

# **Knowledge Dilemmas within Organizations: Resolutions from Game Theory.**

**Ravi S. Sharma\*, Suman Bhattacharya**

*Nanyang Technological University, Wee Kim Wee School of Communication &  
Information, 31 Nanyang Link, Singapore 637718, Singapore*

## **Abstract**

*The knowledge management literature suggests that an organization's knowledge ecosystem is comprised of strategic situations in which behaviours of its knowledge workers show potential conflicts with what would be optimal for the organization. This paper aims to explore how such behaviors in terms of knowledge flows may be modelled and analyzed using a game theoretic approach. While prior research has investigated some use of game theory in knowledge management, a comprehensive understanding of the organisational eco-system remains unexplored. Hence, a qualitative inductive approach was adopted in order to pursue the exploratory nature of the research question. Critical reviews of key literature in both knowledge management and organization theory identified four organizational knowledge dilemmas - "silos of knowledge", "tragedy of the knowledge commons", "knowledge friction" and "knowledge toxicity". These dilemmas were used in various combinations to generate five commonly occurring scenarios in organizations. A game theoretic analysis of these scenarios using the PARTS framework provided a useful understanding of knowledge flows within organizational eco-systems. More specifically, the analysis led to key insights and prescriptive guiding principles in formulating knowledge strategies and policies to combat the major knowledge dilemmas that inhibit effective knowledge flows within organizations.*

## **Keywords**

*Knowledge flows, Knowledge sharing and absorption, Knowledge strategies, Organizational performance, Knowledge dilemmas*

## **1. Introduction**

In today's complex and globalized market economy, organizations view knowledge as one of the most valuable and strategic resource and strive to manage it in order to derive competitive advantage [91, 46, 32, 68, 89, 10, 84]. Knowledge sharing thus becomes a key differentiator of success. As Boer al. [9] state: " It is a key process in creating new products and services, in leveraging organizational knowledge assets and in achieving collective outcomes."

Hence over the last two decades, knowledge management (KM) has drawn considerable interest as a discipline of study in the academic arena and practice in organizations. Despite the successful inroad of KM into leading organizations, numerous scholars have noted the various challenges associated with effective knowledge exploitation (c.f. [4, 5, 8, 18, 24, 26, 35, 41, 42, 47, 61-63, 68, 72, 79, 91, 92, 95]). There is also considerable agreement in the literature that while organizations make significant investments on technology and tools to promote knowledge sharing, this is neither necessary nor sufficient as behavioral, cultural and structural aspects are the primary determinants of success. Indeed the findings of a major study of 431 US and European organizations conducted by a consulting firm (and cited by Ruggles [78]), reveal that the most challenging task of KM is to change behaviors relating to knowledge creation and consumption. As some have argued, knowledge sharing is often held as "unnatural" [23]. More specifically, a review of KM literature suggests that the organizational knowledge transactions are ridden with a tensions between the perceived self-interest of an individual and the cooperative gain for the group or community [60, 14, 20]. Organizations that ignore such tensions in knowledge flows would ineffective in achieving their KM objectives [100].

Knowledge flows refer to the links between creation and consumption and occur at two levels – the intra-organizational flows confined to the boundaries of the organization and inter-organizational knowledge flows that extend beyond the enterprise and involve external entities such as suppliers, alliances, business partners, competitors and industry regulators. The nature of relationships, strategic motivations, situations of usage in inter-

organizational and intra organizational knowledge flows are distinct and therefore, study of these two knowledge ecosystems entails different considerations. In order to manage the scope of paper, this study is limited to the intra-organizational knowledge flows perspective is highly recommended.

In this paper, we address the issue of tensions in knowledge flows within organizations. Specifically, we identify some typical knowledge dilemmas and attempt to resolve them using the analytic lens of game theory. The next section introduces the notion of knowledge flows in organizations and a description of four major knowledge dilemmas. Section Three is a background review of game theory and its application to KM. In Section Four, five typical organizational scenarios, made up of a combination of dilemmas, are introduced and resolved using game theory. The paper concludes with the key finding and implications of the study in prescribing some design rules for organizational knowledge management strategy in Section Five.

## **2. Knowledge Flows in Organizations**

The dictionary meaning of the word “dilemma” (Websters, n.d.) suggests a situation necessitating a choice among apparently undesirable alternatives. The organizational knowledge ecosystem comprises situations where agents, as creators and consumers of knowledge, make strategic choices to derive the best possible outcomes for the organization. Mutual dependence of such choices might result in outcomes with undesirable utilities for some or all the stakeholders. In order to capture and articulate the essence of such complexity of decision making in knowledge situations, this paper introduces the notion of dilemmas in the knowledge ecosystem. These dilemmas affect the outcome of organizational knowledge initiatives to a great extent. Therefore, in an organizational context, a specification of the dilemmas is necessary in order to combat them effectively.

An extensive review of the KM literature provides a vantage point to some of the organizational dilemmas related to the knowledge ecosystem. These dilemmas may be specified through multiple perspectives and levels such as, strategic, implementation, cultural, economic, and political. This section of the article identifies some key

knowledge dilemmas that characterize conflict of interest situations among agents of the organization. Using such a criterion, four key dilemmas of organizational knowledge ecosystems, summarized in Table 1, are identified and described below.

