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A Contingency Theory of Organizational Strategies for Facilitating Knowledge Sharing in Engineering Organizations¹

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Abstract: Encouraging knowledge sharing amongst employees is critical for organizations to capitalize on organizational knowledge and gain a competitive advantage. Unfortunately, little is known about individual knowledge sharing behaviors in an organization or community of practice. Because knowledge sharing behaviors are the cornerstone of successful knowledge management (KM) systems, this research seeks to add to the emerging literature of knowledge-sharing dynamics by deriving strategies aimed to encourage knowledge sharing amongst employees. To do this, we identified critical variables from a literature review and case studies of construction and engineering organizations and developed game-theoretic models. Through game theory modeling of knowledge sharing dynamics, we solved equilibrium solutions applicable to various situations and developed a contingency theory for knowledge sharing strategies. These strategies shed light on how organizations can be better designed to encourage the sharing of knowledge.

Keywords: knowledge management, knowledge sharing, game theory, organization, strategy.

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1 Introduction

The importance of knowledge, and as a result, knowledge sharing, to an organization has been well recognized (Cohen and Levinthal 1990; Haas and Hansen 2007; Grant 1996; Spender 1996). The knowledge based view (KBV) of the firm recognizes knowledge as a resource with as much importance as capital (Conner and Prahalad 1996; Grant 1996; Spender 1996). Recently, many large organizations, from manufacturing companies to engineering firms, have devoted tremendous resources to knowledge management due to their need for sharing scarce, specialized intra-organizational knowledge. However, implementing knowledge management solutions in practice has had varied success, with indications that the majority of knowledge management solutions fail to meet initial expectations (Akhavan et al. 2005). In fact, knowledge is a sustained competitive advantage only if it can be transferred between individuals (Grant 1996; Argote and Ingram 2000). In particular, the project-based industry of engineering and construction is inherently learning disabled, because teams disband and reform in new configurations so that much of the tacit knowledge accrued during a given project disappears at the end of the project. Thus the engineering and construction industry requires effective knowledge exchange to function well—it enables organizations to capture tacit project-based

knowledge needed to coordinate their specialized and interdependent activities to design and construct future projects (Jin and Levitt 1996).

Knowledge does not flow spontaneously; instead, immobilized knowledge will remain at rest (Nissen 2005). Organizations are thus interested in the transfer and mobilization of knowledge: it can lead to improved productivity (Dyer and Nobeoka 2000), performance (Haas and Hansen 2007) and other capabilities. In this regard, many companies have developed Information and Communication Technology (ICT) platforms to transfer knowledge and ease knowledge accessibility. However, implementing ICT platforms alone will not automatically enable knowledge flow in an organization, because knowledge resides with people and is transferred through the actions of motivated people, not just technology. As a result, intra-organizational knowledge sharing requires a focus not only on organizational barriers and facilitators, but also on understanding why and when individuals are willing to share their knowledge internally with peers.

The dynamics of intra-organizational knowledge sharing are quite complex with multiple forces—both positive and negative—at play. On the one hand, positive forces that motivate individuals to engage in knowledge sharing behaviors may include monetary rewards, altruism and reputation or other intrinsic or social motivations (Ho et al 2011, Javernick-Will 2011, Davenport and Prusak 1998).

However, monetary rewards have been found to exert much less influence on knowledge sharing than either reputation or altruism (Bobrow and Whalen 2002) and can even reduce knowledge sharing (Bock and Kim 2002). In contrast, social motivations, such as reputation and peer recognition, and intrinsic rewards due to altruism or self-actualization, are often found to be much more influential than monetary rewards. For example, in Xerox's widely admired Eureka system, service technicians stated that building a reputation for competence within their "natural community of practice" of fellow service technicians was a significant and major incentive for knowledge sharing (Bobrow and Whalen 2002). Including knowledge providers' names along with shared knowledge is one meaningful way to harness this important positive reinforcement for knowledge sharing (Javernick-Will and Levitt 2010).

On the other hand, barriers, or negative forces that inhibit individuals' willingness to share their knowledge with others, often co-exist with incentives. First of all, it may be costly for employees to share their knowledge. Some costs, such as the workers' time and effort required for sharing, are obvious. Other, less obvious, costs may be equally or more significant. For instance, employees may be afraid that sharing their knowledge might reduce their uniqueness, power or status within the organization (Goh 2002, Carrillo and Chinowsky 2006, Ho et al. 2011). Other employees may

enjoy higher payoffs by being free riders, a paradigmatic social situation known as the “social dilemma” problem (Connolly and Thorn 1990). Social dilemmas describe paradoxical situations in which individual rationality—simply trying to maximize individual payoff by being a free rider—leads to collective irrationality (Kollock 1998) and collective damage (Cabrera and Cabrera 2002). In the arena of knowledge management, social dilemmas can lead to a lack of intra-organizational knowledge sharing.

In response to the calls in literature to better understand the circumstances that enable the individual to share at the collective level (Foss et al. 2010), we must first understand the positive and negative factors affecting the willingness of employees to share knowledge. Ho et al. (2011) argue that strategic interactions between employers and employees play a crucial role in understanding how knowledge sharing interactions affect the dynamics of collective organizational knowledge sharing. Through game theory analysis, they showed that employees’ decisions to share or withhold knowledge and employers’ strategies to promote knowledge sharing depended on knowledge characteristics. For instance, in considering the adoption of ICT platforms, firms should evaluate the size of the firm and the proportion of employees who possess highly demanded knowledge—a concept similar to scale economy. However, it is not clear from Ho et al.’s (2011) study how the interactions

between individual employees will impact the sharing dynamics in the organization.

In this paper, we aim to build a more complete theory on knowledge sharing strategies with a focus on the interactions between employees contingent on different organizational contexts, including firm size and task repetitiveness. Based on the results of game theory modeling, we build a contingency theory of knowledge sharing strategies to reinforce the equilibrium wherein individuals share their valuable knowledge.

In this paper, we develop a game theory model to solve for the conditions that determine the knowledge sharing behaviors of employees in different organizational contexts. Since the sharing of knowledge relates to the competitive and cooperative relationships between employees, game theory is considered to be a natural method to analyze the knowledge sharing problems. Multiple case studies were conducted to provide empirical grounding for our model assumptions and setup. Based on the modeling and analysis, we propose a contingent theory that suggests three different strategies for reinforcing the sharing equilibrium in different knowledge sharing contextual configuration. Lastly, we derive three testable propositions for the effectiveness of knowledge sharing strategies.

2 Research Strategy and Methods

Game theory is the major method used in this study to build a contingency theory of knowledge sharing. Game theory can be defined as “the study of mathematical models of conflict and cooperation between intelligent rational decision-makers” (Myerson 1991). In the engineering and construction industry, conflict and strategic interactions between project owners and contractors are very common. Given this understanding, game theory is an appealing analytical framework to analyze problems in this industry.

