
Network Externalities and Technology Use: A Quantitative Analysis of Intraorganizational Blogs

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ABSTRACT: We examine the role of network externalities on the use of blogs in an organization. Prior research has considered social influences such as peer pressure, but there is little prior work on how the extent of others' actual usage can influence an individual's use of technology. We also examine how technology usage is influenced by positive feedback from others. Finally, we look at how the relation between technology usage and network effects is moderated by demographic variables such as age and gender. The results of the study show that usage of blogs within an individual's network is associated with an increase in one's own usage. We also show that network effects are stronger for younger generations and that this relation is nonmonotonic with age. This is interesting considering that prior research suggests that social influences are stronger for older employees. Our results also show that network effects are stronger for women than for men. Further, we show that the impact of age on blog usage is not linear. We also find that feedback or appreciation from others is associated with higher blog usage by an individual. Finally, we subdivide the network effects into various subtypes and find that network effects are strongest for relational networks, and that use of blogs by an employee's managers is associated with higher usage by the employee.

KEY WORDS AND PHRASES: corporate blogs, network externalities, social computing, social networks, technology usage.

ORGANIZATIONS EXPEND CONSIDERABLE RESOURCES to evaluate, adopt, and assimilate new technologies. However, previous research suggests that a majority of technology initiatives either fail or remain underutilized. Employee adoption and continued use of technologies or lack thereof has been frequently cited as one of the leading causes of failure of new technologies [32]. Therefore, this topic has been a subject of enduring interest to both researchers and practitioners over a considerable period of time [8, 16, 19, 57, 58, 67]. Research in this area can be broadly classified into two categories:

1. Utility-oriented models stemming from the theory of reasoned action (TRA) [20], innovation diffusion [57], and the technology acceptance model [15]. These studies emphasize the importance of employees' individual characteristics, their perceived behavioral control, and perception regarding the innovation's attributes such as ease of use, usefulness, and complexity. Similarly, task–technology fit theories [24] focus on the perceived compatibility of the new information technology (IT) with employees' and organizations' task characteristics.
2. Social influence models [36, 56] that examine the role of formal and informal social networks on an individual's use of a technology. These theories focus less on the value of a technology but place greater importance on the norma-

tive influences and social processes of the organizational environment through which employees learn about and adopt new technologies [21].

In this paper, we extend the latter perspective to examine the role of network externalities on the use of social computing technologies in an organization. Social influence models have been extensively examined from both sociological and economic perspectives.

Research with a sociological perspective has been driven by a variety of theoretical frameworks. For instance, the theory of social learning [5] suggests that attitude toward new technologies is not only predicated on individuals' direct experience but also on their ability to observe and learn from the consequences of others using the technology. This allows individuals to avoid needless and often costly errors. Similarly, social information-processing models [59] suggest that information passed through individuals' social networks influences their perceptions of technology, and such influences are stronger in cohesive networks [11]. Social influence also refers to how an individual conforms to the expectations of others by performing a certain action (e.g., using a new technology). In short, the mechanisms of social influence could vary under different circumstances. Deutsch and Gerard [17] formalized this difference by suggesting that there exist two mechanisms of social influence—informational influence (when an individual witnesses benefits firsthand from others' adoption and use) and normative influence (when an individual is obligated to use the system if others use the same).

Researchers with an economic perspective have used the term *network externalities* to capture the broad range of social processes that influence individual behavior. Network externalities arise when the value of participating in a network increases as more people participate in the network [44]. Network externalities introduce dynamic considerations for potential users because users must predict the size of the network in the future to avoid adopting a technology that might not provide the expected benefits owing to the low installed base. Network externalities are evident in areas such as video game markets (where game developers are more likely to develop games for systems that are popular, such as Xbox or PlayStation, and the availability of more games on a system increases the popularity of these systems even further) or technologies (where more independent developers develop widgets, games and applications for popular technologies such as Flickr and iPhone, which makes these technologies even more popular). Researchers have examined the effect of network externalities in areas such as technology adoption, pricing, and competitive dynamics [33, 45].

Social computing tools such as blogs, wikis, discussion boards, and social networking sites are especially suited to study network effects. These tools are highly interconnected and, unlike traditional technologies, are essentially social in nature. In an organizational context, these tools are used for both formal and informal communication as well as collaboration. For instance, if an employee requires clarification on a work-related problem, he or she can post the query on a blog or a social networking platform and attract instant responses from employees in various corners of the organization. Similarly, employees can use these tools to create personal profiles

and find as well as interact with other employees who share similar interests and life-styles. Recent evidence suggests that social computing tools are also being used to develop collaborative spaces within organizations and gradually replace knowledge management systems [25]. Extant research on network effects and technology usage in organizations presents certain interesting limitations:

1. The aforementioned theories have been predominantly applied in the context of traditional organizational technologies such as personal computers/productivity tools [63], groupware technologies [41], and enterprise-level systems [72]. These technologies are essentially top-down in nature in the sense that they are mandated by management and employees have to make a decision whether or not to assimilate them into their day-to-day work. On the other hand, new technologies with a completely different design, such as social computing, are emerging in the business landscape, and it is important to understand their relevance and examine their use within organizations.
2. Prior studies (e.g., [36, 55]) have generally measured network externalities as a function of the cumulative installed base of users within the social networks of individual employees. Consequently, these studies do not consider the actual usage to measure network effects and social influences. We contend that although the overall user base is an important consideration for potential adopters, it is the actual usage by important members in the social network that signals the utility of the new technology.
3. Another type of social influence that is unique to social computing technologies is the potential to receive feedback or appreciation from others when an individual uses the technology. For example, in case of consumers writing online reviews (Amazon.com), replying to questions on discussion boards, or writing a blog, readers have the option to express gratitude for contributions that they find particularly helpful. Prior literature has looked at the perceived benefits of using a technology in general, but there has been little research on the role of feedback from others on an individual's use of a technology.

With these motivations, we propose the following research questions:

RQ1: Do network externalities play a role in influencing the use of social computing technologies in organizations?

RQ2: How do individual characteristics such as age and gender moderate the effect of network externalities on use of social computing technologies?

RQ3: What is the effect of positive feedback from others on the use of social computing technologies in organizations?

