Knowledge Sharing: Effects of Cooperative Type and Reciprocity Level

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ABSTRACT

Knowledge sharing is an important research area in knowledge management. This study broadens the perspective on knowledge sharing by investigating an individual's behavior type as a cooperator, reciprocator, and free rider toward knowledge contribution. In this study, we view shared knowledge in a community of practice as a public good and adopt a theory of reciprocity to explain how different cooperative types affect knowledge contribution. In the perspective of shared knowledge as a public good, people may react in three ways: they share knowledge without need for reciprocity (cooperators), they feel obligated to share their knowledge (reciprocators), or they take knowledge for granted (free riders). Analytic and simulation results reveal that the fraction of cooperators is positively related to total knowledge contribution and to the reciprocity level, while the reciprocity level positively affects knowledge contribution.

Keywords: *communities of practice; knowledge sharing; public goods dilemma; simulation; theory of reciprocity*

INTRODUCTION

In communities of practice (CoP), members share knowledge related to common interest. Members respond to inquiries for knowledge despite weak or nonexistent personal ties (Constant, Sproull, & Kiesler, 1996; Hiltz, Johnson, & Turoff, 1986; Walther, 1994; Wellman & Gulia, 1999). Rational choice and Nash equilibrium (Nash, 1950) assume that rational participants seek answers from the CoP without responding to questions from others, because responding requires time and effort, and rational self-interest choice would get benefits without incurring costs. If everyone in a CoP follows the behavior of a rational human being according to Nash equilibrium, all should seek information without contributing. However, in real-world settings, interaction and information exchange are observed. This study asks why people contribute their insights and advice, and provides recommendations for more cooperative CoP.

From the economic literature, three types of cooperative behaviors toward public goods have been identified: co-operators, reciprocators, and free riders. The fraction of these types is consistently stable (Fischbacher, Gächter, & Fehr, 2001; Kurzban & Houser, 2005). Shared knowledge in online communities has been viewed as a type of public good (Cabrera & Cabrera, 2002; Lu & Leung, 2004). The public good dilemma is that free riders will take advantage of publicly provided goods without contributing to the development of such goods. The dynamics from each type of sharing behavior require the use of simulation to gather results on knowledge sharing estimation with varying possible situations in a CoP.

The article is organized as follows. First, we review the literature on public goods and theories on voluntary contributions. We also gathered previous studies on behaviors of cooperators, reciprocators, and free riders. Based on these empirical results of the cooperative type and reciprocity level, we develop analytic models and report simulation model results with various combinations of cooperative types in order to evaluate how these combinations actually affect the amount of shared knowledge in a certain amount of time. Finally, we discuss how our empirical findings improve our understanding on how knowledge is shared in a CoP based on the cooperative type and reciprocity level.

KNOWLEDGE SHARING

A great deal of research has been conducted to explain the knowledge sharing (contribution) behavior in weak relationships from varying perspectives, including embeddedness (Uzzi & Lancaster, 2003), social exchange theory (Kankanhalli, Tan, & Wei, 2005; Wasko & Faraj, 2005), and motivation theory (BockZmud, Kim, & Lee, 2005). This study broadens the perspective on knowledge sharing behavior by investigating an individual's cooperative type as a cooperator, reciprocator, or free rider.

Communities of Practice

A community of practice is a conceptual gathering of people who are informally bound together in a shared expertise or practice. Wenger (1998) argued that strong interpersonal ties and norms of direct reciprocity are formed by joint sense making and problem solving in a community of practice. Brown and Duguid (2001) expanded the concept into the network version of community of practices, called networks of practice, that consist of a larger, loosely knit, geographically distributed group of individuals who may not know each other and are engaged in a shared practice. Building upon this general description of networks of practice, Wasko and Faraj (2005) defined an electronic network of practice as a special case of the broader concept of networks of practice in which the sharing of practice-related knowledge occurs primarily through computer-based communication technologies. These previous studies suggest that a CoP provides a collective knowledge base that varying members can access freely and to which they can contribute with or without expecting benefits. Stein (2005) found that organizational champions (e.g., cooperators) who bring sufficient knowledge and foster a rich intellectual environment are one of the key success factors of CoP, especially in its early growth and survival. He observed that "several core members …volunteered to make presentations until a network of 'topic providers' was created" (Stein, 2005, p. 17). Therefore, cooperators in CoP are important in terms of knowledge sharing, and their effect should be investigated in detail.