**Table 1: Four Key Knowledge Dilemmas.**

<b>Dilemma</b>	<b>Related challenges within knowledge ecosystem</b>
1 Silos of knowledge	A concept of power being associated with possession of knowledge, the dominant individual rationality is to retain monopoly of knowledge through hoarding [20]. In multi-unit organizations, asymmetry of knowledge repositories, authorities, structural and cultural dispositions among the units, can result in poor knowledge flows[93, 45]. Additionally, asymmetry of information in knowledge exchanges impairs knowledge flow in organizations [24].
2 Tragedy of the commons	Knowledge is considered to be a public good with its “non-excludable” and “non-rival” characteristics. Individual rationality of enjoying the benefits of knowledge without any contribution, makes it susceptible to underinvestment and free-riding [48, 14]. Such free-riding results in a sub-optimal outcome for the knowledge ecosystem as a whole.
3 Knowledge friction	While organizations pursue benchmarking their knowledge and replication of their superior practices within their boundaries, such transfer of knowledge may be inhibited by contingency factors such as similarity of context, motivational dispositions, strength of relationships and absorptive capacity [90, 69, 5, 73].
4 Toxicity of knowledge	Possession of knowledge can generate biases in the organizations that prohibit learning from contradictions or past failures and replenishing their old knowledge stock. Such biases severely impair organizational performance [10, 31, 63, 17]. Moreover, knowledge may be used in organizations may pursuing self-serving and political agendas that endanger organizational reputation and stability [4, 13].

### *2.1 Silos of Knowledge*

Knowledge flows in organizations depend heavily on creation of new knowledge through voluntary contribution and transfer of such knowledge through sharing throughout the organizational to be utilized as needed. However, possession of knowledge is associated with a sense of holding power that knowledge agents may not be willing to share such

assets. Instead they make choices on investing limited time and efforts in exchanging knowledge, based upon perceived self-interests [24]. Accordingly, knowledge sharing situations reflect conflict of interests, where individuals make strategic choices on whether to contribute or hoard their knowledge depending on the perceived benefits from the exchanges.

Asymmetry of information in knowledge exchanges can also propagate inefficiency in the knowledge ecosystem [24, 94, 47]. Such asymmetry of information affects the perceived value of knowledge by the recipient and consequently the effectiveness of the knowledge flow. Lin confirmed such asymmetric information structures as a dimension of relationship between the agents of knowledge flows [58]. Knowledge exchanges often take place with incomplete information between the two parties; that is, the knowledge seeker and the knowledge provider [24]. There are operational inefficiencies in knowledge transfer as the nature of knowledge and its value is uncertain in the sharing stage. The three problem areas, taken together, contribute to a dilemma that affects the process of knowledge creation and sharing in the organization; producing pockets of disjointed knowledge. Such a dilemma is hence considered “silos of knowledge”.

## *2.2 Tragedy of the Knowledge Commons*

Organization knowledge, with its non-excludable and non-rival characteristics, is best considered a “public good” or “commons”. As with any other public good, is susceptible to underinvestment. Since the consumption of knowledge can be enjoyed without any corresponding contribution, the benefit maximizing strategy for any agent in the organization is to “free ride”. This individual rationality leads to a sub-optimal outcome for the organizational knowledge ecosystem and poses a social dilemma [14]. Such a social dilemma in turn leads to a paradoxical situation where individual rationality towards maximizing self-interest leads to collective irrationality in over-exploiting common resources like public goods, producing a sub-optimal outcome for the organization as a whole [53]. This is identical to the “tragedy of the commons” situation for shared public goods, described by Hardin [48] and later popularized by Lessig [55].

Borrowing the concept, such an organization dilemma may be labelled as the “tragedy of the knowledge commons”.

### *2.2.3 Knowledge Friction*

Several scholars have observed that knowledge resides in organizational agents and their tools, tasks, and networks. Transfer of such contextual knowledge is difficult (cf. [5,86,21,90]). Intra-organizational knowledge flows are impaired by the formal hierarchical structure of the organizations [93]. Knowledge initiatives that focus on transfer and adoption of organizational assets and practices fundamentally encapsulate change management agendas. As with the case of most change management programs, organizations have replication and adoptions issues across business units and with their partners [90,69]. Motivational dispositions like the “not-invented-here” mentality of some organizational units may be a barrier to the free flow of knowledge [24,47].

Organizations strive to diffuse their knowledge effectively among their employees, reaping the business benefits of organizational learning. The KM literature attributes an impaired flow of knowledge to the stickiness of knowledge and asymmetry among agents, in terms of power, motivation, structure and absorptive capacities [90,45,49,21,93].

As with the dilemma of “silos of knowledge”, pockets of excellence co-exist with paucity in any organization. Whether complementary, redundant or contradictory these treasure houses of knowledge often remain unknown and untapped. In theory, organizations seek to benchmark their knowledge and spread the superior practices and know-how in every corner of them, reaping the business value from that knowledge [69]. Successful transfer of knowledge from one part of the organization to another entails absorption and utilization of knowledge by the recipient entity. Although organizations invest heavily on processes and tools in making such transfers, reuse of knowledge assets is often fraught with challenges associated with deliberate uptake and application [35,61]. Several factors including the nature and context of knowledge, motivations and abilities of the entities involved in the knowledge exchange limit the application of knowledge [90,5,73]. In the parlance of KM, re-creating knowledge or repeating mistakes is the

common outcome of such a dilemma [84]. Metaphorically, this situation can be described as “knowledge friction” – a dilemma that constrains organizations’ abilities in exploiting their knowledge assets to the fullest potential.