Our study attempts to answer these questions by analyzing the use of corporate blogs in a large U.S.-based multinational firm. We capture information on blog usage by employees, their demographic characteristics, whether an employee received positive feedback on his or her blog posts, and the contribution by other employees in the network. Our results show that network effects play a significant role in usage of

blogs by employees and that the relation is moderated by demographic variables such as age and gender. Younger employees are likely to contribute more to blogs and are also more influenced by others' usage, though the relation is not strictly monotonic. Gender does not play a direct effect on blog usage, but moderates the relation between network effects and blog use. We find that positive feedback from others is associated with more blog posts. The results show that usage by managers has a significant effect on blog usage by an individual, suggesting that even though blogs are bottom-up technologies, managers are likely to influence others' use by their own participation. Moreover, we found that the higher the blog usage by others in an employee's relational network, the higher the blog usage by that employee. Usage in positional and spatial networks did not have a significant effect on blog usage.

This study is closely related to prior literature on the role of network externalities on technology use [36]. Our main contribution is that we extend this literature in several ways. First, we extend the theory of network externalities to complement the explanatory power of various social influence theories. We also study how individual characteristics such as age and gender moderate the role of network externalities on technology use and how positive feedback from others influences an individual's continued use of a technology. Further, we apply these theories to a new technology such as blogging as opposed to previous studies that have typically examined traditional organizational technologies. Second, we examine the effect of positive feedback from peers on an individual's usage of blogs in an organization. Prior work on reinforcement theory in organizations has mainly examined the role of formal mechanisms in influencing individual behavior. Third, we consider the asymmetric nature of network externalities by examining the relative importance of different social groups such as managers, work groups, peers in the organizational hierarchy, as well as location. Fourth, we examine actual usage within the networks as opposed to perceptual measures (e.g., [55]) or overall installed base in the networks (e.g., [36]). Finally, although Kraut et al. [36] studied the role of network externalities on use of communication technologies, there is little research on network externalities in the context of other information systems (IS) (e.g., knowledge management systems).

Corporate Blogs

BLOGS ARE A PART OF THE NEW GENRE OF COMPUTER-MEDIATED COMMUNICATION referred to by various terms such as *social media* and *social computing*. Benkler [7] characterizes them as "peer production systems" through which communities of users pool their resources to produce high-rated information-embedded goods, sometimes altogether replacing the traditional mechanisms of firms and markets. Recently, many Fortune 500 firms such as Hewlett-Packard, Xerox, IBM, and Cisco Systems have deployed organization-wide blogging platforms and encourage employees to use these tools in day-to-day work processes [3]. Internal corporate blogs encompass all nonpublic blogs hosted within the organization on their intranets. Employees use such blogs during the course of their daily responsibilities to share expertise on products and services, to voice opinions, and to initiate discussions on issues of interest to other employees.

To understand the social nature of corporate blogs, we briefly review how they function. A blog (or weblog) is a diary of employees' personal reflections that is shared on the corporate intranets. Each reflection is called a *post*. Readers can react to the posts of the blogger, and these comments are attached to the main post for other readers to examine. Blogs also have a link to the other sections of the same blog or other Web sites. Each post is specified by a URL (known as "permalink") that helps other bloggers to track back to the posts. Often bloggers publish a list of other blogs on their radar called the "blogroll." Blog feed formats such as "RSS" (really simple syndication) and "atom" allow the automatic syndication of numerous blogs. The user is hence able to keep track of all the favorite blogs and select only those messages of interest for reading. This set of features allows blogs to rapidly connect to each other and, as a consequence, enables rapid information dissemination.

IS research on social computing in general, and blogs in particular, is starting to emerge. Parameswaran and Whinston [53] provide a general overview of blogs (and other social computing platforms) and identify their salient characteristics and utility within organizations. Efimova and Grudin [18] examine the use of blogs as personal communication and knowledge management tools within Microsoft and emphasize the benefits to both individuals and organizations. Kolari et al. [34] model the reach and effect of blogs in the corporate hierarchy and examine the social networks enabled by intracorporate blogs. More recently, Jackson et al. [30], Jina et al. [31], and Yardi et al. [71] have explored employees' use of internal corporate blogs in multinational corporations and delineate the social and informational aspects of blog usage.

Blogs have certain characteristics that differentiate them from the traditional organizational technologies. First, blogs are often called *bottom-up technologies*, which have been popular among employees even since before any organization mandated their use (instant messaging is another example of bottom-up technologies). The use of bottom-up technologies often spreads through a group of highly interested individuals who introduce the technology within the organization and popularize it through their social networks. When these networks interlink with other social networks in the organization, the use spreads from network to network, subsequently leading to organizational-level adoption. In the case of such technologies, lead users are of critical importance to the adoption and diffusion process. However, adoption and usage research has overemphasized the role of top management and organizational mandate in driving employee adoption of technology. As Lewis and Seibold have noted:

Researchers have overemphasized management's role in innovation design, implementation and adoption process. Users have been treated as passive recipients of innovation introduction strategy rather than active agents of intra-organizational implementation and adoption. [40, p. 324]

Second, blogs have become the primary tools of self-expression for the younger generation. As the newer generation enters the workforce, they already have extensive experience using these tools and may merely transfer the same habits to the workplace. In the work setting, these tools are also used for collaboration, knowledge transfer, and

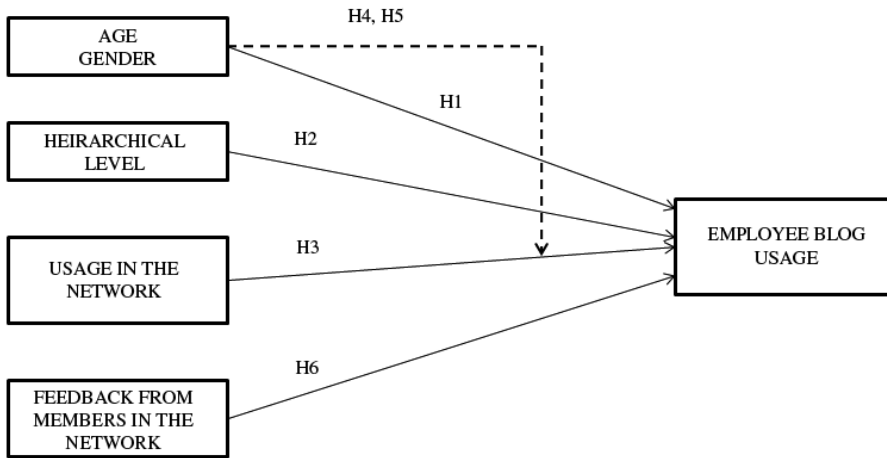


Figure 1. Research Framework of Employee Blog Usage

content creation, which, as we know from previous research, is the forte of experienced and more mature employees.

