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THE PROVISION OF ONLINE PUBLIC GOODS: EXAMINING SOCIAL STRUCTURE IN A NETWORK OF PRACTICE

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Abstract

Networks of practice (NOPs) are social spaces where individuals working on similar problems self-organize to help each other and share perspectives about their occupational practice or common interests, and exist primarily through computer-mediated exchange. This exchange of knowledge through message postings produces an online public good, where all participants in the network can access the knowledge, regardless of their contribution. Thus, this research builds upon theories of collective action and public goods to better understand the provision and maintenance of knowledge in a network of practice. We use social network analysis to examine the following research questions: (1) What is the pattern of contribution that produces and sustains the public good? (2) Are NOPs maintained by a critical mass? (3) How does the heterogeneity of resources and interests of participants impact the collective action of the NOP? We find that the network of practice is sustained through generalized exchange, is supported by a critical mass of active members, and is shaped as a star. The critical mass is significantly related to tenure in the occupation, expertise, availability of local resources, and desire to enhance one's reputation.

1 INTRODUCTION

Recent advances in information and communication technologies have led to the development of extra-organizational electronic networks. These electronic networks enable the creation of weak structural links between thousands of geographically dispersed individuals, who are typically strangers and come from diverse organizational, national, and demographic backgrounds (Sproull and Faraj 1995). In these networks, individuals are able to engage in knowledge sharing, problem solving, and learning through posting and responding to questions on professional advice, storytelling of personal experiences, and debate on issues relevant to the community (Wasko and Faraj 2000). Individuals benefit from these networks since they gain access to new information, expertise, and ideas that are often not available locally. Termed networks of practice (NOPs), these electronic networks exist primarily online and are similar to communities of practice in that they are a social space where individuals working on similar problems self-organize to help each other and share perspectives about their occupational practice or common interests (Brown and Duguid 2000).

Despite the growing interest in online cooperation and virtual organizing, surprisingly little empirical research has investigated the communication and organizing processes in online networks (Lin 2001; Monge et al. 1998). Thus, the goal of this research is to better understand these emerging organizational forms by drawing upon the well-established theories of public goods and collective action. Building upon work by Fulk et al. (1996), we extend collective action theories to interactive communication systems, examining participation in NOPs as a form of collective action. The collective action is exhibited through the interactive posting of and responding to messages on the network. This interaction produces and maintains the public good of a continuous stream of relevant practice knowledge that all participants may access.

This extension of collective action and public goods theories to NOPs is highly exploratory. Thus, rather than test hypotheses, we develop and examine three research questions fundamental to collective action theories in order to enhance our understanding of the dynamics underlying and sustaining NOPs: (1) What is the pattern of contribution that produces and sustains the public good? (2) Are NOPs maintained by a critical mass? (3) How does the heterogeneity of resources and interests of participants impact the collective action of NOPs? To address these questions, we collected postings from a successful NOP during two months and then administered a survey to all active participants. The shared practice of this network was U.S. federal law, where participants (lawyers) actively engaged in exchanging legal advice. The paper concludes with a discussion of findings and areas for future research.

2 THEORY DEVELOPMENT

Members of a collective must often make decisions that balance the benefits of maximizing self-interest with the collective's interests. This phenomenon is best explained through an example, such as wheat farming. Wheat prices are primarily set by market supply and demand. Each farmer attempts to grow and sell as much wheat as possible to obtain the greatest profit. However, in surplus years, there is the risk that prices fall dramatically if farmers flood the market with wheat. Thus, for the collective, the rational action is to restrict the total market supply of wheat to maintain high prices. However, each farmer has the individual incentive to try to sell as much wheat as possible. Yet when each individual acts rationally, the market is flooded and wheat prices fall, leaving everyone with less profit. Thus, the sum of individually rational actions leads to collective irrationality, leaving everyone worse off.

This example is a special problem referred to as a social dilemma. Social dilemmas arise when a set of individuals act rationally in their own self-interest, yet the sum of their actions leads to collective irrationality (Kollock 1998). Social dilemmas involving more than two individuals are N-person dilemmas and fall into two categories. First, the provision of public goods dilemma, or the social fence, involves the *production* of a public good. Public goods are resources from which all individuals in a collective may benefit regardless of whether they have contributed to providing the good, such as a public park or public television (Kollock 1998). In the provision of public goods dilemma, the optimal individual decision is to enjoy the public good without contributing anything to its creation or maintenance.