#### *2.2.4 Toxicity of knowledge*

Overriding negative information and generating a positive spin often provides organizations with inaccurate images of their knowledge assets [74]. This situation encourages agents within to avoid knowledge that is perceived to be associated with past failures. In an organizational environment that does not welcome learning from mistakes, it may be argued that “whitewashing” of facts will prevail by suppression or even falsification of the knowledge. The traditional notion of “knowledge” is based on the positive knowledge which considers knowing as merely a constructive, linear and accumulative process. Some scholars have introduced a concept of “negative knowledge” that discusses the aspects of forgetting knowledge or unlearning and the value of failure [63,72]. The inability to “unlearn” existing knowledge blocks for the purpose of creating new knowledge is a source of bias. Knowledge can be both a source of and a barrier to innovation [31,17]. Knowledge has a shelf life and organizations which exploit such assets for too long miss innovation opportunities and fail to accrue competitive advantage. Boisot [10] has advocated the need for a new paradigm of “Schumpeterian Learning” that facilitates creative destruction of old knowledge assets and building of new ones on different foundations.

While most KM research centers on the positive side of managing knowledge, some have taken the view that knowledge can have a “dark side”. Some scholars argue that since knowledge is associated with power, money, and success, management of knowledge can be highly political [23]. Due to such political considerations, in organizational situations involving high conflict of interests between individuals or groups, misrepresentation and manipulation of knowledge may be used as a “secret weapon” in pursuing self-serving and political agendas endangering organizational performance, reputation and stability (cf. [4,13]). Enron remains a good example of where a large scale manipulation of corporate knowledge led to a financial disaster [4]. Paradoxically before their collapse,

Enron was regarded as one of the “success stories” of KM culture in [22]. Such situations encompass aspects of knowledge that can have negative implications for the organizational knowledge

ecosystem and such a dilemma is labelled “toxicity of knowledge”.

### **3. Brief review of prior work**

Game theory is the formal study of rational behaviour of interacting participants in strategic situations characterizing conflict of interests and mutual dependence [30]. Formally introduced by the eminent Hungarian mathematician von Neumann in his seminal volume “The Theory of Games and Economic Behaviour” in the 1940s, game theory has matured significantly and finds its application across disciplines like mathematics, economics, biology, social and political sciences [96,102]. Many scholars believe that Nash’s formulation of non-cooperative game theory was a great breakthrough in the history of social science [65]. Rapid growth in interest on game theory in academic research and the strength of the discipline is further evidenced by the observation that in last two decades, eight Noble prizes have been awarded for related work in the area of game theory.

A distinction between game and game theory is important to understand the research perspective of this paper. Games are taxonomies of strategic situations. Game theory is a mathematical derivation analysing the cognitive abilities of player’s strategies [16]. The primary purpose of game theoretic reasoning is not to predict the outcome of the game but to elicit how a game is played; and how rational players pursuing their self-interests are likely to make strategic choices in response to the strategies of other participating players [75].

Analytical game-theoretic reasoning traces its roots to the classic theory of rationality and economic models developed by Adam Smith and his contemporaries [83]. It assumes a direct relation between preferences and actions, predicting that a rational decision maker would act out of pure material self-interest. Moreover, such a framework does not recognize any influence of qualitative factors such as emotions, altruism, fairness, and

randomness into human decision making. Though game theory has been extensively used in modelling a wide range of social phenomena, the suggested implications are at times in variance with observations of real-life situations [70]. On the other hand, contemporary research on other game theoretic frameworks like behavioural game theory suggests that factors such as history, culture, and cooperative instincts influence the actual behaviour of human agents in social situations [15,16,33]. Empirical observations from experimental games also strengthen the view that human beings are motivated by reciprocity, conditional cooperation, a sense of equity and fairness; preferring an egalitarian distribution of payoffs [36,11]. Researchers of game theory also recognize the role of a critical mass of human agents in initiating change in the social behaviour of a group [29].

The themes of commonality and conflict of interests proposed by game theorists are congruent with the theories of social exchange, collective action and the perspectives of cooperation discussed earlier, in relation to the organizational knowledge ecosystem [42]. This paper draws inspiration from such alignments in theoretical foundations between two distinct domains of study – KM and game theory and proposes a closer examination of the contexts of organizational knowledge flows; using game-theoretic templates that are available. Organizational knowledge processes are often complex and social in nature. It is a challenge for KM in an organization to be modelled using games and analyzed for their implications. To this end, we review some related work by scholars in investigating organizational knowledge sharing issues from a game theory perspective.

The tension between the need for cooperation and a horde of conflicts of interest, observed in knowledge contribution situations has inspired scholars to explore game theoretic perspectives of such situations. Scholars argue that knowledge sharing behaviors of organizational agents (knowledge workers) are riddled with conflict of interest situations in which they perceive differentiated payoffs based on their strategic choices. Such situations may be modelled as games [60, 20, 80]. Knowledge sharing in organizations may thus be considered as a cooperation problem – how to get knowledge agents to share and receive knowledge in the best interest of the firm. This is similar to public-good or private-advantage situations in political economy [14]. Researchers have

also drawn from other theoretic frameworks such as social exchange theory, economic exchange theory, motivational crowding-out theory, social cognitive theory to model knowledge sharing situations into games, taking into consideration the various motivational, socio-psychological and cultural factors in deriving the perceived payoffs for the involved players [42].