Research Framework and Hypotheses

THE RESEARCH FRAMEWORK IS SHOWN IN FIGURE 1. In this study, we adopt Rogers's [57] definition that adoption and continued use are a result of an employee's decision to make full use of an innovation as the best course of action available. We posit that (1) individual characteristics (age, gender, and position in organizational hierarchy) and (2) social influences such as network externalities and feedback from others are correlated with employees' blog usage.

Individual Characteristics

Age and gender are known to have an important influence on individuals' perceptions toward technology. For instance, age was consistently found to have a moderating effect on performance expectancy (usefulness), effort expectancy (ease of use), social influence, and facilitating conditions [49, 67]. Morris and Venkatesh [49] found a direct effect of age on usefulness perceptions for both short-term and long-term usage. Later, Venkatesh et al. [67] found that older workers show weaker willingness to adopt new IT products and place more importance on subjective norms (social influence). Researchers attribute the effect of age to various aspects such as differences in processing complex stimuli and allocating attention [54] and age-related memory deficits [70]. Therefore, technology characteristics such as ease of use and trialability achieve more salience for older individuals than younger ones.

However, we expect certain differences in the case of corporate blogs. For instance, Kumar et al. [37] found that, based on an analysis of around 1.3 million blogs, more than 60 percent of bloggers were between ages 17 and 24 and that there was a strong correlation between age, life-cycle stage, and the topical interests of bloggers. Also, because contribution to organizational blogs requires that the bloggers possess some knowledge, it is likely that the younger workers may not be in a position to contribute, even if they are familiar with the blogging technology. Overall, we expect to find a positive correlation between employees' age and their blog usage.

Hypothesis 1: The higher an employee's age, the higher will be his or her blog usage.

The evidence on gender differences in blog usage is not consistent. On one hand, previous researchers found significant gender differences in perceptions regarding ease of use and usefulness toward IS [23, 47, 50]. However, Venkatesh and Morris [66] did not show a direct relation between gender and technology adoption. Recent studies [18, 60] suggest that males and females do not differ significantly in the extent of blogging but greatly differ in their topics of interest. Males were more inclined to write about politics, business, and technology, whereas females discussed topics related to personal lives and relationships. Given the contemporary evidence, we do not expect to find a direct relation between gender and intensity of employee blog usage.

The level of the employee in the organizational hierarchy is also considered an important determinant of new technology adoption and continued use. However, there are conflicting viewpoints on its influence. Research suggests that increasing tenure makes employees resistant to change [9]. For instance, top managers with long tenure in their respective organizations are likely to have obligations to existing organizational constituencies that have vested interests in the status quo. The other point of view is that top managers become more aware of the strengths and weaknesses of the organization as well as its needs. Therefore, they are in a better position to recognize the value of the innovation to the organization and, as a result, are more willing to engage in change efforts and to adopt innovations [1]. Because personal expertise increases with experience and level in the organization, individuals higher in the organizational hierarchy might participate more in information-sharing networks [68]. Therefore, we hypothesize that:

Hypothesis 2: The higher an individual's level in the organizational hierarchy, the higher will be his or her blog usage.

Network Externalities

Critical Mass in the Network

Network externalities are largely dependent on the active or passive use of the technology in the employees' social networks [14]. The theory of network externalities [33] suggests that the value of a technology for a user increases if more people use the same technology. Social computing tools such as blogs flourish on user-generated

content, and continued use by employees is essential for their success. Therefore, the value of these technologies depends on the number of other individuals who use the system. For example, an employee is more likely to post a question to a discussion board if he or she believes that there is a high probability that the right person will answer that question, which in turn depends on how many people read and respond to the discussion board. Other theoretical streams also address the importance of social networks. In the literature on communication technologies, researchers emphasize the notion that critical mass is important for the success of a technology [43]. The rationale is that the utility of the communication medium increases with the total number of users connected to the medium. Rice et al. [56], in support of this notion, show that coworkers who were closely connected to each other prior to the implementation of an electronic mail system had similar patterns of adoption. Similarly, the social influence theory of media [22] and social information-processing theory [59] suggest that individuals' perception of a medium is influenced by salient others. Specifically, others can exert influence by (1) serving as a behavioral role model by their own use of the technology, (2) explicitly stating their own assessment of the technology, and (3) providing feedback to others on their use of the medium. Further, studies (e.g., [36]) show that adoption is also influenced by critical mass within a person's work or reference groups. The acceptance of the technology by an employee's peers (e.g., superiors, colleagues, and cohorts) may signal its importance and advantages and motivate the employee to imitate [29, 69].

Hypothesis 3: Blog usage of an individual employee is higher when the number of blogs by individuals in his or her social network is higher.

Moderating Influence of Age and Gender on the Effect of Network Externalities

A growing body of literature has examined whether social effects vary by individual characteristics such as age and gender [49, 61]. The relative effect of various social groups is linked to the extent to which younger/older workers are influenced and respond to the informational input from others in their social networks. Older workers are more amenable and conform to others' input/suggestions because they are more concerned about pleasing others and have higher need for affiliation with coworkers [26].

Gender also accounts for differences in how social information influences attitude toward a technology. Men and women process information using different socially constructed cognitive structures that determine direct and indirect social influences [66]. Women are more socially oriented and strongly motivated by affiliation needs. Because women tend to value connection and achieving interpersonal goals, they tend to place more importance on pleasing superiors and coworkers [46]. Men in general adopt a competitive and potentially overconfident attitude that tends to dilute the influence of others. Considering the above evidence, we expect both age and gender to moderate the impact of network effects on blog usage.

Hypothesis 4: The effect of network externalities on individual blog usage is greater for older workers than for younger workers.

Hypothesis 5: The effect of network externalities on individual blog usage is greater for women than men.

Feedback from the Network

One of the features of interactive technologies such as blogs is that they enable a contributor to get positive (or negative) feedback. This feature performs two critical functions. First, feedback is an important indicator of activity in an online medium that lacks social cues and traditional information exchange mechanisms. Second, it creates a reputation system for every individual contributor that can be easily viewed by others in the network. The effect of feedback on blog usage can be explained in light of the reinforcement theory [62]. In an organizational context, the reinforcement theory has been examined in the context of formal rewards and incentives offered by the organization to influence individual behavior. Feedback mechanisms such as “thank you” or “helpful votes” act as informal mechanisms of reinforcement, where other employees can provide positive reinforcement to an individual’s contribution on the blogs, which can further enhance a person’s desire to contribute to blogs. Also, the social learning theory [5] suggests that observation of performance consequences experienced by other members can reinforce an observer’s perceptions of the consequence of a behavior. In this sense, positive feedback mechanisms can reinforce more activity in the communication medium and vice versa. In studies on open source software, researchers have shown that feedback from other members has a positive effect on an individual member’s activity [28]. Online information exchange is often a social process that depends on the extent of responsiveness from other members [51, 52]. Delays in responses and feedback from other members are one of the reasons for exit from online communities. Given the social nature of blogs, we posit that the extent of positive feedback that an individual contributor receives from the network enhances an individual’s overall activity on the blog.