The specific characteristics of a public good have implications for its provision and use. First, a public good is a resource that can be provided only if members of a collective contribute toward its provision. It is *non-excludable*, i.e., the good cannot be withheld from any member of the collective, even if he or she does not participate in the production or maintenance of the good (Komorita and Parks 1995). The second characteristic refers to *jointness of supply*: the cost of providing the good is the same regardless of the number of people benefiting from the good (Olson 1965; Samuelson 1954). A third characteristic is known as *nonrival*, meaning that one person's use of the good does not diminish its availability to others in the collective. True public goods are completely non-excludable and nonrival and have jointness of supply although many public goods exhibit these characteristics to varying degrees (Kollock 1998).

The second type of social dilemma is the social trap or the tragedy of the commons and involves the *consumption or replenishment* of a joint good. The commons dilemma differs from the provision of public goods dilemma because the joint good is not a public good. Rather the joint good is *subtractable*, the opposite of nonrival. In other words, the use of the joint good by one individual diminishes the availability of the good to another individual, resulting in the "tragedy of the commons" (Kollock and Smith 1996).

This research focuses on the production of knowledge as a public good in NOPs. In the formal language of collective action theory, the network participants are the interest group and the public good is the continuous stream of knowledge produced and jointly held by the network's participants. We argue that the knowledge produced by the NOP in this study is a true public good. First, it is non-excludable due to the network's open nature. When one participant responds to a posting, then all members may benefit from this knowledge, even though they did not contribute to its production through either posting or responding. Second, this knowledge exhibits jointness of supply because it costs just as much to produce the knowledge for use by one person as for use by thousands. Finally, the knowledge is nonrival because even if the person receiving the help uses the knowledge, it still remains available to other members, who may also apply the knowledge in their own situations. Thus, the social dilemma faced in NOPs is the provision of public goods dilemma. Specifically, we are interested in understanding how open, voluntary NOPs are sustained, given that individuals are better off not contributing and free-riding on the efforts of others.

Theoretical and empirical studies of collective action and public goods have been extensively conducted in the past. However, recent advances in computer-mediated communication facilitate online cooperation and communication between strangers, and

have led to the development of a new type of social network and thus a new forum for collective action. As a result, the goal of this research is to examine a new phenomenon—networks of practice—to test the theoretical lens of collective action. Prior research in social dilemmas has identified critical factors underlying the production and maintenance of public goods (Fulk et al. 1996; Oliver and Marwell 1988; Oliver et al. 1985). Building upon this research, we examine these factors through three research questions, providing evidence from our study. Specifically, we examine the patterns of exchange, the presence of a critical mass, and the heterogeneity of resources and interests among actors to better understand the provision of online public goods in networks of practice.

3 STUDY DESIGN AND DATA COLLECTION

Conducted in a field setting, this study examines a single extra-organizational NOP supported by a professional legal association in the United States. All association members have access to the NOP as part of their membership benefits, yet participation is voluntary. Individuals were chosen to take part in this study based on their NOP participation, which consisted of posting a message to the network during a 2-month time frame (April and May 2001). This NOP was supported by bulletin board technology, similar to that of Usenet newsgroups where questions and responses are connected in a thread, resembling a conversation.

The name of the person posting was included in each message. During the 2 months, there were 2,460 messages posted to the network by 526 unique individuals. Each participant was sent a survey, and we received 152 valid responses for a response rate of 29 percent. To assess response bias, we compared the participation rates of survey responders with those of nonresponders and found that the participation rates of the two groups were not significantly different ($F = .823, ns$). We use both the objectively collected message postings as well as survey results to examine our research questions. The following sections examine the three research questions as well as the specific data and methods used to explore each question.