Several empirical studies involving agent-based modelling approach to simulate knowledge sharing behaviors including negotiation and protocols [100, 52]; conducting laboratory experiments to predict knowledge sharing behavior in private-collective innovation [39]; and, surveying individual attitudes toward efficacy, compatibility, advantage in the context of reciprocity and trust [18], have been undertaken.

Theoretical studies in which the role of incentive mechanisms [103] and national cultures (cf. [64]) in knowledge sharing have also been studied through the lens of game theoretic reasoning. Lin et al. [58] and Lin [59] proposed game-theoretic models which predict how information incompleteness and asymmetry may negatively influence knowledge transfers, and generates solutions to alleviate these negative impacts. Boer et al. [9] have introduced the Relational Models Theory (RMT) to analyse the dynamics of communal sharing with respect to authority ranking, equality matching and market pricing. Xu et al. [99] derived a set of theorems and proofs that use what they call the lattice value matrix game to solve practical problems. Other game theoretic studies on decision making models for inter-organizational collaborative knowledge creation and transfer, primarily in technology innovation alliances have also been proposed [79,7,51,27].

However, in our view, no study has taken a holistic approach in analyzing the dual aspects of strategic interactions – need for cooperation as well as conflict in the knowledge flows within an organizational ecosystem. Accordingly, this paper proceeds to investigate the research question of how game theory may be applied to knowledge situations occurring in organizations, in understanding the agents' behaviors laced with strategic interdependence, and finding ways to optimize the knowledge flows within organizations. More specifically, how may the dilemmas of an organization's knowledge ecosystem be analyzed and resolved through the lens of game theoretic reasoning? Such a

study seeks to achieve better understanding of the challenges organizations face in managing their valuable knowledge assets.

## **4. Modelling Knowledge Dilemmas**

### **4.1 Research Approach**

In alignment with the research objective of investigating the application of game theoretic analysis to knowledge management and the relevant literature review of prior work, in this section we construct a framework of analysis that incorporates game theory in typical knowledge management “scenarios”. From the key dilemmas in the organizational knowledge ecosystem we have derived these five scenarios which incorporate one or more of these dilemmas. Following the long-standing academic principle that a model derives its power from its simplicity, this paper employs simple archetypical game models in specific dilemmas and situations. Possible game solutions are then analyzed with the objective of achieving equilibrium strategies.

To offer full disclosure, our first attempt was to capture reactions by mapping our dilemmas to live scenarios in some of the small firms with whom we were engaged. Every single one of them declined for a variety of concerns which ranged from confidentiality of their own client information to the non-usefulness of “toy problem” experiments that they were prepared to consider. Our four dilemmas were considered “intrusive and confrontational” and the firms were not prepared to create conditions under which they could be tested. Our own academic institution’s research ethics board refuses permission for the use of graduate students working on projects as live subjects for experiments such as this. Subsequently, both authors had to retrospectively recreate the five scenarios based on their 10 years in professional services and client engagements. We categorically state in our paper that given the rationality and “best response” assumptions made in game theory and the absence of a validated measurement technique for utility and payoff, game theoretic models should not be applied as quantitative functions but rather to derive what-if considerations of strategic outcomes.

We also acknowledge the limitations of a pure, rationality-driven analytical approach such as the numerical game theory matrix [1] and subsequently combine observations

from other conceptual frameworks such as behavioral game theory, empirical evidences from experimental games and adaptive analyses. The implications of the modelling are discussed for generalization in understanding new situations and key insights are presented as prescriptive guiding principles in formulating knowledge policies in organizations to combat the dilemmas.

Additionally, as an application paper, detailed mathematical theorems and derivations are beyond the scope of discussion. To allow conciseness and precision, standard mathematical symbols are used to describe the game models and their resolution of dilemmas in the various scenarios.

#### **4.2 A Framework for Analysis**

Game theory offers a set of models, which are essentially strategic situations described in a standard nomenclature. Each of the four dilemmas identified in Section Three co-occur in various combinations as typical scenarios that may be analyzed using distinctive game models. Modelling of such scenarios calls for a deliberation of key characteristics that depict the uniqueness of a situation yet amenable to drawing general conclusions. As an illustration of this, the dilemma of “silos of knowledge” encapsulates strategic situations involving hoarding of knowledge, disparities of knowledge repositories and asymmetry of knowledge flows. Each of these situations stipulate distinct considerations for modelling, and accordingly, segregated for game theoretic analysis (c.f. [100]).

It is essential that the underlying assumptions of a model capture the essence of the situation [70]. In mapping the dilemmas to scenarios, this paper draws from the ‘PARTS’ framework of Brandenburger and Nalebuff [12] to formulate and subsequently, analyse game-theoretic models in an organizational context. Table 2 summarises the five dimensions of the PARTS framework and the fundamental questions relating to each.

Scenarios for modelling are derived in a way such that each scenario represents some unique characteristics in terms of PARTS dimensions such as identifying the players in a game, defining the rules, deducing winning tactics, and evaluating added-values from each player.

It may be argued that due to the tacit and complex nature of knowledge in its tacit form, organizations cannot mandate knowledge contribution or adoption through contractual and binding agreements. The assumption of rationality suggests that knowledge workers pursue their individual interests while "playing" in the organizational knowledge ecosystem. This is often in the expectation that, consistent with Adam Smith's theory of the "invisible hand", individual interests obtained through their "best responses" would lead to superior outcomes for the organization. Therefore, game models describing knowledge dilemmas could be structured as non-cooperative in nature. Most of the organizational knowledge dilemmas explored in the paper entail a tension between commonality and conflict of interest. Knowledge is a nondiminishing resource and knowledge transactions offer potential opportunities of gaining for all the participants. From a game modelling perspective, such situations are conceptualized as variablesum in nature. However, dilemmas concerning the negative use of knowledge, such as the dilemma of knowledge toxicity, suggest a situation of absolute conflict. Accordingly, a zero-sum game model could be constructed in depicting such situations [57].