Hypothesis 6: Increase in positive feedback from others will increase individual blog usage.

Network Externalities and Different Social Groups

Next, we focus on the relative influence of externalities created by different types of social networks.

Usage by Managers

Rogers [57] emphasizes that conversation with higher-ups in the formal social structure is important for success of a communication technology. Managers are an important

aspect of an organizational social network. However, technology acceptance studies do not explicitly consider whether managers' use of a new technology has an influence on employees' adoption and continued use [19]. Rather, the role of managers is generally studied as employees' perception of their managers' influence.

Employees are influenced by their immediate supervisors' use of new tools. IS research also lends support to the fact that managers influence their subordinates' usage through their own usage [32], persuasive communication [39], and the employees' perception that the managers favorably view the new technology [15]. However, in highly decentralized organizations characterized by looser structure, increased professionalization of subordinates, and freer communication, a persuasive message by a competent person or member of the social system could be more effective and less costly than formal authority. For instance, Zmud [72] suggests that managers play a more effective role in the diffusion of administrative innovations than technical innovations because, in the latter case, lower-level employees may doubt the adequacy of their manager's expertise to judge the efficacy of an innovation. On the whole, IS research has been quite equivocal on the importance of managerial influences.

In the case of corporate blogs, certain interesting trends have emerged. Lee et al. [38] analyze the corporate blogging strategies of Fortune 500 firms and find that most often organizations tend to maintain control through a top-down blogging strategy and rarely allow employee autonomy. Their study reveals that organizations are still trying to maintain a fine balance between autonomy and control. There is an increasing debate on the extent of freedom that an employee is entitled to while using blogs in a work environment. Various concerns such as untimely leakage of information, loss of productivity, and public relations have forced organizations to put in place stringent blogging policies. At the same time, organizations are encouraging employees to use blogs for more internal communication. Given that corporate blogs are used in a work environment of which immediate managers are an inherent part, managerial usage of blogs will confer a certain amount of legitimacy and therefore will be positively associated with an individual employee's blog adoption.

Hypothesis 7: Increase in blog usage by immediate managers will increase an employee's own blog usage.

Usage in Peer Networks

In an organizational context, three types of peer networks need to be considered [13, 48, 55]:

1. *Relational network.* People influence and are influenced by others with whom they directly interact. Such patterns of direct communication might be similar to or different from the ones prescribed by the organizational structure. Burt [12] refers to these as the cohesive group within which individuals develop attitude similarity after repeated interactions with salient others. The more direct this interaction, the higher will be the influence. Relational networks in an organization can exist in the form of subunits or departments. Employees

who work in the same departments are likely to communicate and act based on collective understanding about agreed-upon tasks [4]. Communication within departments has the potential to forge agreements regarding individual actions and also control the stimuli to which an individual is exposed in the course of organizational activities.

2. *Positional network*, also referred to as the *structural equivalence model* [12]. This network reflects the various other individuals within the organization who have similar patterns of communication. Given the similarity in communication patterns and tasks, structurally equivalent individuals (within similar positional networks) tend to develop similar attitudes toward the technology even though there is no direct interaction.
3. *Spatial network*. Organizations intentionally create spatial networks through office landscaping/layout to group together individuals and departments with similar tasks. Simply being in the same location increases employees' chances of social interaction and, consequently, their exposure to each other's attitude and behavior toward technology [35, 55]. Rogers [57] stresses the importance of space and neighborhood effects on diffusion processes and argues that space is probably the least studied variable. Spatial networks enable diffusion through the vicarious learning process by which individuals learn about the utility of the new technology merely by observing the behavior and payoffs of others using the technology even though it might not involve direct interaction.

The evidence on the relative influence of these networks in an organizational context is still equivocal. Prior research suggests that relational networks (also referred to as *strong ties*) will have a greater influence on individual adoption of a communication medium [21]. Relational networks are characterized by high task interdependence that requires greater levels of coordination and communication. The more the communication, the greater will be the opportunity to communicate the information regarding the focal technology. Assuming that social computing tools enhance this communication, adoption within cohesive relational networks has greater influence on individual adoption [56]. Moreover, in the case of social computing technologies that are primarily communication tools, individual employees will have a greater incentive to use the technology to interact with friends and peers in their closest work group.

At the same time, positional and spatial networks (weak ties) enable information exchange between individuals who communicate infrequently. Strong ties often expose individuals to repeated and redundant knowledge, whereas weak ties provide an individual with an opportunity to access information and resources that are often not available in his or her immediate relational network [27]. Recent studies argue that the fundamental premise of social computing tools such as blogs is to enable such weak ties. In large corporations, blogs create an informal mechanism that links disparate and far-flung parts of the organization into a constructive contact. For instance, Jackson et al. found that some of the primary motives of corporate bloggers include "building a network, getting to know someone, social networking, meeting people from other parts of the company/outside my circle, making a friend, and finding an expert" [30,

p. 5]. More specifically, they cite a comment by one of the bloggers in the firm: “It has given me connections to people around the company that I would have not otherwise have. In rare cases, it answers a technical question I’m struggling with that none of my immediate coworkers has an answer for” [30, p. 5].

We posit, based on the above discussion, that blog usage within employees’ relational, positional, and spatial networks is positively linked to blog adoption. As to the relative influence of these networks, we argue that in an organizational context, the referent group that has a greater influence on adoption may be determined by the formal structures and patterns of communication within the work groups. Therefore, we expect that blog usage in relational networks is more strongly related to individual employee blog usage than in positional and spatial networks.

Hypothesis 8: Increase in blog usage in an employee’s relational network will increase his or her individual blog usage.

Hypothesis 9: Increase in blog usage in an employee’s positional network will increase his or her individual blog usage.

Hypothesis 10: Increase in blog usage in an employee’s spatial network will increase his or her individual blog usage.

Hypothesis 11: Blog usage in the relational network will have a relatively stronger influence on an individual’s usage than usage in the positional and spatial networks.