4 RESEARCH QUESTIONS AND RESULTS

4.1 RQ1: What Is the Pattern of Contribution That Produces and Sustains the NOP Public Good?

The first key issue for examination is the pattern of contributions that create the good. In NOPs, contribution is reflected in the posting of questions and replies that take the form of a conversation. This interaction creates social ties between participants. We define a social tie in NOPs as the tie created between two individuals when one person responds to another's posting. While it has been argued that social ties are important for collective action, it is less well established as to exactly how and why social ties are important (Marwell and Oliver 1988). Initial research proposes that the overall frequency or density of social ties within a group is related to the achievement of collective action. When networks are dense, consisting of direct ties between all members, collective action is relatively easier to achieve. This argument goes back to Marx, who reasoned that the more individuals are in regular contact with one another, the more likely they will develop a "habit of cooperation" and thus act collectively (Marwell and Oliver 1988). Thus, one view is that NOPs may be characterized by a dense network structure, where all members interact with all other members.

An alternative view suggests that the pattern is more like a reciprocal gift exchange. This view suggests there is a dyadic exchange between a help provider and a help seeker, with the expectation that the gift of help will be reciprocated sometime in the future (Kollock 1999). Thus, the nature of exchange in an NOP may be structured as reciprocal dyadic exchanges between individuals, where the motivation to help others stems from the expectation of obligation and reciprocity from the receiver. A third view stemming from collective action argues that public goods can be provided through generalized exchange (Fulk et al. 1996). A generalized exchange occurs when one's giving is not reciprocated by the recipient, but by a third party (Ekeh 1974). In contrast to dyadic exchange characterized by direct reciprocity and accountability, generalized exchange is based on indirect reciprocation and interest-based contribution. Therefore, NOPs may also be sustained through generalized exchange.

RQ1 Results. All NOP messages were examined to determine the identity of the person posting, and were then coded as seeds (the first message in a thread), singletons (seeds without responses), questions, responses, or other. We built a social network matrix consisting of all 526 participants to determine who was responding to whom, creating a directional, social tie. The first

question examines whether individuals are participating equally. If people participate equally, we would expect all participants to have posted the average of 4.7 messages. However, the median participation is two message postings, and 64.8 percent of network members posted less than four messages, indicating that people are not equally sustaining the public good. The frequency rates of participation are provided in Table 1.

Table 1. Frequency of Participation

Messages Posted	Individuals	Percent	Cumulative Percent
1	173	32.89	32.89
2	109	20.72	53.61
3	59	11.22	64.83
4	34	6.46	71.29
5	28	5.32	76.62
6-10	72	13.68	90.30
>10	51	9.69	100.00

We are also interested in examining whether the exchanges are directly reciprocal or generalized. The data indicate that there were 1,306 social ties (exchanges) between 455 individuals, and the same individuals reciprocated 130 of these exchanges. Thus, only 10 percent of the social ties sustaining the network are directly reciprocal. General findings and results are summarized in Table 2. These findings indicate that people do not participate equally in the public good provision; rather, the NOP is sustained through generalized exchange between members.

Table 2. Summary of Exchanges

Number of Unique Participants	526
Number of Messages Posted	2,460
Average Participation Rate	4.7 messages/person
Number of Seeds	1,121 by 436 individuals
Number of Singletons	104 by 71 individuals
Number of Threads	1,017, average length 2.4 messages
Dyadic Exchanges	1,306 between 455 individuals
Unique Exchanges	1,176
Direct Reciprocal Exchanges	130, 10% of total

4.2 RQ2: Are NOPs Maintained by a Critical Mass?

The results of research question 1 indicate that NOPs may be sustained by a critical mass of active participants. Until recently, the majority of formal collective action analyses assumed that contribution was uniformly distributed across members. However, a competing argument suggests that a subset of the group may be responsible for making the majority of the contributions to the production and maintenance of the public good. Borrowing from nuclear physics, this subset is labeled critical mass, referring to the idea that a certain threshold of participation or action has to form before a social movement may come to exist (Oliver et al. 1988). Oliver and Marwell (1985, p. 524) define critical mass as “a small segment of the population that chooses to make big contributions to the collective action while the majority do little or nothing.” They suggest that critical mass consists of those individuals who deviate the greatest from the average, and they argue that the number of such deviants as well as the extremity of their deviance is key to predicting collective action.