Theories for Voluntary Contribution Types Toward Public Goods

In voluntary contribution in which goods and services are allocated among consumers, contributors of these goods and services do not have any entitlement or priority, while users benefit from the contribution. These types of goods or service are called public goods (Komorita & Parks, 1994). Their defining feature is that they are both noncompetitive and nonexcludable (Croson, 1996). They are noncompetitive because multiple people can consume the good simultaneously and nonexcludable because it is not possible to exclude people who did not pay for consuming the goods. Three perspectives of public goods have been studied in order to explain the consequences or behavior of voluntary contribution. Becker's (1974) pure altruism, Sugden's (1984) reciprocity, and Andreoni's (1989, 1990) impure altruism provide unique models of voluntary contribution behavior.

Margolis' General Theory of Nonselfish Behavior: Cooperator

Becker's (1974) pure altruism was the basis for Margolis' (1982) concept of individual utility. As long as people maximize their own utility, no public goods exist. However, some people make contributions to the CoP knowledge bases regardless of the contributions of others. Thus, there are people who do not free-ride, and these people are not explained by utility maximization theory or by the theory of impure altruism. Margolis (1982) argued that each individual has two utility functions: S-utility representing one's self-interest and G-utility representing one's concern of the welfare of the group to which that individual feels that he or she belongs. In his theory, group welfare levels appear positively in an individual's utility function. This is based on the theory of altruism (Becker, 1974), in which individuals act nonselfishly and are motivated by a concern for group members' welfare.

Andreoni's Impure Altruism: Free Riders

If some take the contributions of others as given, they will contribute less as others contribute more and, eventually, will not contribute at all. These people are called free riders. Andreoni's (1989, 1990) impure altruism explains this negative correlation between an individual's contributions and the contributions of others. This definition is based on two assumptions. One is that people do not reduce consumption as their income increases. The other is that people behave in a manner that maximizes personal gain. From the perspective of free riders, there will not be any public good for anyone, because everyone maximizes self-interest by consuming without contributing (Dawes, McTavish, & Shacklee, 1997; Messick et al., 1983).

Sugden's Theory of Reciprocity: Reciprocator

Although Becker (1974) and Margolis (1982) provide possible explanations of voluntary contribution toward public goods through the theories of nonselfish behavior and impure altruism, there are still some unanswered questions that Sugden (1984) asked:

Supposed you have good reason to know that no one else in your group will con-

tribute anything towards a certain public good, irrespective of what you do. The only beneficiaries of your contribution would be yourself and the other members of the group. Why are you obliged to help them, when they refuse to help you?(p. 774)

Sugden (1984) argued that the principle of unconditional commitment may not work because people are not morally obliged to contribute when no one else contributes, and the existence of psychological barriers such as unfairness would repress contribution. He proposed a weaker version of the principle of unconditional commitment. One must not take a free ride when other people are contributing. This is opposed to the principle of unconditional commitment, which says one always must contribute toward public goods.

Theory of reciprocity (Sugden, 1984, 2002) takes the position that individuals choose the level of effort that they would most prefer when all other group members are making an effort of at least a certain amount in the production of a public good. Theory of reciprocity holds that one is never required to contribute more than other people in the group, overcoming unfairness that arises from the principle of unconditional commitment. Sugden (1984) emphasized that the individual has obligations to any group of individuals from whose efforts he drives benefits. Groups may not be formally constituted organizations but rather may be occupational, racial, religious, political, local, national, or international. In the CoP setting, when one feels that he or she has benefited from sharing knowledge with others, then that person may have a certain obligation to the group.

From these three theories on voluntary contribution to public goods, individuals can be categorized as free riders when they always maximize their own utility function by not contributing to other group members, as cooperators if they always contribute toward public goods, and as reciprocators if they always contribute no more than others contribute.

Shared Knowledge in CoP as a Public Good

Knowledge shared in a CoP can be regarded as a public good because people who do not pay or contribute to the CoP also can use the shared knowledge (nonexcludable), and multiple people can access shared knowledge simultaneously (noncompetitive). Cabrera and Cabrera (2002) conceptualized knowledge as a public good and analyzed knowledge sharing behaviors from the perspective of a public goods dilemma. In a CoP, one can choose to share or not to share one's knowledge with others, and others have the same options. If one avoids sharing while others share their knowledge, free riders can take advantage of others. Conversely, if one chooses to share while others do not share their knowledge, one can be a cooperator or a reciprocator. Based on the literature on cooperative type and knowledge as public goods, we categorize CoP members into three types in terms of their knowledge sharing behavior, as shown in Figure 1.