To summarize, we test our main model (see Figure 1) on the role of network effects on blog usage and the moderating effects of demographic variables on the relation between network effects and blog usage in Hypotheses 1–6. We also supplement our analysis by disaggregating overall network effects into various subtypes and test the relative importance of these smaller networks on blog usage. These are represented by Hypotheses 7–11 and are not shown in Figure 1. Hypothesis 6 supports RQ2, and Hypothesis 1, 2, and 5 support RQ3. The rest of the hypotheses support RQ1.

Study Context and Methodology

WE EMPIRICALLY TESTED THE RESEARCH FRAMEWORK using data collected from Electrony (pseudonym), a large electronics company with headquarters in the northeastern United States. Electrony employs more than 100,000 employees in over 150 branch offices located around the world. One of the large divisions in the firm implemented a blogging platform with supporting tools such as tagging, RSS, and discussion boards. The platform also provides tools for individuals to create and update personal spaces (with photos and friend links, similar to social networking sites such as Facebook). Currently, close to 3,000 employees in this division across the country use the blogs to support their day-to-day tasks such as knowledge sharing, coordination, communication, and locating information and expertise. We used both qualitative and quantitative data to analyze the patterns of blog use.

We first conducted an informal roundtable discussion with a group of 12 executives to understand the general domain of social computing and to formulate interesting research questions. Subsequently, two of the authors visited the site of the organization and interviewed the key managers and users. We followed a semistructured interview format with the basic goal of exploring and understanding employees' usage behaviors. In this, we selected 21 employees from diverse backgrounds and hierarchical levels, including the lead developers and users who were the primary driving force behind the deployment of the blogging platform. The interviews were transcribed for analysis. The interview data enabled us to understand the nuances of social computing usage behavior and also guided the development of our research framework as well interpretation of the results from the quantitative analysis.

The quantitative data are log data on blog usage of 2,291 individuals in the company over a period of 12 months.¹ We define the dependent variable as the number of posts by each individual employee. Previous research usually studies factors that influence users' initial intention or decision to adopt or use IS. In this study, the focus is on the intensity of usage. Blog usage typically consists of two steps. The user first creates a user name and password that ensures a dedicated account. Later, the user may or may not use the technology to regularly update the content and also use the platform for other communication purposes. Therefore, we believe that the number of posts by a user is a more appropriate measure of use than mere profile creation (see Table 1 for the definitions and measurement of the variables in the data).

Individual Characteristics

We measure *AGE* as a categorical variable where *AGE* = 1 if the user is from the Millennial generation (born after 1980), *AGE* = 2 for the Gen X users (born between 1965 and 1980), and *AGE* = 3 for the Boomer generation (born before 1965). In our regression analysis, we create two dummy variables—*GENX* and *MILLENNIAL* to represent generations. *BOOMER* is the omitted variable and used as the reference category. *GENDER* is measured as a binary variable (0 for female and 1 for male). We measure *LEVEL* in the hierarchy as an ordinal variable with values from 1 to 9 where 9 is the highest level in the organizational hierarchy (this system of classification is followed by Electrone). We also control for size of an individual's department by using a variable *SIZE*, which is the natural logarithm of the number of employees in an individual's department who are located in the same branch office.

Network Externalities

To measure the strength of network externalities for an individual, we created a variable *NETWORK_POSTS*, which measures the number of blog posts by all other employees in the individual's network. An individual's network consists of people in the same department and location (strong ties) and people located in other departments in the same branch office (weak ties). We measure feedback mechanisms by the variable *AVG_VOTES*, which is an average of the number of votes received by every blog post of an employee (i.e., if an employee has 3 posts with 4, 6, and 8 "thank you"

Table 1. Definition and Measurement of Variables

Construct	Definition	Measurement
<i>POSTS</i>	Total number of blog posts made by an employee in the 12-month period	Continuous variable
<i>AGE</i>	Age of the employee	Categorical variable (1 = Millennial; 2 = Gen X; 3 = Boomer)
<i>GENDER</i>	Gender of the employee	Categorical variable (0 = female; 1 = male)
<i>SIZE</i>	Log of number of employees in an individual's department in the same branch office	Continuous
<i>LEVEL</i>	Hierarchical level of the employee in the organization	Ordinal variable (0 = entry level; 9 = highest level)
<i>AVG_VOTES</i>	Average number of "recommend" votes per blog post received by an employee from others in the network in the 12-month period	Continuous variable
<i>NETWORK_POSTS</i>	Total number of blog posts by all the employees in the individual's network in the 12-month period	Continuous variable
<i>MGR_POSTS</i>	Total number of blog posts by employees who are one level higher than an employee in the same department and same location in the 12-month period	Continuous variable
<i>DEPT_POSTS</i>	Total number of blog posts by employees in an employee's department (excluding managers) in the 12-month period	Continuous variable
<i>LEVEL_POSTS</i>	Total number of blog posts by employees in similar hierarchical levels in the same department and location in the 12-month period	Continuous variable
<i>BRANCH_POSTS</i>	Total number of blog posts by employees in an employee's branch office (excluding an individual's department) in the 12-month period	Continuous variable

votes, $AVG_VOTES = 6$). We calculate the managerial influence for an individual (MGR_POSTS) by measuring the number of blog posts created by all employees in the same department and location who are one level higher than the individual. Finally, we measure usage in peer networks for each employee as follows: we measure the influence of the relational network on blog adoption by calculating the number of blogs by other employees in an employee's department in the same branch office, excluding managers ($DEPT_POSTS$), and the number of blogs by other employees in similar hierarchical positions in the same department and location ($LEVEL_POSTS$); and we measure the influence of the spatial network on blog adoption by the aggregate of blog posts by other employees in an individual's branch office, excluding those in an individual's department ($BRANCH_POSTS$).

Analysis

Descriptive Statistics

THE DESCRIPTIVE STATISTICS OF THE DATA are presented in Table 2. We normalized the variables measuring network externalities ($NETWORK_POSTS$, $BRANCH_POSTS$, MGR_POSTS , $LEVEL_POSTS$, $DEPT_POSTS$) by subtracting the mean and dividing by the standard deviation. One of the main advantages of normalizing is that it brings variables with different ranges on the same scale. This enables us to compare coefficients and avoid high correlations during regression with interaction terms. The variance inflation factors are all less than 7, which is much below the accepted level of 10 [6]. This suggests that the collinearity among independent variables is not a problem in our data set. The correlations between the variables are shown in Table 3.