2.1 Research Strategy: Theory Building Through Game Theory Modeling

Game theory modeling has been applied to construction and engineering research to develop strategies for partnering (Lazar 2000), or for subcontractor selection (Unsul and Taylor 2011), to analyze cooperative (Erikson 2007) and opportunistic (Ho 2004) bidding behaviors, to build theories of governance strategies in Public-Private Partnerships (Ho 2005; Ho 2006) and to build theories of knowledge sharing strategies concerning investment decisions for knowledge management programs, including ICT platforms and monetary rewards (Ho et al. 2011).

Building theories using game theory modeling requires several steps. First, we

abstract the problem under study by developing a game theory model. Doing this requires sufficient knowledge of the problem to make appropriate assumptions to simplify the problem and focus on a few critical components. For this study, the existing literature provided a starting point, but provided insufficient details regarding individual knowledge sharing between employees in an organization. Therefore, we used ethnographic interviews to gather empirical findings to ground our model assumptions and to provide deeper insight into the problem for model abstraction.

The second step is to solve for the conditions of all possible or specific solutions of the game model. The number of possible equilibria and the complexity of the equilibrium solutions depend on the complexity of the game theory model and the number of variables for the players' payoffs. This leads to the last step, which links the equilibrium conditions to problems under analysis. If the equilibrium solutions are complicated, identifying possible contextual variables will narrow the possible solution space and provide additional insights to help understand the problem. Once the logic between different variable configurations and possible equilibria are established, theory can be built from the logic.

Below, we introduce the basic concepts of game theory used in this paper and follow with the methods used to gather supporting evidence from ethnographic case studies.

2.2 Basic Concepts of Game Theory

Game theory studies decision making in strategic situations mathematically. In game theory, a game tree is constructed with choices leading to individual payoffs. In economics, game theory has been applied to many important topics in economics (Mas-Colell et al. 1995), and has become a very powerful method for analysis. In this study, we employ game theory for theoretical investigation of various circumstances under which employees chose to share or not share knowledge.

Games can be classified by the completeness of information and the way in which games are played. There are two basic types of games: static games and dynamic games. In a static game, the players act simultaneously, meaning that each player chooses his action without knowing the decisions of others. In contrast, in a dynamic game, players act sequentially and observe other players' actions in previous moves. Because employees decided to share or not share knowledge after observing others' actions, our study will use dynamic games from modeling and analysis.

In order to determine how each player will behave in the game, we need to determine the "Nash equilibria". A "Nash equilibrium" is a set of strategies, each of which determines the optimal response by each player to other players' strategies. Because the strategies in the Nash equilibrium are all the best possible response by

each player based on the decisions of others, the set of strategies can be viewed as a stable equilibrium. In other words, in a Nash equilibrium, no player can increase its payoff by unilaterally deviating from the equilibrium solution. Thus, the equilibrium is “strategically stable” and “self-enforcing” (Gibbons 1992). However, dynamic games evaluate sequential decision-making processes. Therefore, they require a solution concept that is stronger than Nash equilibrium concept. In a dynamic game, the solution is called “subgame perfect Nash equilibrium”, a solution concept that requires each player in each subgame to choose the action that maximizes his payoff. The detailed process for solving the dynamic game is explained later when the proposed model is solved.

2.3 Ethnographic Case Study

Because literature regarding individual knowledge sharing behaviors is sparse (Foss et al 2010), we use ethnographic interviews from case studies with engineering and construction organizations to supplement our model variables and analysis and build theory from the results. As the research explores an area of largely uncharted territory, a case study approach is valid (Eisenhardt 1989, Yin 2003). These case studies relied primarily on interviews with construction and engineering organizations

to obtain a deeper understanding of knowledge sharing dynamics in order to model the problem using game theory and analyze the derived solutions to develop theory from the model. The interviews were conducted with individual employees to understand the circumstances under which employees shared or withheld their knowledge from others in the organization. In total, 7 firms were studied and 41 interviews were conducted. The studied firms are all actively engaged in knowledge management, although with varying success. These interviews were semi-structured, but allowed for open-ended responses to questions to obtain additional context behind the responses. The interviews focused on knowledge sharing behaviors, incentives and obstacles of sharing, the feelings of sharing knowledge, and what firms did in promoting the sharing. We also collected and analyzed each firm's internal documents associated with knowledge management for better analyzing the responses of interviewees. These interviews helped to determine the variables selected for the game theory model and helped us analyze the results to develop theory. Table 1 summarizes the background information of the seven studied firms. In particular, the number of employees and the task nature of each firm are indicated in the table. As we shall discuss later, the two dimensions play important roles in the magnitudes of model variables.

[INSERT TABLE 1 HERE]

3 The Game Model for Knowledge Sharing Interactions Among Employees

From the case studies, we developed a game model for knowledge sharing interactions between employees within an organization. As described above, this required abstracting the problem under analysis to identify and define the model's variables, develop the model and payoffs, and determine and analyze the model's equilibrium solutions.

3.1 Model Variables and Assumptions

In this study, the formation of model variables and associated assumptions are based on literature reviews, our understanding of knowledge sharing in practice, and the insights and observations derived from the case studies. We shall define these variables and discuss the rationales behind these variables in this section. Table 2 lists these model variables and their meanings for future references in the paper.

[INSERT TABLE 2 HERE]

3.1.1 Variables Contributing Positive Payoffs

In this section, we discuss the variables that increase the payoff from, and therefore encourage, knowledge sharing by employees. The following section describes variable that reduce the payoff from, and thereby inhibit, knowledge sharing.

A: Self-satisfaction from knowledge sharing

From our interviews, we find that employees can gain intangible rewards through self-satisfaction. This self-satisfaction can lead to altruistic motivations and the pure enjoyment of certain activities (Calder and Staw 1975). Javernick-Will's (2011) study found that approximately 10% of responses regarding the reasons people shared knowledge were due to altruistic intentions. Similarly, in our interviews, many respondents expressed that, no matter what others do, sharing their knowledge is the "right" thing to do. One manager from Company A commented, "*I think some people are natural knowledge sharers- they enjoy teaching and telling other people their experiences*". In addition, they feel they are adding value to the organization by sharing their knowledge. As another manager from Company A commented, "*I think it is just a genuine concern and genuine desire to make sure everything goes right*".

B_s: Benefits from increased professional reputation due to sharing knowledge

From our interviews, we identified two benefits of knowledge sharing that are directly associated with professional reputation and career development. The first are the benefits from gaining professional reputation and recognition within the company due to sharing knowledge, denoted by B_s. Results of case study indicated that an increase in reputation is one of the major factors that motivate people to share in an organization. Multiple respondents indicated that recognition from peers and the organization was an important motivator for knowledge sharing. For example, Company D provides honorary titles to recognize employees with expertise through the company and on the KM website. This company provides highly visible awards for knowledge sharing behaviors that can be found in each person's profile. As two knowledge managers of a community of practice from Company D indicated, *"we have the KM [award title] nominations that allow [knowledge sharers] to be recognized across all levels and regions in the company. As a community, we recognize and spotlight them in our community"*. One respondent from Company A indicated that if an employee wanted to be promoted, they would recommend that *"you need to raise your personal profile... if you hadn't been promoted, I may say, 'Well, you are doing all the right thing in all the right places, but nobody's*

noticing' ... the best way to raise your personal profile is to share your knowledge and be recognized for your expertise".