Evolutionarily Stable Strategies: Cooperator, Reciprocator, and Free Rider

Some people prefer to be cooperators or free riders, while others prefer to be reciprocators. In their public goods experiment, Fischbacher et al. (2001) focused on the subject's main task in order to identify the average contribution level of other group

Figure 1. Cooperative types in public goods

		Other People's Behavior: Share	Other People's Behavior: Not Share
Individual's Behavior	Share	Reciprocator	Cooperator
	Not Share	Free rider	Reciprocator

members by estimating how much each subject wanted to contribute to the public good. They found that 50% of the subjects conditionally contributed (reciprocator), and 33% of the subjects never contributed (free rider). Kurzban and Houser (2005) conducted a laboratory experiment and agent-based simulation that supported this result, arguing that individual strategies are not expected to be equally represented in the population and that equilibrium levels exist where all strategies were equally advantageous (13% of average pay-offs) with certain proportions for each strategy (13% of cooperators, 63% of reciprocators, and 20% of free riders). This supports the literature consensus that reciprocators make up the majority of the population with respect to voluntary contribution of public goods, and the other two types are found in relatively smaller fractions of the population.

Behavior of Reciprocator

Unlike cooperators and free riders, reciprocators contribute knowledge in reaction to other group members' knowledge sharing. In the context of knowledge sharing in a CoP, people may not know the exact amount of knowledge contribution made by others, but they may see that people share valuable knowledge in response to the inquiries of other members. As positive experience grows, reciprocators may feel some obligation to contribute to the group.

Laboratory experiments and simulations have shown how certain types of individuals behave differently in terms of their voluntary contribution tendency toward public goods (Engle-Warnick & Slonim, 2005; Fehr & Schmidt, 1999). Croson (1996) conducted an experiment that studied the relationship between an individual's contribution and the contributions of the group for three types: free riding (no correlation), cooperating (negative correlation), and reciprocating (positive correlation). In the experiment, an individual's contribution to a public good was compared with beliefs about the contribution of others in the group. Croson (1996) found a significant positive relationship between individual contributions and beliefs about those contributions. Engle-Warnick and Slonim (2005) conducted a repeated trust game, reviewed three extreme equilibrium strategies, and found that relationship length was related positively to trust and reciprocity, and the average reciprocity rate of 20 repeated games was about 77%. In online learning networks and social networks, Aviv and Ravid (2005) found that the average reciprocity was 0.43 with a standard deviation of 0.13 for online learning networks and 0.58 with a standard deviation of 0.14 for social networks. This implies that about half of the subjects reciprocated. Fehr and Gächter (2000) conducted ultimatum game experiments and found that the fraction of reciprocators was never below 40% and sometimes rose above 60%.

This literature shows that reciprocating as a voluntary contributing behavior on public goods does exist and has a positive relationship to the contributions of others. Therefore, we propose:

Proposition 1: There are three types of voluntary contribution behaviors (cooperating, reciprocating, and free riding).

Proposition 2: The three types of voluntary contribution behavior are stable with certain equilibrium ratios among populations.

Proposition 3: In free-riding and cooperating behaviors, no correlation exists between an individual's contribution and other group members' contributions.

HYPOTHESES

Research Model

Figure 2 presents our research model and hypotheses.

Effect of Cooperator Policy

Given the nature of voluntary contribution behavior toward public goods, the amount of shared knowledge in a CoP depends on the proportions of cooperators, reciprocators, and free riders. Therefore, there should be a certain number of cooperators prior to reciprocator knowledge sharing. To improve the amount of shared knowledge in a CoP, a policy that guarantees a certain proportion of cooperators can be implemented. With the enforced initial cooperator fraction larger than natural (where no policy is implemented), the amount of shared knowledge is expected to increase faster in a given time period.

Hypothesis 1: The cooperator fraction is related positively to the amount of shared knowledge.

Although all reciprocators do not contribute knowledge, prospective contributors will share knowledge when they meet some conditions (e.g., situation, factors, education, and experience) (Croson, 1996; Fehr & Henrich, 2003). One of such factor may be other members' cooperative behaviors, because reciprocators change their behaviors based on the behavior of others. As a reciprocator experiences other members' voluntary contributions, the reciprocity level will increase.