In terms of research approach, this paper leverages simple models offered by game theory, ranging from classic games such as the prisoners' dilemma to exclusive game models like "leader-follower" or "principal-agent". For simplicity, only two-player games are considered, except for the "tragedy of the knowledge commons" dilemma, where the knowledge commons refers to all players of an eco-system. In other works we model non-cooperative bimatrix games with uncertainty along the specifications of Gao [40].

The next section outlines the mappings between the four dilemmas and five scenarios deemed appropriate for modelling using the structure of the PARTS framework by identifying players, added values, roles, tactics and scope.

Table 2: Summary of PARTS Framework.

<b>Dimension</b>	<b>Key related questions for game analysis</b>	<b>Implications for current analysis</b>
Players	Who are the players of the game?	In an organizational ecosystem, members engaged in knowledge processes such as knowledge creation, transfer and application constitute the players.
Added Values	The additional value each player brings to the game with respect to other players. This suggests how the players can increase their own utilities or limit other players' payoffs.	In an organizational context, an employee's reputation as a knowledge source can provide added values to him.
Rules	Are the rules fixed or manipulable by any player ? If one or more player has the power to manipulate the rules by using strategic moves, the added values and tactics for the players are impacted. In a strategic sense, the player making the first move can create an advantage for himself. The manipulation of rules for advantage is known as a game-changer.	In an organizational knowledge ecosystem, there is no universal set of rules. There could be formal organizational policies that mandate knowledge contribution as an employee assessment criterion. But in a practical sense, it is the organizational culture that determines whether some of the dilemmas permeate.
Tactics	What are the perceptions of different players in the game ? The players' perceptions of the game such as a pure competition (win-loss) or a cooperative (win-win) opportunity for all, influences the tactics to be adopted by players in the game.	Under what circumstances do players (co-)create, transfer and apply knowledge in order to maximise their payoffs. This is the set of tactics to be formulated.
Scope	What is the current scope of the game ? Players can change the scope by extending or shrinking the boundaries of the game.	The scope of games is limited to the boundaries of the organization. It is possible to change the scope of the games by also allowing interorganizational knowledge flows such as partnerships, alliances and outsourcing.

### 4.3 Proposed scenarios for modelling

The dilemmas described in the previous paper are obviously not stand-alone and occur in various combinations as challenging scenarios. For the purpose of applying game theoretic analytical models in order to arrive at solutions for the research objective of the paper, five realistic scenarios have been developed. Note that these scenarios are developed for the purpose of deriving what-if situations and resolutions for knowledge strategies. Table 3 summarizes the scenarios modelled and subsequently analyzed in this section.

Each of these scenarios are discussed, modelled and analyzed in the following sections.

Table 3: Mapping of scenarios with dilemmas for game modelling.

<b>Scenario</b>	<b>Description</b>	<b>Representing dilemma (s)</b>	<b>Key parameters for modelling</b>
Scenario A	Lack of collective action and free-riding on knowledge initiatives	Silos of knowledge, Tragedy of the knowledge commons	Multi-player, sequential move, variable-sum game
Scenario B	Asymmetry of knowledge repositories between organizational units	Silos of knowledge Knowledge friction	Two-player, sequential move, variable-sum game
Scenario C	Asymmetry of information in knowledge flows within ecosystem	Silos of knowledge, Knowledge friction	Two-player, sequential move, variable-sum game
Scenario D	Lack of adoption of organizational knowledge	Knowledge friction	Two-player, sequential move, variable-sum game
Scenario E	Improper usage of knowledge in unhealthy competitive situation	Knowledge toxicity	Two-player, simultaneous move, zero-sum game

Each of these scenarios are discussed, modelled and analyzed in the following sections.

#### 4.3.1 Scenario A - Lack of collective action and free-riding on knowledge initiatives

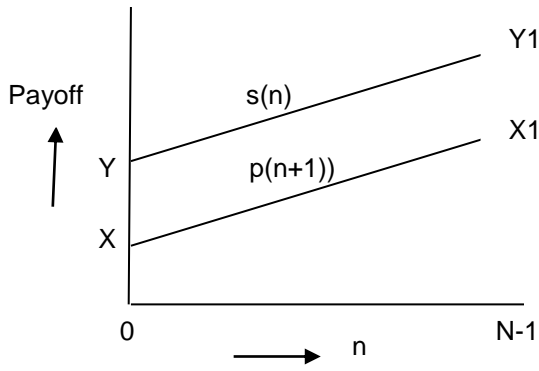
##### 4.3.1.1 Strategic situation (game model):

At a basic level, this situation reflects the issue of cooperation and collective decisions among members in the ecosystem, in terms of knowledge contribution. As the dilemma of knowledge commons suggests, organizational knowledge may be considered a public good. As with all public goods, knowledge contribution is also susceptible to less than optimal contribution and free-riding behavior (what economists call an externality). To analyze such situations from a game theory perspective, a representative scenario is proposed. In an organizational team of  $N$  members, suppose  $n$  persons contribute knowledge or participate while remaining  $(N-n)$  decide to hoard or shirk. Cost of participation ( $c$ ), in terms of time and effort, depends on the number of participations  $n$  and may be expressed as a function  $c(n)$ . Benefits from the knowledge contribution are enjoyed by all – contributor or free-rider. It can be expressed as a function of  $n$ ,  $b(n)$ . Thus, the payoff for each participant  $p(n)$  equals to a value of  $b(n)$  minus  $c(n)$ , whereas for each shirker, the payoff  $s(n)$  is equal to  $b(n)$  since  $c(n) = 0$ .