Research has often found that group size is the best predictor of collective action since larger groups have more people and potential resources for action (Scott and El-Assal 1969). Theoretically, however, it has also been suggested that it is more difficult to sustain collective action in large groups as contributions are more likely to go unnoticed or be seen as unnecessary (Hardin 1982). The Oliver-Marwell studies suggest that the effect of group size depends on the costs of providing the good. If the costs of the good rise with the number who share it, larger groups are less likely to act than smaller ones. However, under pure jointness of supply (the costs of providing the good are the same, regardless of the number that consumes the good), large groups are more likely to attain a critical mass of interested individuals. In other words, under conditions of pure jointness, free-riders are not a burden to those who contribute, thus it is not necessary to have the participation of all members (Macy 1990).

Networks of practice are characterized by pure jointness of supply. Thus, theoretically, we can expect that the collective action in the NOP under study is sustained through the efforts of a few core individuals who constitute a critical mass. This suggests that there is a core number of participants who are contributing responses to all other members. Thus, we are interested in examining whether the NOP has a critical mass of participants sustaining the good for all, or whether the NOP is sustained through some other pattern of exchange. For instance, an alternative explanation is that there are cliques or small groups of active participants that only respond to each other. Thus, in lieu of a critical mass, the NOP might consist of a collection of smaller social networks with little interaction across cliques. A third alternative is that a central core sustains the NOP. A core would consist of a small group of individuals corresponding with each other (one clique), with little regard to peripheral members.

RQ2 Results. As in RQ1, we examine critical mass by looking at the pattern of social ties. The presence of a critical mass is determined by the degree to which social ties are centralized or concentrated to a few individuals rather than spread across the entire group. We investigate the question of critical mass by examining the participant matrix. As apparent from Table 1, some members are significantly more active than others, indicating the likelihood of a critical mass. Based upon the analysis of messages and drawing upon previous research (Wenger 1998), we created four categories of participants: outsiders (people that posted seeds, but never received a response), seekers (people that posted only questions), periphery (people that posted 10 or less responses) and insiders (people that posted more than 10 responses). Using UCINET software (Borgatti et al. 1999), we analyzed the ego network of each individual to determine centrality in terms of “in degree” (the number of times other people respond to an individual) and “out degree” (the number of times an individual responds to others). Table 3 summarizes these categories.

Table 3. Categorization of Participation

Category	#	Average In Degree	Range In Degree	Total In Degree	Average Out Degree	Range Out Degree	Total Out Degree
Outsiders	71	0	n/a		0	n/a	0
Seekers	166	2.08	1-15	346	0	n/a	0
Periphery	266	2.53	1-15	673	2.48	1-10	660
Insiders	23	12.48	4-33	287	28.09	11-114	646

This analysis indicates that there are 23 insiders who are the most active in posting responses to other members. In addition, we analyzed the data matrix using UCINET to determine whether the network has a core/periphery or clique structure. Results indicate a low core/periphery score of 0.27, indicating that there is no central core of individuals closely tied to each other. Second, we performed a component analysis, which revealed that the NOP is characterized by only one component and not a set of subsets, indicating that the NOP does not have multiple cliques. This indicates that the critical mass consists of these 23 insiders who sustain the network by helping other members, not simply engaged in conversations with each other within the core.

Additional analysis indicates that the 4 percent of total members (comprising the insider critical mass) posted 646 responses (approximately 50 percent of the exchanges). Of these responses, 84 percent were to unique individuals, also indicating little overlap within the critical mass. In addition, this analysis indicates that peripheral members are actively engaged in generalized reciprocity: Individuals in the periphery are the recipients of 52 percent of the exchanges and are responsible for sustaining 50 percent of the exchanges by replying to others. By analyzing the unique number of participants in these exchanges, we note that of the 673 messages received by members in the periphery, 614 (91%) were from unique individuals. Of the 660 response messages posted to others, 635 were to unique individuals (96%). Thus, in addition to the critical mass, this analysis indicates that there is a second group of peripheral individuals that help sustain the network through less active, generalized reciprocity.