Hypothesis 2: The fraction of cooperators will be related positively to the reciprocity level.

Effect of Reciprocity Level

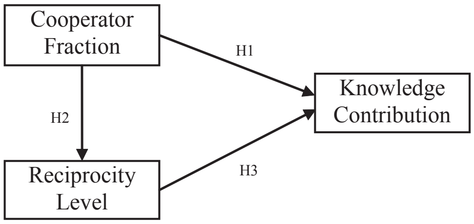
Engle-Warnick and Slonim (2005) found that there are varying levels of reciprocating. The reciprocity level is the probability of reciprocating in response to cooperators or other reciprocators' contribution behaviors, and a higher reciprocity level indicates a higher probability of reciprocating. The average reciprocity level found in their experiment was 77%. The reciprocity index (Zeggelink, 1993) is another measure of varying levels of reciprocity. Reciprocators with higher reciprocity levels will share more knowledge than reciprocators with lower reciprocity levels. The arbitrary reciprocity level is greater than 0 (free rider) and less than or equal to 1 (if he or she receives one, he or she contributes one)

Hypothesis 3: The reciprocity level will be related positively to the total shared knowledge.

METHODOLOGY

We adopt probability modeling (analytic models and simulation) in order to test the hypotheses of the study. Simulation is

Figure 2. Research model and hypotheses



preferred to standard analytical modeling approaches because simulation can provide information about dynamic behaviors of various actors in a CoP. The assumption of a distribution of each cooperative type in the population also makes simulation the preferred method. This numerical approach also allows us to manipulate the model and to make some guesses on how quantitatively important is the effect of fraction of cooperator and reciprocity levels in terms of knowledge sharing.

Assumptions

Based on the literature review in previous sections, the following conditions are assumed in conducting the simulation.

1. Knowledge is a type of public good.
2. Individuals fall into three types, and the individual's type is stable.
3. A group's cooperative outcomes can be well-predicted if one knows its type composition.
4. The amount of shared knowledge is determined by membership in the classes of cooperators, reciprocators, and free riders.

Reciprocity Level

Among three cooperative types, contributors and reciprocators are contributing knowledge. Reciprocators are influenced positively not only by cooperators but also by reciprocators who reciprocate positively. Therefore, we need to consider both the effect of cooperator policy and the increasing tendency of the reciprocity level reflected on the cooperator level simultaneously, because both affect the reciprocity level.

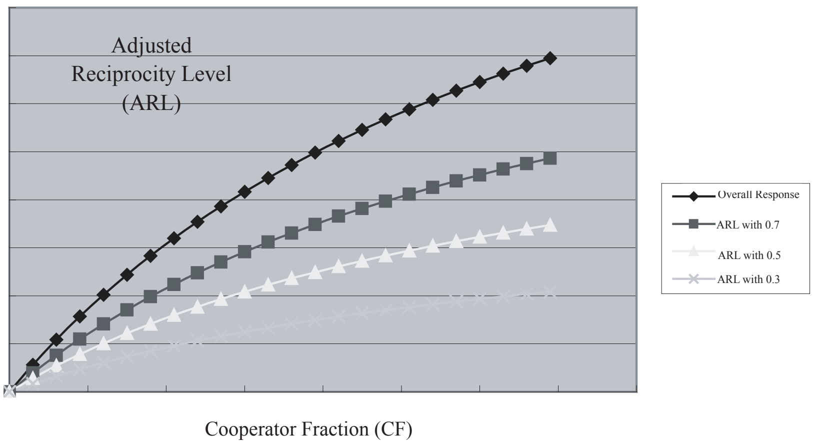
Since reciprocators have more contact with other members, their reciprocity levels are adjusted, and we assume that as reciprocators experience more of other members' sharing, their reciprocity level will increase. For this study, we label reciprocators as strong, median, and weak, based on their initial reciprocity level of 70%, 50%, and 30%. A demonstration of reciprocity levels as a function of cooperator fraction is provided in Table 1, which uses a membership ratio of 1-6-3 when initial reciprocity level is 0.7. A naïve reciprocator who never had negative experience from a CoP may believe that he or she always will get a response or an answer from a CoP. So his or her initial reciprocity level is 0.7. However, as he or she experiences responses from a CoP with such a combination, the probability that the reciprocator gets a response is much less than his or her initial reciprocity level because of free riders and reciprocators. However, this reduction of overall response from the CoP converges at some point, and adjusted reciprocity level is calculated based on the converged overall response shown in Table 1.