For any given player, the decision to participate or shirk would depend upon the decision of the other  $(N-1)$  members consisting of  $n$  contributors and  $(N-1-n)$  hoarders. If a player decides to contribute, her payoff becomes  $p(n+1)$  and if the player decides to hoard, the payoff remains  $s(n)$ . Therefore, the player's decision in favour of contribution becomes a best response if the condition  $p(n+1) > s(n)$  is met. The decision in favor of hoarding becomes a best response if  $p(n+1) < s(n)$ . Plotting the graphs for these payoff functions against the proportion of players pursuing one strategy or the other, reveals the nature of the game and the corresponding equilibrium strategies. For simplicity,  $p(n+1)$  and  $s(n)$  are considered to be linear functions, represented by straight line graphs.

#### 4.3.1.3 Analysis:

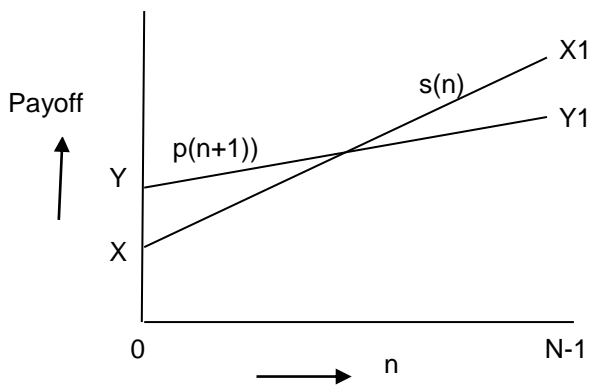
**Case 1:**  $s(n) > p(n+1)$  for all  $n$ , where  $0 < n < N-1$



**FIGURE 1: MULTI-PERSON PRISONERS' DILEMMA GAME. SOURCE: DIXIT & SKEATH [30].**

This sub-scenario represents a multi-person prisoners' dilemma game where hoarding remains the dominant strategy, irrespective of the number of players who participate i.e.  $s(n) > p(n + 1)$  for all values of  $n$ . Here, the Nash equilibrium of the game evolves through all organizational members hoarding their knowledge. However  $Y < X_1$  shows that if everyone hoards their knowledge (i.e. the Nash equilibrium strategy), individual payoff D remains less than A, the situation where everyone contributes.

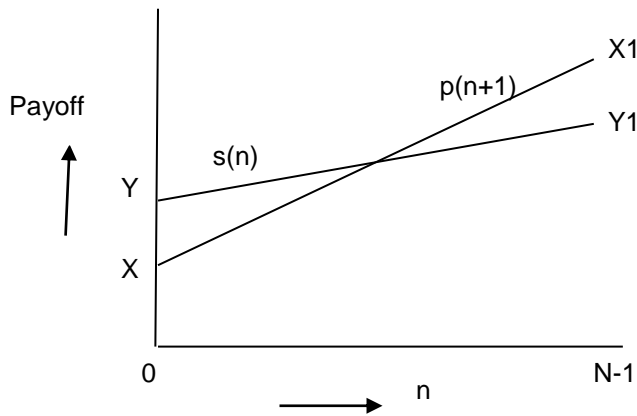
**Case 2:**  $p(n+1) > s(n)$  for low values of  $n$ , where  $0 < n < N-1$



**FIGURE 2: MULTI-PERSON CHICKEN GAME. SOURCE: DIXIT & SKEATH [30].**

This sub-scenario represents a multi-person game of chicken where for small values of  $n$ ,  $p(n+1) > s(n)$  and  $p(n+1) < s(n)$ , for large values of  $n$ . Thus, when a large part of the population participates in the game, an individual's best payoff comes when she does the opposite i.e. shirks ( $X_1 > Y_1$ ). When there are only few participants in the game, it may be better for an individual to participate ( $Y > X$ ) as recognition and rewards may be forthcoming. Here, the intersection of the two lines can roughly be considered the Nash equilibrium for the game. It can be noted that the payoff corresponding to the intersection point is lower than the payoff  $Y_1$ , a better outcome where everyone contributes.

**Case 3:**  $s(n) > p(n+1)$  for low values of  $n$ , where  $0 < n < N - 1$



**FIGURE 3: MULTI-PERSON COORDINATION GAME. SOURCE: DIXIT AND SKEATH[30].**

This sub-scenario represents a multi-person game of coordination (like ‘‘Battle of the Sexes’’ or ‘‘Stag Hunt’’) where  $p(n + 1) < s(n)$  for small values of  $n$  and  $p(n + 1) > s(n)$ , for large values of  $n$ . Thus, when a large part of the population participates in the game, an individual's best payoff comes when he does the same i.e. contributes knowledge ( $X_1 > Y_1$ ), perhaps due to the returns on an economy of scale. When only few participate in the game, it works better for an individual to hoard ( $X < Y$ ). This game has two Nash equilibria, at  $X_1$  (where everyone participates) and  $Y_1$  (where everyone shirks). Point  $X_1$  denotes the best outcome for the organization (the Pareto-efficient solution).