B₀: Benefits of receiving knowledge from others in an organization

The second type of professional or career development benefits is the benefits of receiving knowledge from others in an organization, B₀. Employees can benefit from others who share knowledge by acquiring new work-related knowledge. The new knowledge can broaden their knowledge base and increase their productivity and job performance. In fact, these benefits directly contribute to increased organizational knowledge and thus performance at the collective level. This is the fundamental reason and typical view for companies managing knowledge and promoting the sharing of knowledge.

R₁: Social rewards from knowledge sharing

In addition to benefits associated with career growth and personal fulfillment, many people share knowledge due to social rewards from sharing knowledge. In fact, Javernick-Will (2011) found that the most frequently mentioned motivation for sharing knowledge were social motivations, including reciprocity, conformity to a

corporate culture and expectations, or honoring a commitment to develop trust among peers. One respondent from Company C indicated that *“I think if you share more, then you become more likable and more approachable. If you tend not to share, then people find you unapproachable.”* Another respondent from Company C talked about people that shared their knowledge freely became well known and respected for these behaviors: *“I think both [employee’s name] and [employee’s name] share everything and I think people really respect them for that”.*

Note on extrinsic rewards for knowledge sharing

Some companies implement extrinsic rewards, such as monetary compensation, to reward knowledge sharers and promote knowledge sharing. However, Bobrow and Whalen (2002), among other studies, show that monetary rewards play a relatively small role in knowledge sharing, or can even be negatively related to knowledge sharing (Brock and Kim 2002). As a result, we exclude extrinsic rewards from this model.

3.1.2 Variables Contributing Negative Payoffs

In the previous section, we discussed the variables that increase the payoff from, and

therefore encourage, knowledge sharing by employees. This section discusses variable that reduce the payoff from, and thereby inhibit, knowledge sharing.

C, The costs of knowledge sharing:

According to the game theory model of Ho et al. (2011), two types of costs for sharing knowledge were modeled: the explicit costs and the implicit costs. The explicit costs refer to the time and effort needed to share knowledge with others. Generally, explicit costs are higher when the shared knowledge is more complex; for example, the explicit costs of sharing lessons learned from a project are much higher than forwarding an article downloaded from the internet to others. This requires additional time and effort that the employees may not have.

As one manager from Company A described in Javernick-Will (2011), *“I tend to see people not sharing knowledge because they don’t have the time... there doesn’t seem to be a reluctance to share knowledge, but some people just don’t have the time to do it”*.

In addition to the explicit, or direct costs, of sharing knowledge, employees can also incur implicit costs. These costs refer to the negative consequences that employees experience when they share their knowledge. For instance, if an employee

possesses unique knowledge that is valuable to a firm, he may enjoy power and status.

This power and status—and even the employee’s job security—may be reduced if s/he chose to share this unique knowledge with others. The magnitude of these costs depends on the degree of uniqueness of the knowledge and/or the importance of the knowledge to the organization.

In order to avoid complicating the model with too many variables, we combine the explicit costs and implicit costs into one single variable, C . However, it is crucial to acknowledge that, conceptually, C consists the two different types of costs of sharing.

R₂: Social punishment faced due to withholding one’s knowledge

From the behavioral economics and behavioral game theory perspectives (Camerer 2003), in social interactions or economic activities, humans tend to impose punishment on individuals who exhibit antisocial behaviors such as “free-riding” or not being a good citizen of a society. The social obligation to repay others for what we have received from them may be one of the strongest and most persuasive social forces (Gouldner 1960). Experiments have confirmed that people tend to behave prosocially and punish antisocial behavior in groups and teams (Gintis 2000). Fehr et

al. (2002) term this behavioral propensity, “strong reciprocity”, which emphasizes the tendency to punish non-cooperators. In order to consider such behavioral characteristic and associated consequences, we model the strong form of reciprocity by considering not only social rewards, R_1 , listed in previous section but also the social punishment, R_2 , faced due to withholding one’s knowledge or being a free-rider.

3.2 The Game-Theoretic Model of Knowledge Sharing in Organizations

Figure 1 shows the game-theoretic modeling of the knowledge sharing behaviors in an organization. The knowledge sharing dynamics between two employees are modeled by a two-person game. Employee 1 is labeled as Player 1 and employee 2 is labeled as Player 2. Payoffs are modeled for three scenarios and the payoff profiles, denoted as (payoffs for Player 1, payoffs for Player 2), are shown for each player at the end of the branch. The three scenarios are described below:

[INSERT FIGURE 1 ABOUT HERE]

Scenario 1

When both players share their knowledge, they are both rewarded by the benefits of increased professional reputation, B_s , the benefits of receiving knowledge shared by the other, B_o , social rewards due to sharing, R_1 , and self-satisfaction, A . Meanwhile, their rewards are also partially offset or even outweighed by the efforts and implicit costs required to share their knowledge, C .

Scenario 2

When knowledge sharing is one-sided; i.e., only one player shares, the sharer is rewarded by B_s , R_1 , and A . In this scenario, the sharer does not receive new knowledge, B_o ; however, he still exerts effort to share his knowledge with the freerider, C . The other player, the free-rider, obtains new knowledge, B_o , for zero costs; however, he may also receive social punishment, R_2 , from members of the Organization.

Scenario 3

When neither of the two players shares their knowledge, they end up with zero

positive payoff and zero cost for sharing. Note that there will be no social punishment if no one shares, so this is not a classic “prisoners’ dilemma” game..

As discussed earlier, we use a dynamic game of perfect information to model and abstract the interactions between community members. We use a dynamic game because: (1) players are able to observe other’s actions and (2) the game involves sequential interactions between employees. In the model, we assume that each community member can easily observe whether other members in the Organization share their knowledge and can reasonably evaluate the total payoffs in each scenario. Note that whereas it might be difficult to determine the precise value of every model variable, practically, as in most economic decisions, most people should be able to assess or determine the comparative magnitudes of overall payoffs under different scenarios so as to decide which decision is optimal. Given this assumption, we are able to derive relatively strong qualitative implications about decision making from the analysis of players’ strategic interactions.