Thus, the network is structured as a star with a critical mass surrounded by peripheral connections emanating outwards. There are no cliques; rather, the critical mass actively responds to many unique and overlapping individuals, and the periphery engages in both receiving and providing advice to others. Figure 1 shows the network structure (using Krackplot) and was created using only survey respondents (to create a manageable subset of participants).

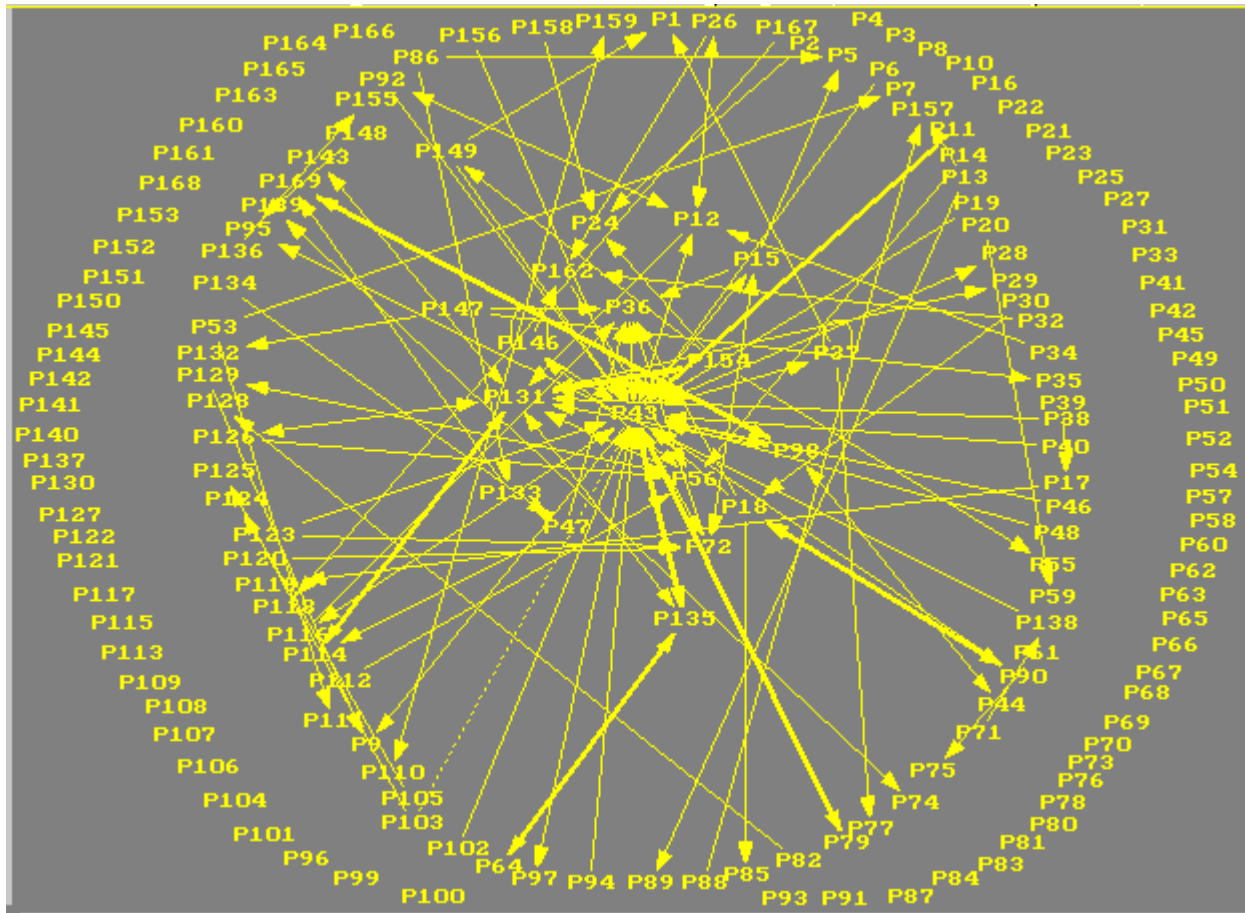


Figure 1. Network Structure

4.3 RQ3: How Does the Heterogeneity of Resources and Interests of Participants Impact NOP Collective Action?

The results of research question 2, indicating the presence of a critical mass, suggest that there is heterogeneity of resources across individuals. The population’s heterogeneity of resources and interests is argued to affect collective action (Hardin 1982; Oliver et al. 1985; Olson 1965). The more heterogeneous a group is, the more likely there is a critical mass or subset of members who have a high enough level of resources and/or interest to produce the public good. However, heterogeneity can also hinder collective action even when the mean levels of heterogeneity appear sufficient. As such, the distribution of heterogeneity is important in terms of collective action, i.e., the more positive skew and deviation from the mean, the more likely a critical mass may result (Oliver et al. 1985).

In most collectives, individuals have differing levels of interest in seeing the public good realized, and individuals with higher interest levels are those who tend to gain more from additional contributions to the public good. Hardin (1982) argued that individuals with a high interest level are those who lack private alternatives. Individual interests also vary in their underlying motivations for seeing the good realized, which also affects the potential contribution level (Marwell and Oliver 1988), and these motivations may include social and/or professional motivations (Wasko and Faraj 2000). In addition to interests, individuals also

possess differing levels of resources. Resources include money, time, expertise, energy, and influence (Oliver et al. 1985). For a public good to be produced and maintained, it is argued that those forming the critical mass are more likely to have access to the required resources. Previous research has found that people who have higher levels of professional expertise and organizational tenure are more likely to provide useful advice on computer networks (Constant et al. 1996). Thus, the final research question examines the role of individual interests and resources underlying the provision of online public goods.