Findings from the analyses of the sub-scenarios suggest that hoarding of knowledge by individuals resemble the classic prisoners' dilemma game situation, where individual rationalities dominate and lead to an inefficient organizational outcome. Only coordinated and collective action among knowledge workers and groups would provide the optimal solution (Pareto-efficient Nash equilibrium) for the organization. In this situation, it is in every member's best private interest to take the action that turns to be best for the organization as well. Observations from role-playing games suggest that strategic and reciprocal cooperation among players is induced in the course of repeated interactions, through observations of mutual behaviors [6]. However real-life game situations reveal that convergence to an inferior equilibrium is often self-perpetuating. Hence, in order to achieve the better Nash equilibrium, the expectations of all the members need to converge in a manner that supports knowledge contribution. This elicits the question of what organizational policies and interventions should be in place in order to ensure convergence of employees' expectations and deriving a better outcome for knowledge initiatives.

#### 4.3.1.4 Implications for knowledge strategy:

Collective action on knowledge contribution requires commonality of employees' expectations in a manner that in a game theoretic parlance may be thought as a "focal point" in which players' expectations converge [81]. Empirical evidence from numerous game experiments show that existence of a focal point depends much on the common experience of the players, including their social, cultural, and linguistic backgrounds [34,33]. It has been argued that organizations driven by a clear purpose and a cohesive cultural disposition will find it easier to bring a commonality in employees' expectations and derive better knowledge management outcomes [35]. This is evidently in alignment with views on the critical role of organizational culture in driving knowledge management initiatives [62]. This can be promoted by a clear vision and "meaning-making" in knowledge organizations [54,76]. Geoff and Jones [43] have observed that a strong corporate culture built on solidarity and sociability, can hold the organization together against disintegration challenges. The empirical work of Chen et al. [19] found

that attitude and other factors such as self-efficacy and organizational climate positively contribute to knowledge sharing intentions within an organization.

An analysis of the three game sub-scenarios (cases 1–3 above) suggests that strategic and reciprocal cooperation among players engaged in repeated interactions would produce the best outcome. Reciprocity acts as a key motivator for knowledge sharing as individuals expect future benefits from others. Some researchers proposed the idea of learning in games where players adjust their moves based on their experience over repeated rounds of interactions

and equilibria in such cases correspond to the long-run outcome of the adjustment process [38]. Such views strengthen the critical role of open communication, trust and positive work climate in success of organizational knowledge initiatives [28].

Lessons from practical game situations point to the role of critical mass of human agents in initiating collective action of the players and subsequently, change of social behavior of a group [29]. In the context of organizational knowledge eco-systems, a similar argument can be presented where a change agenda involving a critical mass of members can promote conversion of free-riders to active knowledge contributors, thus perpetuating a better and self sustaining equilibrium outcome. However today's organizations operate in a dynamic business environment and as people move in and out of it, the heterogeneity makes the equilibrium unstable and short-lasting – aggravating the “tipping point”. To sustain the equilibrium, the organization needs to advocate a continuously strong commitment like the famed “HP way” of the past [85].

Another insight from game theory is that using threats and commitments from management in order to change the rules of the game will lead to a better equilibrium. In an organizational context, a certain level commitment is implicitly embedded in the organizational culture, vision and values (distinct from key performance indicators). Explicit commitments can be made through appropriate design of incentive schemes. A strategic move like a threat can be communicated by mandating knowledge contribution as a vital employee performance assessment criterion, a practice often followed by

knowledge intensive organizations such as leading consulting firms where capability development is a prerequisite for promotion to “partner”.

<b><i>Scenario A: Lack of collective action and free-riding on knowledge initiatives.</i></b>	
Players	Knowledge workers and their managers engaged in the processes of knowledge creation and transfer
Added Values	Possession of knowledge that other players do not have, provides added value for a player.
Rules	Rules are not fixed. Organizational leadership can manipulate the rules through strategic moves such as threats and commitments.
Tactics	The dominant perception of an individual player is to act according to pure self- interest, that produces free-riding and a Pareto-inefficient outcome for the collective.
Scope	The boundaries of the game can range from small individual groups to the entire organization.
Impact on organizational knowledge ecosystem	Analysis suggests that a coordinated and collective action among the knowledge workers and groups can provide the optimal solution (Pareto-efficient Nash equilibrium) for the organization. Such action requires employee expectations to converge in a way that supports knowledge contribution. Game theory suggests that existence of such a focal point would depend much on the common experience of the players, including their social, cultural, and linguistic background (Schelling, 1958). Such a view establishes the critical role of organizational vision, strategy and culture in bringing a commonality in employees’ expectations and goals. An organization can deploy strategic moves – threats and commitments to change the rules of a game. These moves can be in the form of designing incentive schemes, mandating knowledge contribution as a vital employee performance assessment criterion and so on. Such moves need to be clearly communicated within the organization.