The fraction of cooperator in a group has positive effects on the reciprocity level, as shown in Figure 3 (Hypothesis 2). Under the consistency assumption, strong reciprocators are encouraged more to share knowledge as cooperator fraction increases.

Table 1. Change of response rate of strong reciprocators for 1-6-3 combination

Round	Contribution Fraction from			Overall Response (OR)	Adjusted Reciprocity Level (ARL)
	Cooperator (CFC)	Reciprocators (CFR)	Free Rider (CFF)		
0	100%	0%	0%	100%	70%
1	10%	42% $(=\frac{6}{10}\times 0.70\times 1.0)$	0%	52%	36.40%
2	10%	21.84% $(=\frac{6}{10}\times 0.70\times 0.52)$	0%	31.84%	22.29%
3	10%	13.37% $(=\frac{6}{10}\times 0.70\times 0.3184)$	0%	23.37%	16.36%
4	10%	9.82% $(=\frac{6}{10}\times 0.70\times 0.2337)$	0%	19.82%	13.87%
5	10%	8.32% $(=\frac{6}{10}\times 0.70\times 0.1982)$	0%	18.32%	12.83%
6	10%	7.70% $(=\frac{6}{10}\times 0.70\times 0.1832)$	0%	17.70%	12.39%
7	10%	7.43% $(=\frac{6}{10}\times 0.70\times 0.1770)$	0%	17.43%	12.20%
8	10%	7.32% $(=\frac{6}{10}\times 0.70\times 0.1743)$	0%	17.32%	12.13%

Figure 3. Cooperator fraction and reciprocity level



This means that reciprocators in a 1-6-3 combination would be discouraged more and would adjust their reciprocity level by lowering it, while reciprocators in a 5-2-3 combination would be encouraged most and would increase their reciprocity level. This verifies Hypothesis 2 that more cooperators in the CoP leads to a higher adjusted reciprocity level of reciprocators.

Simulation

Algorithm for Classification of Cooperative Type

To represent the stable fraction of cooperators, reciprocators, and free riders in the population, we adopt a positive feedback process model that reinforces a given tendency of the system that can lead away from equilibrium states. Arthur (1990) built this model to explain why one technology ultimately would dominate other technologies when multiple technologies are competing in the same market. In the positive feedback model, if one technology is slightly preferred over others in the initial stage, this initial small preference will attract more people to choose the technology instead of alternatives, and more people will select the technology while fewer people eventually will select alternative technologies (Arthur, 1990).

In a CoP, some may prefer to be free riders who are not willing to share knowledge under any conditions or cooperators who are willing to share anyway, while others act as reciprocators who sit back and watch what others are doing and reciprocate based on others' behaviors. Such preferences are set initially based on personal characteristics. As the positive feedback of each choice is processed or experienced, a certain portion of the population will stick to certain cooperating types, and the ratio of each type will be consistent (Kurzban & Houser, 2005). Using this cooperative type classification with the positive feedback process, the fraction of cooperators, reciprocators, and free riders will stabilize if we believe that there are fixed ratios of behavior (Fischbacher et al., 2001; Kurzban & Houser, 2005).