Hypotheses Testing

We used ordinary least squares to test our empirical model. For ease of illustration, we introduce the independent variables in four models. In model 1, we introduce only the individual characteristics and the control variable, $SIZE$. In model 2, we add overall network effects and feedback variables to the first model. In model 3, we add interaction terms between age/gender and network effects to model 2. Finally, in model 4, we subdivide network effects into relational, positional, and spatial networks and add these to model 1 along with the feedback variable. The equations for the different models are as follows:

Model 1

$$POSTS = GENX + MILLENNIALS + GENDER + SIZE + ORGN_LEVEL$$

Model 2

$$POSTS = GENX + MILLENNIALS + GENDER + SIZE + ORGN_LEVEL + FEEDBACK + NETWORK_POSTS$$

Table 2. Descriptive Statistics

	Mean	Minimum	Maximum	Standard deviation
Independent variables				
<i>GENX</i>	0.39			
<i>MILLENNIAL</i>	0.18			
<i>BOOMERS</i>	0.43			
<i>GENDER_MALE</i>	0.72			
<i>SIZE</i>	4.1	0.63	6.46	1.8
<i>LEVEL</i>	3.9	1	9	1.7
<i>AVG_VOTES</i>	0.02	0	3	0.18
<i>NETWORK_POSTS</i>	271.4	0	876	392.7
<i>MGR_POSTS</i>	36.4	0	277	77.9
<i>DEPT_POSTS</i>	193.2	0	824	307
<i>LEVEL_POSTS</i>	116.8	0	343	116.9
<i>BRANCH_POSTS</i>	41.9	0	876	138.7
Dependent variable				
<i>POSTS</i>	0.5	0	58	3.17

Model 3

$$\begin{aligned}
 POSTS = & GENX + MILLENNIALS + GENDER + SIZE + ORGN_LEVEL \\
 & + FEEDBACK + NETWORK_POSTS + NETWORK_POSTS * GENX \\
 & + NETWORK_POSTS * MILLENNIALS + NETWORK_POSTS * GENDER
 \end{aligned}$$

Model 4

$$\begin{aligned}
 POSTS = & GENX + MILLENNIALS + GENDER + SIZE + ORGN_LEVEL \\
 & + FEEDBACK + MGR_POSTS + DEPT_POSTS \\
 & + LEVEL_POSTS + BRANCH_POSTS.
 \end{aligned}$$

The results are summarized in Table 4. The results show certain interesting trends. The data do not support Hypothesis 1 that age of employees is always positively associated with blog usage. The coefficients suggest that compared with the Boomer generation (the reference category), blog usage of Gen X and Millennials is higher ($p < 0.05$); however, the blog usage of Millennials is not higher than that of Gen X, which suggests that the relation between age and blog usage is nonmonotonic. The results show the coefficient for gender is not significant, which supports prior findings that there are no gender differences in the extent of usage. Hypothesis 2 is not supported, because the coefficient of *LEVEL* is not significant at the 0.1 level.

The coefficient of *NETWORK_POSTS* is significant ($p < 0.01$), which provides support for Hypotheses 3. Hypothesis 6 is also supported ($p < 0.001$) because the coefficient of *AVG_VOTES* is positive and significant. This implies that external influences such as network externalities created by others using blogs or positive feedback from others on one's contributions are associated with higher blog usage by an individual.

Table 3. Correlation Matrix

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12
V1 GENX	1.00											
V2 MILLENNIAL	-0.37	1.00										
V3 GENDER_MALE	-0.02	-0.04	1.00									
V4 SIZE	0.02	0.14	0.02	1.00								
V5 LEVEL	-0.12	-0.60	0.18	-0.17	1.00							
V6 AVG_VOTES	0.04	0.04	0.02	0.10	-0.05	1.00						
V7 NETWORK_POSTS	0.00	0.11	0.03	0.76	-0.11	0.11	1.00					
V8 MGR_POSTS	0.03	0.29	-0.04	0.60	-0.38	0.13	—	1.00				
V9 DEPT_POSTS	0.00	0.06	0.04	0.80	-0.07	0.10	—	0.63	1.00			
V10 LEVEL_POSTS	0.24	0.02	-0.06	0.46	-0.32	0.07	—	0.36	0.30	1.00		
V11 BRANCH_POSTS	-0.02	0.00	0.04	0.04	0.04	0.01	—	0.03	0.04	-0.12	1.00	
V12 POSTS	0.08	0.02	0.00	0.13	-0.05	0.23	0.14	0.14	0.14	0.08	0.01	1.00

Table 4. Results of Hypotheses Testing

	Model 1			Model 2			Model 3			Model 4		
	Individual characteristics			Individual characteristics + social influences			Individual characteristics + interaction effects			Individual characteristics + networks subtypes		
	β	σ	p	β	σ	p	β	σ	p	β	σ	p
Intercept	-0.12	0.05	**	-0.01	0.05		-0.02	0.05	*	0.002	0.05	
GENX	0.12	0.02	***	0.1	0.02	***	0.1	0.02	***	0.1	0.02	***
MILLENNIAL	0.09	0.04	**	0.07	0.03	**	0.08	0.03	**	0.08	0.04	**
GENDER	0.02	0.02		0.01	0.02		0.01	0.02		0.015	0.02	
SIZE	0.04	0.01	***	0.01	0.007		0.01	0.007		0.004	0.01	
LEVEL	0.002	0.01		0.002	0.007		-0.01	0.01		0.01	0.01	
AVG_VOTES				0.8	0.05	***	0.8	0.05	***	0.8	0.05	***
NETWORK_POSTS				0.06	0.01	***	0.04	0.02	**			
NETWORK_POSTS * GENX							0.09	0.02	***			
NETWORK_POSTS * MILLENNIAL							0.05	0.025	**			
NETWORK_POSTS * GENDER							-0.36	0.02	*			
DEPT_POSTS										0.05	0.01	***
BRANCH_POSTS										0.01	0.01	
LEVEL_POSTS										0.01	0.01	
MGR_POSTS										0.02	0.01	**
Adjusted R^2	4			15.26				16.02			15.35	
F-value	21.44			59.93				44.68			42.53	
p	< 0.0001			< 0.0001				< 0.0001			< 0.0001	
N	2,291			2,291				2,291			2,291	

Notes: β and σ denote the regression coefficient and standard error, respectively. *, **, and *** indicate significance at the 0.1, 0.05, and 0.01 levels, respectively.

We test the interaction effect of demographic variables and network effects. The coefficients of $NETWORK_POSTS * GENX$, $NETWORK_POSTS * MILLINNEALS$, and $NETWORK_POSTS * GENDER$ are significant, suggesting that demographic variables such as age and gender moderate the effect of network externalities on an individual's use of blogs. However, the positive coefficient of $NETWORK_POSTS * GENX$ and $NETWORK_POSTS * MILLINNEALS$ suggests that the network effects are stronger for Gen X and Millennials than for Boomers. Hypothesis 4 is therefore not supported. The negative coefficient of $NETWORK_POSTS * GENDER$ suggests that the impact of network effects is stronger for women than for men. Hypothesis 5 is therefore supported.