RQ3 Results. We examine the importance of resources and interests by analyzing the correlations between network centrality data and survey measures of resources and interests. The survey assessed two types of resources: (1) NOP expertise measured by the number of months an individual was a member of the professional association (objective measure from association member database) and (2) professional expertise measured by self-rated expertise. We assessed four types of interests: (1) professional motivations of reputation, (2) a desire to learn and challenge oneself, (3) social motivation of sustainability of participation, and (4) lack of private alternatives. Alternatives were assessed by examining the type of law firm (sole practitioner = 1, associate = 2, partner = 3), indicating that a lawyer in a sole partnership would have fewer private alternatives for professional discussion than a lawyer in a law firm with more colleagues. The multi-item constructs collected via survey demonstrated adequate reliability, convergent and discriminant validity, and were calculated by taking the average of the items. Actual items, reliabilities, and factor analysis are reported in Appendix A. Table 4 presents the correlations between constructs.

Table 4. Correlations of Constructs

	1	2	3	4	5	6	7
1 Months in Association							
2 Expertise	.44**						
3 Type of Firm	.16*	.01					
4 Reputation	.04	-.01	.05				
5 Sustainability	-.40**	-.26**	-.04	.25**			
6 Challenge	-.39**	-.23**	-.10	.16*	.68**		
7 In Degree	-.01	.03	-.09	.12	.23**	.15*	
8 Out Degree	.17**	.15*	-.15*	.18*	.12	.02	.73**

* $p < .05$

** $p < .01$

This analysis suggests that the resources and interests examined in this study had little correlation with people *receiving help* (in degree). The only significant relationships with in degree are sustainability and challenge, thus those who receive help are interested in continuing their NOP participation and the challenge associated with doing so. Resources and interests had higher associations with *responding to others* (out degree). The results indicate that longer professional association tenure and higher levels of expertise are associated with responding to others. In addition, individuals who are sole practitioners are significantly related to responding to others as are those concerned with enhancing their reputations. Thus, while interests and resources were not as significant for people who receive help, they are reasonably good indicators of why people provide knowledge to others.

5 DISCUSSION AND AREAS FOR FURTHER RESEARCH

Theories of collective action and public goods contribute significantly to our understanding of NOPs. In this particular NOP, the public good of knowledge was produced through a generalized exchange between members. However, this exchange was not evenly conducted by all members; rather, it was sustained by a critical mass of individuals who primarily responded to others and not only to themselves. This critical mass was then surrounded by a group of peripheral individuals who both asked and received advice. Thus, the network is structured as a star with a central critical mass and connections radiating outwards. In addition, the heterogeneity of resources and interests provided good indications of why people contributed to the public good provision. Therefore, we have support to proceed further with these theories to help us understand NOP dynamics.