Distribution of Reciprocity Level for Reciprocators

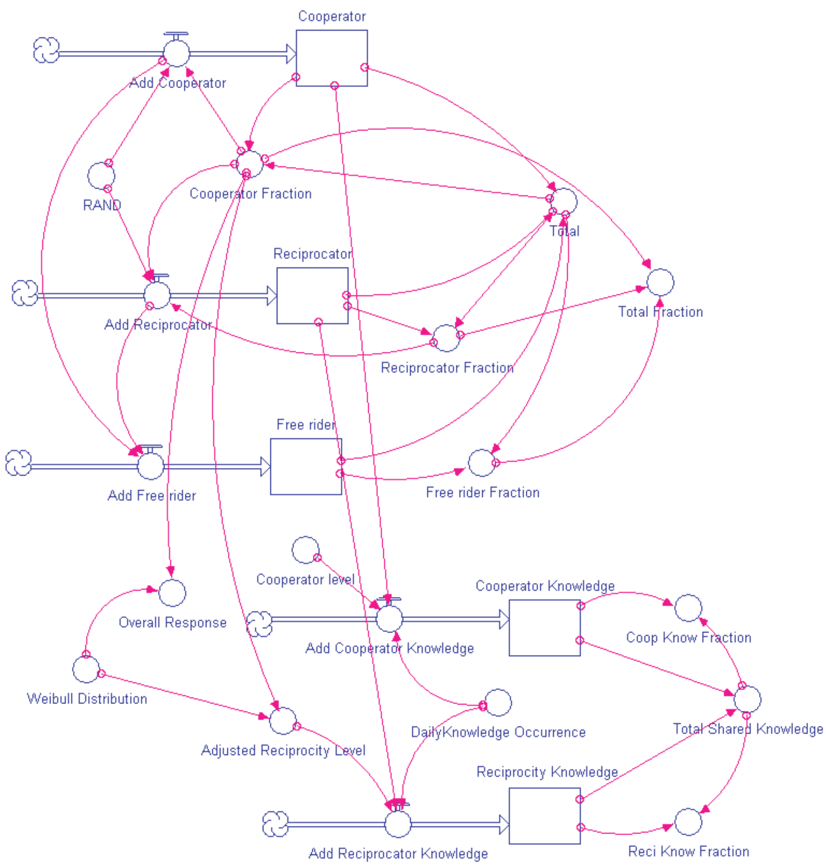
By studying the distribution of the reciprocity level of members from a social system such as a CoP, we can assume a positively skewed normal curve representing the distribution pattern of the reciprocity level in weak ties and a negatively skewed normal curve in strong ties. In a weak tie setting, people have difficulty identifying each other, and reciprocators are less obligated to reciprocate by their positive experiences from cooperators. Thus, most reciprocators are gathered around the lower reciprocity level. In strong tie settings, people will contact each other physically, and reciprocators are more obligated to reciprocate to their positive experiences from cooperators and other reciprocators. Consequently, most reciprocators are gathered around the higher reciprocity level. Since our setting of CoP is a weak tie, we assume that most reciprocators are found at the weak reciprocity level.

In order to show the distribution of reciprocators with varying reciprocity levels (theoretically, the reciprocity level is greater than 0 and less than 1), we use the Weibull probability distribution function with $\alpha=32$ and $\beta=2$ to represent positively skewed reciprocator distribution.

Simulation Results

Based on the propositions, we developed a simulation model for varying combinations of cooperative types, as shown in Table 2. We developed a system dynamics model for the reciprocity level and knowledge contribution based upon the positive feedback process (Hannon & Ruth, 1994). We set 5% cooperators, 65% reciprocators, and 30% free riders as the natural setting, since in an online environment in which no physical contact exists, people have less of a tendency to contribute toward public goods, and thus, few cooperators are expected. We set five possible cooperator policies with varying fractions of cooperators and reciprocators. Then, we compared the amount of shared knowledge from the natural setting with other policies using variance analysis to check whether the difference in the amount of shared knowledge is statistically significant.

Figure 4. Simulation model



For each combination, we conducted 100 simulation runs. For each simulation, a reciprocator accesses the CoP for 100 interactions. In each interaction, each individual has a chance to share a piece of knowledge into a CoP; a cooperator contributes a piece of knowledge into a CoP, while a reciprocator shares partial knowledge based on the reciprocity level. The reciprocity level was calculated based on the overall response and various reciprocators' combinations following the Weibull distribution. The cooperator level is calculated based on the positive feedback process. Each cooperative type was stable during the simulation, although a small fluctuation of each faction occurred due to the randomness. Free riders never will share their knowledge no matter how many interactions they have. Figure 4 depicts the simulation model for this study. To test Hypotheses 1 and 3, we controlled the fraction of cooperators and measured the amount of shared knowledge in the CoP simulation setting. Then, the amount of shared knowledge from each level of cooperators was compared and tested with one-way analysis of variance.

Data

For each simulation run, we recorded the amount of shared knowledge for every 10 interactions in a total of 100 interactions. We tested the data from each 10th interaction using one-way analysis of variance to compare the results of each setting. Table 3 shows how we gathered data from simulation and how each combination was compared using the analysis of variance test.

HYPOTHESIS TESTING

We start the analysis of variance test with data sets from every 10th interaction. These data sets come from the result of the first 10 interactions in each combination. The mean differences between adjacent combinations, which have a 5% increase in cooperator fraction, were not statistically significant at $\alpha=0.01$ level for knowledge contribution from cooperators. However, if the cooperator fraction is increased to 10%, the mean difference of cooperators' knowledge contribution becomes statistically significant at $\alpha = 0.01$ level. Table 4 shows the details of the result of the first 10 interactions.

