emitted in a period of time.

Hence,

(5)

$$\frac{d\theta_k(t)}{dt} = \lambda k \mu(t) [1 - \theta_k(t)]$$

When equilibrium is reached (and the information stops spreading), both forces (equations 4 and 5) are equal and thus:

(6)

$$\delta\theta_k = \lambda k \mu [1 - \theta_k]$$

This allows us to work out $\theta_k(k)$:

(7)

$$\theta_k = \frac{\frac{\lambda k \mu}{\delta}}{1 + \frac{\lambda k \mu}{\delta}}$$

And this can now be used in the definition of $\mu^{(t)}$ to find the value of equilibrium in the number of messages exchanged by consumers aware of the information:

(8)

$$\mu = \sum_{k=1}^{\infty} \frac{\frac{\lambda \mu}{\delta} k^2 p(k)}{1 + \frac{\lambda k \mu}{\delta}}$$

This last equation enables us to find the values of μ at equilibrium. A possible solution is $\mu = 0$. In such a case, all $\theta_k = 0$ and the diffusion has stopped, the information has become obsolete, and ceases to spread. Another solution, when μ differs from zero, can be given by equation (8), simplified by μ :

(9)

$$1 = \sum_{k=1}^{\infty} \frac{\frac{\lambda}{\delta} k^2 p(k)}{1 + \frac{\lambda k}{\delta}} = f(\mu)$$

However, this last equation (9) does not always have a solution for μ . Since $f(\mu)$ is the sum of decreasing functions, it clearly

decreases, from $f(0) = \frac{\lambda}{\delta} \langle k^2 \rangle$ to $f(\infty) = 0$.

Therefore, $f(\mu)$ can only be 1 if $\frac{\lambda}{\delta} \langle k^2 \rangle$ is greater than 1. This can only be the case for strongly relevant information, that is when λ is large and greater than $\delta / \langle k^2 \rangle$.

In the type of networks observed in the discussion groups for the two product categories the situation is different, given the Pareto-Levy distribution, $\langle k^2 \rangle = \infty$ and hence $\delta / \langle k^2 \rangle$.

Consequently, as all λ are greater than zero, all information will diffuse and reach equilibria different from zero. As such, there is no critical mass effect, no threshold beyond which information diffusion can be expected to be self-sustaining. There is no selection of information by the social network on the basis of relevance, and all information can be said to diffuse in such networks, regardless of the number of initial 'opinion leaders'.

Some Marketing Implications: Critical Mass and Word-of-Mouth

The concept of critical mass, initially introduced by Schelling (1978), reflects a point beyond which diffusion is self-sustaining (Rogers 2003). From this point onwards diffusion accelerates, justifying strategies aimed at reaching it as soon as possible. From a marketing perspective, this means identifying and targeting innovators and opinion leaders to kick start the diffusion process. This assumption has motivated a prolific stream of empirical research in this area (Valente 1995).

Word-of-mouth, in that context, plays the role of a 'virus' in the social networks it uses to spread information. Although word-of-mouth occurs between individuals fundamentally asymmetrical in terms of influence, expertise and so on, most diffusion models have relied on the assumption of uniformity in the probability of contact between individuals (Bass 1969), or have assumed some degree of normality in the degree of innovativeness exhibited by consumers (Rogers 1976). Only recently has the concept of strong and weak links emerged from the literature (Goldenberg, Libai, and Muller 2001). The epidemiological approach adopted here would seem highly relevant to the phenomenon of word-of-mouth, with information diffusion emulating contamination by a virus.

As demonstrated by our findings in relation to two product categories, the assumption of equi-probable contacts between individuals does not appear to be justified: individuals enter in contact with others in a non-random fashion and some individuals contribute more than others to discussion about products. Clearly, therefore, it is necessary to rethink about social network as non-random communication 'small worlds' and to determine new ways of dealing with them.

A distribution of messages according to a power law, as opposed to an exponential law, provides a number of insights in relation to the behavior of group members. In particular, it points to asymmetries in relation to power, influence, and contribution between group members. Beyond the simple observation of communication behavior within online

discussion groups, our research may indicate how individual contributions influence word-of-mouth communication within large social networks.

A specific characteristic of the Levy-Pareto distribution with alphas between 1 and 2, as was revealed by our examination of the two discussion groups for very different products, is the absence of any threshold beyond which the process of diffusion is self-sustaining. In such networks, there are no critical mass effects, in contrast with traditional models of epidemiology or diffusion of innovation. The concept of critical mass, so central to previous diffusion models despite the non-random nature of these networks, simply does not apply. Hence, there are several important implications that can be derived from the finding that distribution of information on the Internet follows a power law and that its variance is infinite.

Managerial Implications of the Findings

Applying an epidemiological approach to the marketing phenomenon of word-of-mouth and innovation diffusion contributes some practical insights for marketing decision-makers.

The assumption of critical mass effects has long motivated marketers to focus on the number of innovators with strategies advocating that marketers: boost trial rates by promoting heavily, foster word-of-mouth (Holmes and Lett 1977), target opinion leaders so they can initiate the diffusion to followers (Mancuso 1969), or rely on evidence of take-off in sales (and the reaching of critical mass) to determine the success of the diffusion process (Mahajan, Muller, and Bass 1995).

Our findings, that critical mass effects do not exist in at least two product categories, would appear to weaken such strategic advice, as these would only yield unpredictable results. Indeed, the targeting of those emitting more messages [the opinion leaders according to Granitz and Ward (1996)], would appear unlikely to enhance the increased exposure by others to the brand information or, ultimately, to the product itself.

Rather, a strategy aimed at the total group (with games or sweepstakes open to all, as is the case for movies), or the introduction of (unidentified) messages to group discussions, a technique known as viral or buzz marketing, would appear just as effective. Furthermore, it would avoid the inherent practical difficulties marketers have in identifying and targeting opinion leaders, known to differ for different product categories.

Directions for Future Research

This research has revealed one particular instance where the diffusion of marketing information operates according to a power law and has demonstrated the absence of the sort of critical mass effects heretofore assumed by marketers.

We believe that many other marketing phenomena could also have been mistakenly assumed as based on random interactions between consumers. Instead, we argue, we should always expect consumers to relate more to other specific individuals with whom they share greater similarity or proximity. While this study has looked at word-of-mouth and the diffusion of information, we expect that the process by which consumers adopt innovations is equally likely to follow a power law. Moreover, beyond innovative products, we believe that many consumer choices result from imitation and vicarious learning, a process once again more likely to occur between some individuals than others. As a result, it is quite possible that other consumer choices, be they restaurant meals or items of clothing, could be better described by a power law than by any other alternative model.

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