3.3 Equilibrium Solutions of the Model

We obtained four possible equilibria for the model. We will solve the game backward by first analyzing Player 2's choice of strategies. Player 2's possible strategies are categorized into four cases, including Case I, "always share," Case II "be a follower," Case III, "never share," and Case IV, "do the opposite." In the following analysis, we use [Player 1's action, Player 2's action] to represent decisions taken by two players. For example, we use [Share, Don't Share] to represent the dynamics when Player 1 shares his knowledge but Player 2 doesn't.

3.3.1 *Equilibria of Case I*

In Case I, Player 2 "always shares." If Player 2 always shares, the possible equilibrium paths will be [Share, Share] or [Don't Share, Share]. For Player 2 to "always share," the payoffs for choosing "Share" must be greater than the payoffs for choosing "don't share," regardless of Player 1's choice. As a result, the following two conditions have to be satisfied.

$$B_s + B_0 - C + R_1 + A > B_0 - R_2 \rightarrow B_s - C + R_1 + A > - R_2 \quad \text{Eq. (1)}$$

$$B_s - C + R_1 + A > 0 \quad \rightarrow \quad B_s - C + R_1 + A > 0 \quad \text{Eq. (2)}$$

Eq. (1) and Eq. (2) can be summarized or implied by Eq. (2). Next, we solve for Player 1's decision by comparing the respective payoffs of choosing "Share" and "not share." According to the payoffs shown in Figure 1, Player 1 will "Share" when Eq. (3) is satisfied and will choose "Don't Share" when Eq. (4) is satisfied.

$$B_s + B_0 - C + R_1 + A > B_0 - R_2 \Rightarrow B_s - C + R_1 + A > -R_2 \quad \text{Eq. (3)}$$

$$B_s + B_0 - C + R_1 + A < B_0 - R_2 \Rightarrow B_s - C + R_1 + A < -R_2 \quad \text{Eq. (4)}$$

As a result, the first possible equilibrium of the game, *Equilibrium #1*, following [Share, Share] is obtained when Eq. (2) and Eq. (3) are satisfied. Eq. (2) and Eq. (3) can be summarized again by Eq. (2), $B_s - C + R_1 + A > 0$. Note that [Don't Share, Share] cannot be the equilibrium path since Eq. (2) and Eq. (4) are contradictory and, thus, cannot be satisfied concurrently.

3.3.2 Equilibria of Case II

In Case II, Player 2's strategy is to "be a follower." If Player 2 chooses to "be a follower", [Share, Share] and [Don't Share, Don't Share] will be the possible equilibrium paths. Similar to the equilibrium solving procedure in *Case I*, the following two conditions have to be satisfied for Player 2 to "be a follower."

$$B_s + B_0 - C + R_1 + A > B_0 - R_2 \Rightarrow B_s - C + R_1 + A > -R_2 \quad \text{Eq. (5)}$$

$$0 > B_s - C + R_1 + A \quad \Rightarrow B_s - C + R_1 + A < 0 \quad \text{Eq. (6)}$$

Combining Eq. (5) and Eq. (6), we have Eq. (7).

$$-R_2 < B_s - C + R_1 + A < 0 \quad \text{Eq. (7)}$$

Considering Player 1's sequential rationality and given condition (7), [Share, Share] will be the equilibrium path if Eq. (8) is satisfied and [Don't Share, Don't Share] is the path if Eq. (9) is satisfied.

$$B_s + B_0 - C + R_1 + A > 0 \quad \Rightarrow B_s - C + R_1 + A > -B_0 \quad \text{Eq. (8)}$$

$$B_s + B_0 - C + R_1 + A < 0 \quad \Rightarrow B_s - C + R_1 + A < -B_0 \quad \text{Eq. (9)}$$

Our second possible equilibrium, *Equilibrium #2*, following [Share, Share], can be obtained when Eq. (7) and Eq. (8) are satisfied. Although mathematically the inequality in Eq. (7) can be satisfied as long as R_2 is greater than zero, it does not make practical sense for R_2 to be too small. If R_2 were too small, it would minimize the range $[-R_2, 0]$ such that the probability of the sum of $(B_s - C + R_1 + A)$ falling in the narrow range is slim. Therefore, for this equilibrium to be practical, we argue that R_2 must be large. As such, we shall supplement a restriction, Eq. (10), for this equilibrium.

$$R_2 \gg 0 \quad \text{Eq. (10)}$$

Note that the conditions for *Equilibrium #2*, Eq. (7) and Eq. (8), can be summarized

by $-B_0 < B_s - C + R_1 + A < 0$, identical to the structure of Eq. (7). Therefore, we shall add another restriction, Eq. (11), for this equilibrium.

$$B_0 \gg 0 \quad \text{Eq. (11)}$$

To summarize, practically, the conditions for *Equilibrium #2* following [Share, Share] are Eq. (7), Eq. (8), Eq. (10), and Eq. (11).

Our third possible equilibrium, *Equilibrium #3*, following [Don't Share, Don't Share] can be obtained when Eq. (7) and Eq. (9) are satisfied, which can be re-written as Eq. (12).

$$-R_2 < B_s - C + R_1 + A < -B_0 \quad \text{Eq. (12)}$$

Following the same logic for adding restrictions to the previous equilibrium, we add an additional restriction that $R_2 \gg B_0$ to ensure that the range $[-R_2, -B_0]$ is not too narrow to be satisfied. In addition, note that although it is possible that $B_0 \gg 0$, it is unlikely that social punishment would be so large that $R_2 \gg B_0 \gg 0$. Thus, for *Equilibrium #3*, we may add the restriction that $R_2 \gg B_0 \gtrsim 0$, where \gtrsim denotes greater than but close to, in order to prevent R_2 from being unreasonably high.

$$R_2 \gg B_0 \gtrsim 0 \quad \text{Eq. (13)}$$

The insight from this equilibrium condition is that when the overall payoffs due to sharing, $B_s + B_0 - C + R_1 + A$, is negative, social punishment cannot facilitate the sharing of knowledge if the benefits from receiving knowledge shared by others are

limited.

3.3.3 *Equilibria of Case III*

In Case III, Player 2's strategy is "never share." Given this scenario, [Share, Don't Share] and [Don't Share, Don't Share] will be the possible equilibrium paths. According to the payoff structure shown in the game tree, the following two conditions have to be satisfied for Player 2 to choose to never share.

$$B_0 - R_2 > B_0 + B_s - C + R_1 + A \Rightarrow -R_2 > B_s - C + R_1 + A \quad \text{Eq. (14)}$$

$$0 > B_s - C + R_1 + A \quad \text{Eq. (15)}$$

Considering Player 1's sequential rationality and conditions (14) and (15), [Share, Don't Share] is the equilibrium path if Eq. (16) is satisfied and [Don't Share, Don't Share] is the path if Eq. (17) is satisfied.