Reciprocators' knowledge contribution is somewhat different from that of cooperators. As cooperator fraction increases from natural setting to policy 1 and from policy 1 to policy 2, this 5% increment significantly increases the reciprocators' shared knowledge. However, this is not the case for a 5% increase in cooperator fraction from policy 2 to policy 3, from policy 3 to policy 4, and from policy 4 to policy 5. This is due to the nature of the reciprocity level. The reciprocity level shows an exponential distribution with a sharp increase in the reciprocity level during the early cooperator fraction increase and stagnant increase during the later cooperator fraction increase, as shown in Figure 3.

Total shared knowledge in a CoP, a combined amount of shared knowledge from cooperators and reciprocators, is not increased significantly as cooperator fraction is initially increased in 5% at all comparisons, although the results are not included in Table 4.

After the second 10 interactions (11th to 20th) until the last 10 interactions (91st to 100th), all the mean differences between natural setting and five policies had statistically significant differences at $\alpha = 0.01$ level. The results are summarized in Table 5. The amount of shared knowledge significantly increased as the cooperators' fraction increased 5%. All comparisons were found to be statistically significant. We thus accept Hypothesis 1, positing that the cooperator fraction is related positively to the amount of shared knowledge. Knowledge from reciprocators also increased as the reciprocity level increased. We therefore accept Hypothesis 3, which proposed that the reciprocity level would be positively related to total shared knowledge. We also accept Hypothesis 2 in Section 4.2 with graphical expression of the positive relationship between cooperator fraction and reciprocity level of reciprocators.

For the first 10 interactions, the knowledge did not increase. Reciprocators shared less amount of knowledge. After the first 10 interactions, increasing cooperators 5% shared enough knowledge to affect reciprocators who shared more knowledge, leading to a statistically significant difference in the amount of shared knowledge. This implies that a cooperator policy that increases cooperators at least 5% will significantly

Table 3. Structure of data and statistical test

Interaction	Combination	Simulation Run	Knowledge from Cooperators	Knowledge form Reciprocators	Total Shared Knowledge	ANOVA
10th	0.5-6.5-3.0	1	3.8	2.1	5.9	Each combination is compared using the analysis of variance
		2	3.5	2.1	5.6	
		⋮	⋮	⋮	⋮	
		99	4.0	2.2	6.2	
		100	3.5	2.1	5.6	
	⋮	⋮	⋮	⋮	⋮	
	3.0-4.0-3.0	1	16	4.4	20	
		2	17	4.4	21	
		⋮	⋮	⋮	⋮	
		99	16	4.4	21	
		100	16	4.5	21	
20th ⋮ 90th	⋮	⋮	⋮	⋮	⋮	
100th	0.5-6.5-3.0	1	39.25	13.55	52.8	Each combination is compared using the analysis of variance
		2	38.45	13.03	51.48	
		⋮	⋮	⋮	⋮	
		99	27.35	9.63	36.98	
		100	40.65	13.36	54.01	
	⋮	⋮	⋮	⋮	⋮	
	3.0-4.0-3.0	1	215.55	37.51	253.06	
		2	217.6	35.87	253.47	
		⋮	⋮	⋮	⋮	
		99	207.45	38.57	246.02	
		100	229.3	40.61	269.91	