In model 4, we find that the coefficients of $DEPT_POSTS$ and MGR_POSTS are positive and significant, suggesting that increase in the use of blogs by managers and individuals in the same department is associated with an increase in an employee's blog usage. This provides support for Hypotheses 7 and 8. Hypothesis 11 is also supported because the coefficient of $DEPT_POSTS$ is significantly higher than that of both $LEVEL_POSTS$ and $BRANCH_POSTS$ at the 0.01 level (we use a t -test to compare the coefficients). Hypotheses 9 and 10 are, however, not supported, which suggests that the impact of network externalities at the relational and spatial levels is not significant.

The increase in R^2 between models 1 and 2, and models 2 and 3, is significant (we use the test provided by Aguinis [2]), which suggests that adding network effects and interaction terms increases the explanatory power of predicting blog usage.

Discussion

IN THIS STUDY, WE EXAMINE THE ROLE OF NETWORK EXTERNALITIES in usage of corporate blogs. We develop and test a research model incorporating both individual-specific factors such as age, gender, and hierarchical level as well as social factors such as network effects and feedback from others. Our results offer several interesting insights to managers and academics alike on the adoption of social computing tools in organizations. In this section, we reiterate our research questions and summarize how our findings address these.

RQ1: Do network externalities play a role in influencing the use of social computing technologies in organizations?

Our results show that network externalities play an important role in driving blog usage. The critical mass of the network has important implications for the continued usage of blogs. Many of the employees also emphasized this critical aspect of the blog network. Our interview respondents indicated that enhanced searchability is one of the most important advantages of having a large network of users. In the initial stages, only a select group of employees and teams were using the network, and this discouraged many potential users from actively sharing content through the platform. However, as the network started growing, many of the late entrants saw the benefits of being online and began using the blogs.

We further extended our analysis to examine whether the network effects vary by the source—that is, the type of social group that influences the individual. To this end, we subdivided the overall network into four important social groups—managers and relational, positional, and spatial networks. Our results show that network effects differ in size depending on the social group with which the employee communicates using the medium.

The results also show that managers' use is associated with higher individual use. This finding departs from previous assertions [65] that managerial influence does not hold sway in the case of technologies that are perceived as voluntary and whose usage is not supported by formal organizational mandates. Even though blog usage in Electrony was mostly voluntary, managerial influence still seems to drive employee usage. As we indicated in our discussion on Hypothesis 2, more and more managers at Electrony are seeing social computing as an important workplace tool that can be used to both communicate with and keep track of employees. Therefore, employees may feel that there is no other option but to use their managers' most preferred communication tool. However, the employees we talked with pointed out that managers' usage has both positive and negative consequences. Some employees felt that it was politically expedient to have an online profile and regularly update the content as it made them accessible to the higher-level managers. However, the regular use and close scrutiny of the managers is not without its pitfalls. There was a general perception that the open nature of the social computing tools tends to conflict with business needs, and many times managers do not appreciate the content that is generated in the blog forums.

Our hypotheses about the importance of relational networks on blog usage are also supported. This lends credence to the notion that networks whose members' tasks are highly interdependent are more conducive to diffusion of new communication technologies than networks that have low task interdependence. Relational networks in an organization are typically an employee's work groups, which are characterized by formal structures of communication and other social norms. Therefore, it is likely that even if the blog tools were not mandated by the organization, employees are primarily using it to communicate mostly with their closest group members as opposed to others. Our discussions with employees provided insights into how employees' work groups have become important sources of social norms and work benefits that drive blog usage. Many respondents identified teams and work groups as the most important social groups that motivated them to use the social computing tools more than usual. Because the blogs were being used in an organizational context, many employees felt that only business needs drive continued usage.

Surprisingly, the data do not support our conjecture that usage in an employee's positional spatial network (same office location) is associated with employee blog usage. Evidence suggests that weak ties play an important role in the diffusion of social network-driven communication tools such as instant messaging (positional and spatial networks) [64] primarily for two reasons: (1) these networks enable observability of payoffs of using the technology, and (2) they enable the technology to diffuse beyond cohesive networks, especially in the case of technologies that do not have a formal

organizational mandate. Our discussions with the employees revealed that the blog platform in Electrony has not yet achieved the required critical mass that can motivate employees to reach out beyond their immediate work group. Further, given that blogs are a relatively new tool of communication, employees did not see the benefit in exposing their work-related issues to a large audience outside their comfort zone.

RQ2: How do individual characteristics such as age and gender moderate the effect of network externalities on use of social computing technologies?

We show that the relation between blog usage and age is nonmonotonic. For example, individuals in Gen X are likely to have more blog posts than Boomers. But the blog usage of Millennials is not statistically higher than that of Gen X. The result is at odds with the previous research that shows evidence of a straight negative correlation between employee age and technology adoption. Our interviews with users and their managers revealed certain interesting insights on the relationship between employees' age and blog usage. Even in the era of technology-dominated workplaces, many employees felt that age was still a very important issue. One manager who led the blog rollout in the division commented that older employees tend to believe that there is an automatic generation gap at work and may not have the mind-set of sharing and working in open systems, as it is more of a "cultural shift" for them. Interestingly, our interviews suggest that the age issue is not that straightforward. One employee suggested what is important is not age itself but when a person went to college. Older employees who went to college when e-mail and instant messaging were emerging as popular communication tools are more comfortable with those technologies, whereas individuals who went to college in the Facebook era are more comfortable using social computing technologies.

The results on the interaction terms were quite interesting. The result with age is contradictory to previous research that suggests that older employees tend to place greater importance on affiliative behavior and subjective norms. It is possible that the deviation could be due to the very nature of the focal technology. Blogs are a part of the new genre of computer-mediated communication that is, on average, more popular with the younger generation. In fact, the younger workforce has extensive experience using these tools both inside and outside the workplace. Given that they have more people of their generation to communicate with, the aspect of network externalities and critical mass seems to have a significant influence on younger employees' usage.