$$B_s - C + R_1 + A > 0 \quad \text{Eq. (16)}$$

$$B_s - C + R_1 + A < 0 \quad \text{Eq. (17)}$$

Note that no equilibrium will follow [Share, Don't Share] in *Case III* since conditions (15) and (16) are contradictory. However, we can obtain our fourth equilibrium, *Equilibrium #4*, following path [Don't share, Don't share] when Eq. (14), Eq. (15), and Eq. (17) are satisfied. The three equations can be summarized by Eq. (14). Note

that when Eq. (14) is compared with the conditions for *Equilibrium #2* and *Equilibrium #3*, we may add a further restriction for *Equilibrium #4* that R_2 is close to zero, because, if R_2 is large, then Eq. (7) for *Equilibrium #2* and Eq. (9) for *Equilibrium #3* are more likely to be satisfied. Thus, the revised conditions for *Equilibrium #4* are Eq. (14) and the added restriction, Eq. (18).

$$R_2 \gtrsim 0 \quad \text{Eq. (18)}$$

3.3.4 *Equilibria of Case IV*

In Case IV, Player 2 will always “do the opposite” of Player 1’s choice of action. Given this scenario, [Share, Don’t Share] and [Don’t Share, Share] will be the possible equilibrium paths for the equilibria. For Player 2 to always do the opposite of Player 1, the following two conditions have to be satisfied.

$$B_o - R_2 > B_s + B_o - C + R_1 + A \Rightarrow -R_2 > B_s - C + R_1 + A \quad \text{Eq. (19)}$$

$$B_s - C + R_1 + A > 0 \quad \text{Eq. (20)}$$

Note that since Eq. (19) and Eq. (20) contradict each other, equilibrium paths in *Case IV* cannot lead to any equilibria.

3.4 Observations from the theoretical model

During the modeling and analysis process, we observed variables that became important indicators of sharing knowledge with others.

3.4.1 $B_s - C + R_1 + A$: Strong Condition for Sharing

According to the equilibrium conditions, an important indicator of our analysis is the combination of four variables, “ $B_s - C + R_1 + A$,” where B_s , R_1 , A are the benefits of sharing due to increased professional reputation, social rewards, and self-satisfaction, respectively, and C are the explicit and implicit costs of sharing. Therefore, here we discuss the original definitions of these variables to explore the implications of these variables. $B_s - C + R_1 + A$ is the minimum payoff for a player who shares, no matter what others do. Thus, condition (2) alone, $B_s - C + R_1 + A > 0$, will guarantee the [Share, Share] dynamics. In this paper, we shall call this condition “the strong condition for sharing.” If the strong condition for sharing is not satisfied, [Share, Share] can still be obtained by imposing the other requirements as shown in *Equilibrium #2*. In *Equilibrium #2*, the additional requirements are that B_0 and R_2 are both large enough. In other words, the benefits of receiving knowledge shared by others and the social punishment faced due to withholding knowledge will restore the dynamics back to [Share, Share] when the strong condition for sharing is not satisfied.

3.4.2 *The Effectiveness of Strong Reciprocity*

In addition to the social rewards, R_1 , that contribute to intrinsic rewards, culture and social norms for reciprocity can also add social punishment, R_2 , to the payoffs due to social interactions. By contrasting *Equilibrium #2* for [Share, Share] and *Equilibrium #3* for [Don't Share, Don't Share], we may conclude that the punishment for withholding knowledge, R_2 , will only be effective when the benefits of receiving knowledge shared by others are large enough. Otherwise, *Equilibrium #3* following [Don't Share, Don't Share] will be the solution since [Don't Share, Don't Share] prevents employees from negative payoffs and, at the same time, the players will not be penalized socially when no employees share. We may also conclude that, when the strong condition for sharing is not satisfied, strong reciprocity becomes the necessary, but not the sufficient, condition for [Share, Share], as indicated by *Equilibrium #4*, when R_2 is close to zero.

4 A Contingency Theory for Promoting Knowledge Sharing

Although we focused on the micro-level variables influencing individual employee's decisions to share their knowledge in an organization, many variables remain

contingent upon organizational related factors that influenced the relative size of the variables. As a result, the equilibrium conditions above can be transformed to new sets of equilibrium conditions that are contingent on different contexts. These contexts have implications for deriving organizational strategies to increase knowledge sharing. In this paper, we introduce two contingency variables, company size and the nature of tasks.

4.1 *Organization Size*

During our case studies and from the observations of prior research (Ho et al. 2006, Javernick-Will and Levitt 2010), it appears that the size of the organization or community has a significant impact on two variables: namely, the costs of sharing knowledge, C , and the reputational benefits of sharing one's own knowledge, B_s . According to Table 1, among the seven studied firms, Companies D, F, and G are the largest companies, having more than 36,000 employees, Companies A and E are smaller firms, having less than 10,000 employees, and Companies B and C are the smallest firms, having less than 2,000 employees.

According to our case study, the cost of sharing knowledge, C , is impacted by the size of the organization. We find that the size of the organization or community of

practice impacts the costs, C, primarily due to job security concerns versus the time spent to share knowledge. For instance, in Javernick-Will's (2011) study, which consisted of fifteen large multi-national engineering and construction organizations, job security concerns were never seen as a barrier to sharing knowledge. Instead, sharing knowledge was viewed as a way to become known throughout the diversified and globally distributed organizations. Our interviews for this research found the same results in the larger organizations.

Within the smaller organizations that we studied, employees indicated that they either tended to withhold information to maintain their power and uniqueness or considered that the implicit costs of sharing valuable knowledge are significant. As one respondent from Company C, the smallest among all studied firms, indicated, *"People withhold knowledge... perceivably for personal gain... knowledge is power so some people want to maintain and retain that knowledge"*. Another respondent from Company C also indicated, *"if they hold some level of knowledge ... they become more valuable... they assure themselves continued employment by withholding information"*. Furthermore, one respondent from Company B, one of the smallest studied firms, expressed his concern that *"If the knowledge I shared relates to my core knowledge, I would worry about the negative impacts on my competitive advantage in the firm."* From these findings, it appears that smaller companies have a higher cost

for sharing their knowledge, particularly implicit knowledge, than their larger counterparts. On the contrary, employees from larger firms in our cases seldom expressed their concerns regarding the loss of power or status due to sharing knowledge.

In larger companies, the uniqueness or competitive advantage of employees seem to be less threatened by those who learn from the sharer. Larger companies typically have more experts in each specific domain and the uniqueness of these experts is lower compared to that in smaller companies. For very large, geographically dispersed companies, it is even more unlikely that an employee will be replaced by another with the same level of expertise on the other side of the world. This is generally not the same case in smaller companies since they tend to be collocated. By sharing in a larger company, an employee who shares their knowledge can be recognized as an expert that is utilized across the firm and become even more irreplaceable. As one respondent from Company D, one of the largest studied firms, indicated: *“I just don’t think I am losing anything by sharing my knowledge...”* and *“I could write my knowledge as much as I could and I still have a lot of value left...”*

Based on these observations, we identify the first contingency variable and describe its impacts on the costs of sharing knowledge in contingency assumption #1. Note that here contingency assumptions refers to the assumptions regarding

contingency variables that are used in modeling for building a contingency theory.