However, we examined only one specific type of NOP, an extra-organizational network using bulletin board technology. Other types of NOP interactive technology exist (such as moderated bulletin boards, listservs and chatrooms), and the use of these different media may affect NOP dynamics. For instance, the norms of the professional association listserv supporting this conference (ISWorld) dictate that responses should be sent privately to the seeker, not posted publicly. This type of exchange may be better supported theoretically as a dyadic social exchange, rather than maintenance of a public good (Blau 1964). In addition, this study was conducted over 2 months and relied on cross-sectional survey data. Thus, we were not able to investigate changes over time, how the critical mass formed, or how the public good was achieved in the first place. Subsequent studies should include longitudinal data to better understand NOP life cycles, as well as increase our understanding about the nature of interdependence of individuals' decisions to contribute to the public good. It has been argued that reciprocal interdependence and not sequential interdependence characterizes interactive communication systems (Fulk et al. 1996). However, it has yet to be tested empirically.

A final issue of interest to managers and researchers is the problem of free-riders and how they affect NOP dynamics. Free-riders are those "who do not contribute sufficiently to the jointly held body of information while continuing to enjoy its benefits" (Fulk et al. 1996, p. 78). Two explanations have been provided: (1) individual greed or the desire to obtain the best possible outcome for oneself and (2) the "fear of being a sucker" or the fear that no one else will contribute even though one wants to (Kollock 1988, p. 189). In NOPs, individuals may free-ride through lurking, reading all messages to gain access to the network's knowledge without ever posting themselves. There is also the issue of whether people who continually ask questions, receive help from the NOP, but never bother to help anyone else in the NOP are free-riders. It can be argued that these individuals actually do contribute to the public good because they stimulate the thought processes by other participants. However, this participation only works if there is a critical mass who continue responding to questions, basically providing a free help-desk to others.

In conclusion, this study's goal was to apply the theoretical lens of collective action and public goods to examine online cooperation through the provision and maintenance of knowledge in NOPs. Our findings suggest some practical implications for the development and maintenance of NOPs. First, it seems possible that NOPs do not need equal member participation, but rather can be sustained through the collective actions of a small percentage of members who form a critical mass. At least in the case of our study, this critical mass was able to provide the public good through generalized exchange of advice and solutions. One of the key findings from this study was that individuals who make up the critical mass in this NOP were concerned with enhancing their reputations in the network, thus technology that supports identifiers of individuals may be more likely to succeed than systems where participation is anonymous. In addition, we found in our case that those most likely to develop the critical mass were tenured experts in their area, but did not have easy access to colleagues. This suggests that when a local community of practice is not available for face-to face interaction, NOPs may present a viable alternative for sustaining knowledge exchange.

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Appendix A

	α	1	2	3	4	5	6
Number of Months in Association		0.88	0.27	0.09	0.05	-0.25	-0.13
Self-Rated Expertise		0.22	0.94	0.00	-0.02	-0.13	-0.10
Type of Practice		0.07	0.00	0.99	0.06	-0.02	-0.03
I earn respect from others by participating on the NOP	.87	0.00	0.18	-0.04	0.87	0.06	0.11
I feel that participation improves my status in the profession		-0.09	-0.04	0.07	0.91	0.10	0.00
Participating on the NOP improves my reputation in the profession		0.13	-0.16	0.05	0.85	0.11	0.05
I intend to continue participating on the NOP	.83	-0.15	-0.03	0.03	0.15	0.79	0.31
I intend to use the NOP for the foreseeable future		-0.11	-0.08	-0.01	0.09	0.82	0.40
I intend to use the NOP at least as regularly as I do now		-0.09	-0.12	-0.04	0.10	0.91	0.14
Participating on the NOP gives me the opportunity to learn new things	.88	-0.33	-0.12	-0.12	0.01	0.44	0.69
I participate on the NOP to be exposed to complex problems and issues		0.12	-0.10	-0.03	0.08	0.21	0.89
I find participating on the NOP interesting		-0.31	0.05	0.07	0.08	0.42	0.72