Our interviews also uncovered interesting relations between age and social computing usage. The respondents indicate that the overall network membership may not matter as much as having more people from the same generation to communicate with. As one young employee explained, older employees do not feel comfortable using the new technology and feel marginalized in a public forum where the issues and topics are set by the younger generation. The younger employees felt that one needs to be "hip" to blog and do not share the same areas of interest with the older generations. Therefore, the younger generations did not see real value in blogging about "cool new stuff" as the senior employees might ignore them. Surprisingly, the

older employees identified similar problems, but from an entirely different perspective. One older employee, who was pending retirement at the time of the interview, wanted to use social computing tools to create a repository of all his knowledge and expertise but worried that the younger employees might not have interest in what he wanted to write about.

In this regard, organizations focusing on promoting nontraditional technologies such as social computing platforms should move beyond the traditional understanding of the effect of age and gender on technology adoption and usage. In driving these initiatives, organizations may have to focus not only on the younger employees but also on those individuals that actively participate and share information, and give incentives to these individuals to discuss the benefits of the technology with other employees of the same age group.

Our results suggest that the level of an employee in the hierarchy does not have a significant association with blog usage. This result contradicts the general assumption (also supported by previous research, e.g., [9]) that employees, as they move up the organizational hierarchy, tend to become resistant to change and have less time and resources to assess and use a new technology. This result can perhaps be explained by the fact that top management work is typically communication intensive and personnel oriented. Therefore, managers might have preferred blogs because they provide an easy means of communication that is richer than other tools such as e-mail. Two of our interview respondents, a functional-level manager and an enterprise-level IT services manager, explained that social computing tools have become an important tool in their communication with their subordinates, including keeping track of work reports as well monitoring organization-wide IT initiatives.

RQ3: What is the effect of positive feedback from others on the use of social computing technologies in organizations?

The results on the role of feedback suggest that continued use of technology is influenced not only by mere usage in the network but also by the constant feedback from others in the network. Corporate blogs are not just information transmission tools. They create opportunities for participative behavior. If others exploit this behavior, the blog author may create or maintain closer relationship with them via the tool. Our interview respondents suggested that feedback from the network can help the blog users in three ways. First, it helps them gain a perception of social existence. Blog usage is directly connected with being a part of an interactive community, and feedback votes help the employees activate communication with, and gain acceptance from, people who are most important to them. Second, feedback is an important indicator of perceived critical mass—that is, employees' perception that the network has reached sufficient acceptance to be useful and sustainable. In other words, feedback is essentially a visible evidence of critical mass. Third, it enables individuals to observe the consequences of usage (by themselves and others). Feedback votes influence the perceptions of both the capabilities of various tools and the appropriateness of use. Feedback, therefore, helps reinforce the norms of usage that subsequently become routinized. Previous research

on communication tools such as groupware suggests that perceptions of critical mass and social existence are important determinants of sustained usage [41]. However, in this study, we do not specifically delineate the feedback votes from various social groups in the organization. It can be assumed that while any feedback is encouraging, the relative effect of the source of feedback need not be symmetric. Further, the influence of feedback on sustained use of technology might be heterogeneous—that is, it can vary in the characteristics of both the user and the provider. It is important for future research to examine these aspects of social computing tools.

Limitations and Future Research

The main limitation of the paper is that we use only log data to analyze the usage of blogs. This prevents us from analyzing psychographic characteristics, motivations, and procedural rules that drive employee usage of blogs in the corporate environment. Also, we measure usage by the number of blog posts that an individual creates. Blog posts can be of various types, such as posting new content or commenting on an existing blog. Our aggregation does not distinguish between these types. Further, our research consists of data from a single organization, and it would be interesting to study how organizational characteristics such as culture and structure moderate the relation between network effects and blog usage.

There is little research on the usage of technologies where usage is bottom-up. On one hand, because these technologies do not have proven benefits and structures, businesses generally adopt and use them in an ad hoc manner. At the same time, our results indicate that the use of these new technologies does get subjected to organizational rules and procedures. However, it is still not clear how these contradictory aspects affect adoption and usage, especially when studied at different levels of analysis—that is, at both the organization and the individual level. Future research should employ cross-sectional surveys to develop comprehensive theoretical models that can guide the study of such technologies in organizational contexts.

An interesting feature of blogs is the practice of tagging. Tagging and trackbacks create a social bookmarking system that enhances the utility of the blogs. When individual bloggers refer to each other, and create tag clouds, it leads to rapid information dissemination, and also formation of topics (and blogger) clusters. Recent studies show that such social networks and clusters of blogs have both positive and negative consequences. However, such information is not available in the case of corporate blogs. It is important that IS researchers explore the structural and social attributes of blogs in organizations and how they affect information flow and knowledge sharing.

Finally, social computing tools differ from typical message-centric mediums because they enable individuals to construct their digital identity by photo sharing, friend lists, and other socially relevant information. Modern organizational communication is information rich, and social processes are critical to information search, access, and retrieval. A structured social interface, therefore, provides ready access to coworkers, reflecting both affiliations and social relationships, and is useful in the associative retrieval processes characteristic of social information gathering [10, 42] (“I can’t

remember the name of the person who knows about topic X, but I can remember the other people she worked with"). Future research should examine the role of these characteristics in driving blog usage.

Conclusions

TO SUMMARIZE, WE EXTEND THE EXISTING LITERATURE on the role of social influences in technology use in the following ways:

1. We apply the concept of network externalities from economic theory to complement the explanatory power of social influence theories on how others' usage influences use of social computing tools such as blogging. This is also new because although network effects have been studied for generic communication technologies, they have not been directly studied for blogging. The generally positive results show that network effects are important as hypothesized. The work validates the intuition that it is the "socialness" of this new breed of technology that leads to usage and that use by others begets additional use.
2. We also contribute to this literature by studying blog usage in different types of networks such as managers, relational networks, positional networks, and spatial networks. Further, we also show how the moderating effect of individual characteristics, especially age, is different for social technologies such as blogs as compared to traditional technologies studied in prior literature. The results will also be helpful for managers who want to increase and manage the use of social technologies, as well as for researchers interested in further deconstructing the form and nature of network effects and usage.
3. We contribute to the discussion on reinforcement theory in organizations by showing that individual behavior can be shaped through reinforcements from peers in an organization through informal and voluntary mechanisms such as "thank you votes" as opposed to formal mechanisms such as rewards and punishments.
4. The context of use and methodology are also relatively novel. We examine actual (as opposed to perceptual) use and connect that usage with objective factors such as actual use by others. The focus is on voluntary usage in a bottom-up manner. Traditional use and adoption research meanwhile tends to focus on transactional and enterprise tools that are introduced in a top-down manner and typically mandate use.

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NOTE

1. The company provided us data on blog usage by 2,978 individuals; after deleting observations with one or more missing fields, we are left with data on 2,291 individuals.

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