Table 4. Result of ANOVA at the first 10 interactions

Dependent Variable	(I) Factor	(J) Factor	Mean Difference (I-J)	Sig.	Dependent Variable	(I) Factor	(J) Factor	Mean Difference (I-J)	Sig.
Knowledge Contribution from Cooperators	Natural Setting	Policy 1	-2.7085	0.041	Knowledge Contribution from Reciprocators	Natural Setting	Policy 1*	-0.8878	0.000
		Policy 2*	-5.4695	0.000			Policy 2*	-1.5489	0.000
		Policy 3*	-8.375	0.000			Policy 3*	-2.0272	0.000
		Policy 4*	-11.0025	0.000			Policy 4*	-2.2775	0.000
		Policy 5*	-13.871	0.000			Policy 5*	-2.5155	0.000
	Policy 1	Policy 2	-2.761	0.035		Policy 1	Policy 2*	-0.6611	0.001
		Policy 3*	-5.6665	0.000			Policy 3*	-1.1394	0.000
		Policy 4*	-8.294	0.000			Policy 4*	-1.3897	0.000
		Policy 5*	-11.1625	0.000			Policy 5*	-1.6277	0.000
	Policy 2	Policy 3	-2.9055	0.021		Policy 2	Policy 3	-0.4783	0.061
		Policy 4*	-5.533	0.000			Policy 4*	-0.7286	0.000
		Policy 5*	-8.4015	0.000			Policy 5*	-0.9666	0.000
	Policy 3	Policy 4	-2.6275	0.054		Policy 3	Policy 4	-0.2503	0.713
		Policy 5	-2.8685	0.024			Policy 5	-0.4883	0.051
	Policy 4	Policy 5	-2.8685	0.024		Policy 4	Policy 5	-0.238	0.756

* The mean difference is significant at the .01 level

Table 5. Result of analysis of varience

Interaction	Cooperator Fraction	Knowledge from Cooperators	Knowledge form Reciprocators	Total Shared Knowledge
10th	0.5 vs. 1.0	Accept H_0	Accept H_0	Accept H_0
	0.5 vs. 1.5	Reject H_0	Reject H_0	Reject H_0
	0.5 vs. 2.0	Reject H_0	Reject H_0	Reject H_0
	0.5 vs. 2.5	Reject H_0	Reject H_0	Reject H_0
	0.5 vs. 3.0	Reject H_0	Reject H_0	Reject H_0
20^{th} ~100^{th}	All Comparisons	Reject H_0	Reject H_0	Reject H_0

increase shared knowledge not only from cooperators but also from reciprocators after at least 20 interactions. As more interactions among CoP members occur, people will share knowledge more.

IMPLICATIONS AND LIMITATIONS

In this study, we found that raising cooperator fraction not only increases knowledge sharing but also encourages reciprocators to share more knowledge. Two possible ways to increase cooperator fraction are mentoring and utilizing retirees in an organization. Mentoring is one way of generating cooperators in CoP. Mentors can be experienced members in the organization who have more knowledge and willingness to share than other less experienced members (Kram, 1985). In the case study, Hunt (2005) argued that e-mentoring can be used as an effective development approach for organizations across distances. Bjørnsson and Dingsøyr (2005) found that the mentor program supports learning in a software consultancy company. Hiring retirees is another way to increase the cooperator fraction. Retirees are the most experienced employees in the field of their work, and they have a vast amount of organizational knowledge (Lesser & Prusak, 2001). Current employees may feel that they have fewer resources for contributing to a CoP, as their current work takes all of their energy. Mentoring and hiring retirees may help both keep organizational knowledge and increase cooperators in a CoP.

This study also has several limitations. First, we assume that free riders may not be affected by any condition. However, this may not be true. For our simulation settings, we controlled the free rider fraction at 30%. The average fraction of the contribution type may not be constant. For example, cooperators may migrate into reciprocators at a certain point, while reciprocators may migrate into the free rider group. If the fraction of free riders changes and if they are affected by other contributors, the shared knowledge amount will be greater than the simulation result of the study. Second, we arbitrarily selected the unit of shared knowledge and applied this to all cooperators and reciprocators. However, some cooperators may contribute more knowledge than other cooperators, which also might be the case for reciprocators. This varying unit of shared knowledge may inflate the result of the study. Finally, the Weibull distribution with α=32 and β=2 was also our arbitrary choice, motivated to match observed distributions. Varying share and scale parameters of the Weibull distribution may result in varying conclusions. Simulation is valuable, as it allows changes in any of these assumptions.

CONCLUSION

In this study, we investigate the relationship between an individual's contribution behavioral type and knowledge sharing in a CoP. We argued that the fraction of cooperators in a CoP affect not only the amount of shared knowledge but also the sharing decision of reciprocators (reciprocity level) positively, which increases the total shared knowledge in a CoP, and we ran a simulation model adopting a positive feedback process to test the possible relationship between the fraction of cooperation and the amount of shared knowledge. Analysis of variance shows that raising the cooperator fraction by 5% will significantly increase total shared knowledge in a CoP, not only due to more cooperators but also due to the higher reciprocity level of fewer reciprocators. Therefore, CoP can benefit by attracting more cooperators into the system in which they positively influence reciprocators as well as share more knowledge.

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