Contingency Assumption #1: Employees' knowledge sharing cost, C, is generally smaller in larger companies and larger in smaller companies.

For the reputational benefits of sharing one's own knowledge, the impact of company size also affects career advancement. In a larger company, when an individual shares his/her knowledge and her contributions are recognized, instead of losing his/her uniqueness in the company, her name becomes recognized across disciplines and regions and thus, he/she is more likely to be well-known and may be more likely to be promoted. For instance, in Company D, a special recognition title is given to subject matter experts for enhancing enterprise-wide expertise recognition. Several respondents from Company D, one of the largest studied firms, expressed receiving benefits from their expertise and recognition for knowledge sharing in their career track. Although there is no explicit company policy linking knowledge sharing with promotion, our interviews show that knowledge sharing leads to expertise being recognized, which in turn has a positive relationship with career advancement. A respondent from Company G, another large firm that has more than 140,000 employees, indicated that one of the primary reasons to share knowledge was to know

who was knowledgeable about different subjects across the organization: “*The reason for knowledge management was the owners realized that we have a huge number of staff that have tripled in recent years, so people are not aware of who people are or who to talk to... the KM system allows people to recognize others in the organization...*” On the contrary, in smaller companies such as Company C, which has only 1,000 or so employees, the relatively small audience and the lack of a clear enterprise-wide expertise recognition system lead to a potential lack of career advancement with knowledge sharing.

Contingency Assumption #2: The reputational benefits of sharing one’s own knowledge, B_s , are generally larger in larger companies and smaller in smaller companies.

4.2 Nature of tasks: task repetitiveness

In this paper, the nature of tasks refers to the degree of repetitiveness of a firm’s major tasks. We assume that task repetitiveness has a significant impact on the benefit of receiving knowledge shared from others, B_o .

Some companies build unique projects that are often highly context- specific and

customized, such that employees within this company find that applying others' previously learned knowledge to new projects is of little benefit because projects are so drastically different from each other. For example, in Company C, where the project success often relies on creativity instead of repetitive utilization of best practice, employees indicated that the current best practices are so generic that users still have to spend considerable time consulting with others to make appropriate modifications. Respondents from Company C indicated that these modifications often take more effort than starting over from scratch: *"What's standard here might not be standard in another location [project]"* and *"We tend to not repeat things exactly"*.

As one respondent from Company C indicated, *"We don't learn that much from one building to another because we switch people to different product types and the projects change from one to another... you don't put that much effort into trying to learn something from an existing project because you know it isn't going to have meaning because the next project will be different"*. This often comes from employee's perspectives regarding the uniqueness of projects. Many respondents from Company C indicated, *"We are not in the replication business; we are in the creation business"...* *"Most of the time, we are doing new things"*.

In contrast, employees can benefit from other employee's knowledge when job-related tasks are similar and repeated. For example, in Company D, whose task

repetitiveness is considerably high, most interviewed employees within Company D feel that learning from peers is very useful for their work because much of the content from knowledge sharing can be replicated with little modification. If employees have repetitive work with similar project scopes, constraints, tasks and outcomes, they have a greater appreciation for the collective organizational knowledge because knowledge gained from past experiences can be re-utilized with minimal contextualization. For example, Company F implemented a knowledge management system in conjunction with standardizing their designs for residential projects, a highly repetitive task. As one respondent from Company F indicated, *“If you transfer knowledge it will only be for an overall view, but if you can standardize [the design and tasks] more, it will be much, much easier to transfer... because if this building has been built a couple of times before, then we can take advantage of capturing and transferring the knowledge”*. The aforementioned difference in the usefulness of shared knowledge can be explained by the nature of tasks from the perspective of the re-utilization rate of existing knowledge, which is similar to the concept of “half-life of knowledge” (Javernick-Will and Levitt 2009). Here we limit the scope of the nature of tasks to task repetitiveness, although the rate of obsolescence, and hence depreciation, of knowledge should be explored in future research related to organizational strategies.

Contingency Assumption #3: Employees working for companies that primarily perform unique, non-repetitive tasks receive less benefit from the knowledge shared by others, whereas employees working for companies that primarily perform repetitive work receive more benefits from the knowledge shared.

4.3 Contingency Equilibria and Strategies for Promoting Knowledge Sharing

By introducing two contingent variables that characterize an organization or community, the relative magnitude of three variables, B_s , B_o and C , can be determined. This will determine the optimal knowledge sharing strategies in each case, contingent on the different organizational contexts. We use [Company size, Nature of tasks] to represent different contextual situations, which are categorized into four scenarios based upon the size of the organization and the nature of the organization's tasks. Table 3 shows the Nash Equilibria for four different scenarios. The results of the following analysis are summarized in Table 3 and strategies are presented for each scenario.

[INSERT TABLE 3 HERE]

4.3.1 Contingency Equilibria and Strategies for Larger Organizations with

Repetitive Tasks

Given the contingency assumptions that larger companies will have smaller costs, C , and a larger professional benefit to sharing knowledge, B_s , condition (2), $B_s - C + R_1 + A > 0$, for *Equilibrium #1* following [Share, Share] is generally satisfied. This equilibrium will be further reinforced when the intrinsic rewards, $R_1 + A$, are not small. Therefore, employees in firms characterized by large firm size and repetitive tasks will tend to choose to “Share” in an organization.

While intrinsic rewards are generally helpful in encouraging the sharing of knowledge, for large companies, it is very important to create an environment that sustains a high B_s . For example, clear formal or informal policies that recognize and honor employees who share valuable knowledge with special titles, indicating that they are experts or knowledge sharers, will help to increase or maintain a high perceived value for B_s . Employees carrying “expert” titles will have higher visibility and, thus, a better chance for future promotion; consequently, the perceived B_s in large companies with proper recognition mechanisms to identify experts will be significantly enhanced. We refer to this strategy as the “be an expert strategy.” Note that the smaller C and larger B may not necessarily guarantee the satisfaction of the strong conditions for sharing. Large companies should still emphasize the perceived

intrinsic rewards from sharing valuable knowledge in an organization so as to reinforce the equilibrium for [Share, Share].

4.3.2 Contingency Equilibria and Strategies for Larger Organizations with Less Repetitive Tasks

According to the condition of *Equilibrium #1*, the degree of repetitiveness of the firm's tasks does not play a role in knowledge sharing dynamics when the firm is relatively large. Thus, *Equilibrium #1* remains the solution for this scenario.

4.3.3 Contingency Equilibria and Strategies for Smaller Organizations with Repetitive Tasks

There are three possible equilibria for smaller organizations with repetitive tasks. First, with a larger C and a smaller B_s often presented in smaller companies, condition (2), $B_s - C + R_1 + A > 0$, for *Equilibrium #1* following [Share, Share] will generally not be satisfied. However, when the intrinsic rewards, $R_1 + A$, for sharing knowledge are large enough, condition (2) for *Equilibrium #1* can be satisfied, causing employees to share. Second, when Eq. (2) is not satisfied, given that B_o for repetitive tasks is high, conditions for *Equilibrium #2* following [Share, Share], i.e., Eq. (7), Eq. (8), Eq.

(10), and Eq. (11), can still be satisfied provided that R_2 is not too small. The insight from this equilibrium is that firms with repetitive tasks will have a larger value for R_2 , social punishment, which will restore the equilibrium path back to [Share, Share]. Third, as discussed in previous section, when the strong condition for sharing is not satisfied, *Equilibrium #4* following [Don't Share, Don't Share] will be obtained if R_2 is close to zero.

For smaller companies, the intrinsic and social rewards are the major strategies that can facilitate knowledge sharing. Therefore, small firms may consider using social events and interactions that would help to establish reciprocity and friendliness amongst employees to increase the social rewards, R_1 . This strategy is especially important to firms that are in the early stage of implementing community of practice for sharing or have not established the culture or norm of sharing knowledge. We call this strategy “be a good person strategy,” which emphasizes being a person who helps others.

Alternatively, as implied by *Equilibrium #2*, smaller firms with repetitive tasks can emphasize the negative social punishment that is incurred by being a free rider who benefits from others' sharing but does not actively share. Smaller firms can therefore focus on establishing an environment or culture in an organization where sharing knowledge is set as a community expectation and norm that is part of the

corporate or community culture. This becomes standardized within the culture, which enforces the norm and the social punishment resulting from violation of the norm. We refer to this strategy as “be a good citizen strategy.”

Note that “be a good person strategy” and “be a good citizen strategy” are not contradictory strategies. The two strategies can be adopted simultaneously so that employees can be motivated to share by either one of the strategies depending on their characters.

4.3.4 Contingency Equilibria and Strategies for Smaller Organizations with Less

Repetitive Tasks

There are also three equilibria for an organization that is smaller with less repetitive tasks. Similar to the previous scenario for small organizations with repetitive tasks, *Equilibrium #1* following [Share, Share] can be obtained only when the intrinsic rewards, $R_1 + A$, for sharing are large enough. If the intrinsic rewards are not large enough, *Equilibrium #4* following [Don't Share, Don't Share] will be obtained. However, in contrast to previous scenarios, since B_0 is relatively small, Eq. (13) for *Equilibrium #3*, instead of Eq. (11) for *Equilibrium #2*, will be satisfied. As a result, although a large R_2 will yield *Equilibrium #2* following [Share, Share], a large R_2

cannot encourage employees to share in the presence of a small B_o . The insight of this analysis of *Equilibrium #3* indicates that because B_o is negligible and R_2 will not be imposed if others do not share, it is in both players' interests not to share.

As indicated by *Equilibrium #1* and *Equilibrium #3* in this scenario, the “be a good person strategy” continues to be an effective for knowledge sharing in small organizations with repetitive tasks, but the “be a good citizen strategy” becomes ineffective in motivating knowledge sharing. Even if firms intend to create the culture or norm of sharing, the culture and norm are not sustainable due to the fact that the perceived benefits from the knowledge shared by others, B_o , are negligible, meaning that the employees will not experience benefits. As a result, as more people violate the norm, the norm loses its power of punishing those who do not share.

4.4 Propositions for the Effectiveness of Knowledge Sharing Strategies

Based on the analysis of contingency solutions and implied strategies for knowledge sharing, we develop a contingency theory that suggests the effectiveness of various strategies for knowledge sharing, which is contingent on different types of firms, as shown in Table 4. For larger firms, the “be an expert strategy” and “be a good person strategy” are effective strategies for promoting knowledge sharing in an organization.

For smaller firms with repetitive tasks, “be a good person strategy” and “be a good citizen strategy” are suggested for promoting knowledge sharing. For smaller firms with less-repetitive tasks, “be a good person strategy” is the only effective strategy for promoting knowledge sharing.

The contingency theory can be expressed by the following three propositions for knowledge sharing strategies in organizations.

Proposition 1

Given the model assumptions and contingency assumptions, “be a good person strategy”, a strategy emphasizing intrinsic and social rewards from helping others, is generally an effective strategy for firms of all types in promoting knowledge sharing.

Proposition 2

Given the model assumptions and contingency assumptions, “be an expert strategy”, a strategy where firms recognize and reward employees publically for sharing knowledge, is more effective for larger firms for promoting knowledge sharing.

Proposition 3

Given the model assumptions and contingency assumptions, the “be a good citizen strategy”—a strategy where firms encourage the development of social norms of reciprocity, including social punishment for knowledge hoarding—is more effective for smaller firms with repetitive tasks in promoting knowledge sharing.

[INSERT TABLE 4 HERE]

5 Conclusions

This research explored knowledge sharing dynamics between employees in an organization to determine strategies that encourage organizational knowledge sharing.

Although knowledge sharing is well acknowledged as a source of competitive advantage for organizations, little research exists on the knowledge sharing dynamics

between individuals in the larger organizational context. To address this gap, we aimed to derive strategies for organizations that would encourage knowledge sharing

amongst employees. To do this, we developed a basic game-theoretic model that would analyze the interactive decisions of whether to share or hoard knowledge with

others. To develop the model, we first selected payoff variables from prior studies and developed new variables from case studies with engineering and construction firms.

Through the lens of case study results, we identified two variables for the contingent conditions of the larger organizational context: organizational size and the degree of

repetitiveness of tasks performed by employees within the organization. Lastly, we solved the equilibria considering the contingency variables to determine the

conditions that enabled or discouraged knowledge sharing. Based on the equilibrium conditions obtained, we derived strategies and propositions concerning the promotion of knowledge sharing.

From the game theory analysis, several important insights are revealed by the possible equilibria obtained. First, as indicated by *Equilibrium #1*, we find that, as long as the individuals' overall payoffs from sharing (excluding the benefits from learning others' shared knowledge) are positive, individuals will choose to "Share," no matter what other players' actions or strategies are. Unfortunately, the costs of sharing are often not balanced by the individuals' benefits of sharing, causing unwillingness to share knowledge. Second, as indicated by *Equilibrium #2*, when the conditions of *Equilibrium #1* are not satisfied, social pressure imposed on those who hoard their knowledge may facilitate the sharing equilibrium, provided that the overall payoffs including the learning from others' shared knowledge are positive. This important insight sheds light on the importance of social norms. Third, as indicated by *Equilibrium #3*, if the overall payoffs including the learning from others' shared knowledge are still negative, imposing social pressure or norms on free-riders is unlikely to produce sustainable impacts on facilitating knowledge sharing.

By further integrating two contingency variables into the model; we develop a contingency theory for promoting knowledge sharing. This theory enables people to

derive strategies to increase knowledge sharing, which will depend on the size of the organization and the nature of their tasks. The contingency theory of knowledge sharing is expressed by three propositions. Strategy implications due to the propositions include:

- The first proposition implies that all organizations should consider the “be a good person strategy,” which emphasizes social rewards and the intrinsic value employees receive from helping others.
- The second proposition suggests that larger organizations should further consider the “be an expert strategy,” which entails creating a formal structure that recognizes and rewards employees publicly for sharing their knowledge with others.
- The third proposition implies that smaller organizations with repetitive tasks should further consider the “be a good citizen strategy,” which emphasizes creating strong norms of reciprocity in the culture to encourage knowledge sharing and discourage knowledge hoarding.

This research has contributed to theory by focusing on the knowledge sharing dynamics between individuals in an organization and developing a contingency theory of knowledge sharing strategies. In addition, three propositions derived from the game theoretic model can be further tested and validated in future research using case

studies or surveys. For practice, strategies were suggested that might encourage knowledge sharing between employees in different organizational and task contexts. These strategies shed light on how managers of different sized rooms with more or less repetitive project tasks can design policies and develop organizational cultures to encourage knowledge sharing between their employees.

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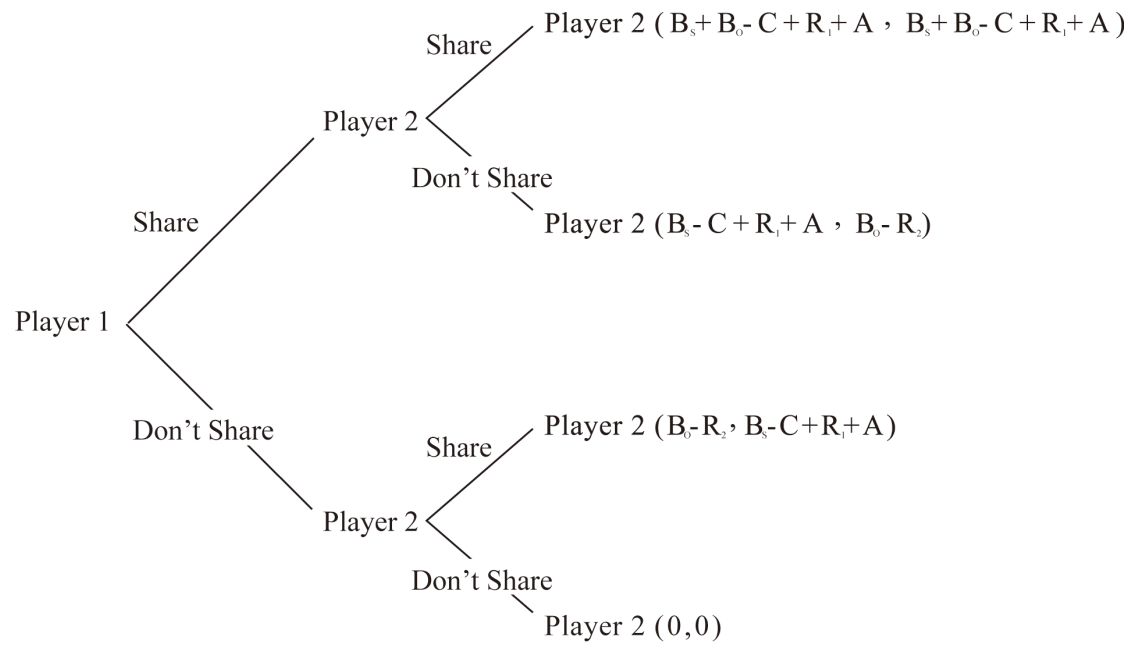


Figure 1. Game tree

Table 1: Background Information of Studied Companies

Studied Company	Business Scope	Number of employees	Task Nature
A	A global firm in engineering consulting, design, planning and project management	7,000+	Mix
B	A major engineering consulting firm based in Asia	1,800+	Mix
C	The design, R&D, engineering, construction, and project management arm of a firm in entertainment industry	1,000+	Less Repetitive
D	A global company that delivers engineering, procurement, construction, maintenance (EPCM), and project management	36,000+	Repetitive
E	A company specializing in engineering, project/construction management, business consulting, and operational services to the mining, metallurgical, energy and infrastructure industries	6,000+	Repetitive
F	A global firm specializing in construction, development of commercial and residential projects	60,000+	Mix
G	A construction firm specializing in design-build construction, general contracting and construction management	140,000+	Repetitive

*In large multinational organizations, there is typically a wide-variety of tasks. The nature of the task for each organization is mainly based upon the group of respondents within the company.

Table 2: Model Variables and Their Descriptions

Variables	Descriptions
C	The costs of knowledge sharing: including explicit costs and implicit costs
A	Self-satisfaction from knowledge sharing
B_s	Benefits from increased professional reputation due to sharing knowledge
B_o	Benefits of receiving knowledge from others in an organization
R₁	Social rewards from knowledge sharing
R₂	Social punishment faced due to withholding one's knowledge

Table 3. Contingency Equilibria Solutions

	Larger Company (smaller C, larger B_s)	Smaller Company (larger C, smaller B_s)
Repetitive Tasks (larger B₀)	<p>Smaller C and larger B_s → $B_s - C + R_1 + A > 0$ →</p> <p>Nash Equilibrium path is: ● [Share, Share]: NE #1</p>	<p>Larger C and smaller B_s → $B_s - C + R_1 + A < 0$ →</p> <p>Nash Equilibrium paths are:</p> <ul style="list-style-type: none"> ● [Share, Share] if $R_1 + A$ is large: NE #1 ● [Share, Share] if $R_1 + A$ is small but R_2 is large: NE #2 ● [No, No] if both $R_1 + A$ and R_2 are small: NE #4
Less- repetitive Tasks (smaller B₀)	<p>Smaller C and larger B_s → $B_s - C + R_1 + A > 0$ →</p> <p>Nash Equilibrium path is: ● [Share, Share]: NE #1</p>	<p>Larger C and smaller B_s → $B_s - C + R_1 + A < 0$ →</p> <p>Nash Equilibrium paths are:</p> <ul style="list-style-type: none"> ● [Share, Share] if $R_1 + A$ is large: NE #1 ● [No, No] if $R_1 + A$ is small but R_2 is large: NE #3 ● [No, No] if both $R_1 + A$ and R_2 are small: NE #4

Table 4. Contingent Strategies for Facilitating Knowledge Sharing

	Larger Company	Smaller Company
Repetitive Tasks	<ul style="list-style-type: none">● Be an expert strategy● Be a good man strategy	<ul style="list-style-type: none">● Be a good man strategy● Be a good citizen strategy
Less-repetitive Tasks	<ul style="list-style-type: none">● Be an expert strategy● Be a good man strategy	<ul style="list-style-type: none">● Be a good man strategy