#### 4.3.2 *Scenario B - Asymmetry of knowledge repositories between organizational units*

##### 4.3.2.1 Strategic situation (game model):

In multi-unit organizations, differences in knowledge repository, decision making authority, structural and cultural dispositions among the units, can result in asymmetric knowledge flow. Gupta and Govindarajan [45] and Tsai [93], among others, suggest that organizational units compete with each other for internal resources. In this scenario, we depict a strategic situation that involves two business units – one with a stronger knowledge repository and decision making power (core unit) and the other, a weaker

entity (partner unit), but both with individualistic competitive postures as independent business units. Organizational units often compete with each other for internal resources and have conflict of interest [93], but at the same time they have a strategic need for collaboration in co-creating and exploiting intellectual capital to achieve organizational business goals. Several researchers have noted that collaborative knowledge creation and transfer between organizations engaged in technology innovation alliances are guided by resource allocation and sharing decisions [79, 51, 27]. Such situations can successfully be described using the “Leader-Follower” game model proposed by the German economist Heinrich Stackelberg [51]. The Stackelberg model applies to non-cooperative and unbalanced games where the stronger player assumes a leadership role and makes the first move, while the weaker player follows sequentially. These type of game situations may be resolved using a pair of strategies – one for the leader and the other for the follower. Taken together, they are known as the Stackelberg equilibrium strategy. This paper proposes that a similar modelling approach may be applied to the knowledge flows between the core (leader) and the partner (follower) units.

The game situation can be summarized as follows:

- a. An unbalanced, variable-sum, non-cooperative, two-player, sequential move game where the core unit (stronger player) takes the leadership role in deciding on its strategy and announces it to the partner unit (weaker player).
- b. The leader makes the first move that is observable by the partner.
- c. The partner unit (follower) reacts to the leader’s strategy, with its own strategic choices

#### 4.3.2.3 Analysis:

Analysis of the Stackelberg equilibrium strategies for a “leader-follower” game model is highly mathematical in nature. For the sake of simplicity, we would like to limit the scope of this analysis to some key observations made by scholars in analyzing such situation.

- A. The partner units adjust their knowledge transfer strategies according to the proportion structure of their own marginal revenues from the alliance [51].

- B. The leader has incentives to participate in collaborative knowledge creation only when its benefits from the knowledge incoming spill-over are bigger than the follower [27].
- C. The greater the leader's participation, the higher is the knowledge creation. And the performance of the current collaboration depends on the prior experience of working together [79].
- D. With equal decision making power and a partnership-based relationship between the units, modelling of such situations take the form of simultaneous move cooperative games. While cooperation is present to maximize the expected system gain, players still bargain on their participation rate [79]. In the context of an outsourcing project, empirical research suggests that when the degree of complementarities of knowledge is high enough between the firms, an enforcement of cooperation among the employees produces better equilibrium payoffs [7].

#### 4.3.2.4. Implications for knowledge strategy

Using the opportunities and access to the higher knowledge level of the leading group, the follower units can take advantage of the knowledge spill-over effects and gain through the collaborative knowledge co-creation and sharing. The observations of the modelling and analysis suggest that knowledge flow is enhanced when the dominant group, in terms of knowledge stock and power, commits higher participation and intensity. An important observation of game analysis implied that prior engagement among groups facilitates the collaboration. The model also underscores the role of absorptive capacity [21] in knowledge transfer situations. It is important for the organization to ensure that a shared context between the knowledge exchanging units exists. It may be argued that creating such a shared context entails some sort of redundancy in the organization structure and role design. A less formalized and decentralized organizational structure and social interaction among the units engender

knowledge flow [93, 59]. Adoption of such a “leader–follower” model may therefore reasonably lead to successful knowledge flows between the parent company and its subsidiaries as in the case of global multi-national corporations [45].

<b><i>Scenario B: Asymmetry of knowledge repositories between organizational units.</i></b>	
Players	Organizational units with asymmetries in terms of knowledge repositories, engaged in the co-creation and transfer of knowledge
Added Values	Possession of strategic knowledge by one business unit provides added value for it, while it limits the value for other units that wish to acquire and apply the knowledge.
Rules	Rules are typically not fixed and can be manipulated by the player with higher knowledge capability or absorptive capacity and taking the lead in the knowledge transaction process as the source of the requisite knowledge.
Tactics	The weaker player (follower or recipient) tries to enhance its added value through collaboration with the stronger player (leader).
Scope	The boundaries of the game are limited to interactions between two or more organizational units engaged in knowledge co-creation or transfer process.

#### 4.3.3 Scenario C - Asymmetry of information in knowledge flows within ecosystem

##### 4.3.3.1 Strategic situation (game model):

The KM literature describes how asymmetry of information in knowledge exchanges can propagate inefficiency in the knowledge ecosystem [24,94,47]. This scenario tries to address the flows of structural, human or relational capital in the procession of a unit within the

organization that others in the ecosystem wish to acquire. How do sources and targets of knowledge flows ensure that the knowledge is of good quality? The strategic situation arises in a knowledge transaction when the knowledge seeker is uncertain about the quality or potential value of the knowledge. Since the knowledge provider has more information about the value of his knowledge stock, an information asymmetry exists between them. Since this information asymmetry affects the players’ perceptions of the situation and consequently, their strategic decisions, these games are characterised by strategies to manipulate information. While the less informed player will try to elicit the

information, the better informed player will either reveal or conceal the private information, depending on his perceived payoffs.

The economics Nobel Laureate George Akerlof investigated such asymmetry in market transactions through his seminal work on “The Market for Lemons” [2]. His study was based on the private used car market, illustrating how markets can fail due to the information asymmetry between buyers and sellers. In Akerlof’s scenario, an individual wishes to buy a used car from an owner. There are two possibilities – the car can be good quality merchandise (mint) or a bad quality (lemon). This strategic situation reflects the uncertainty of product quality and the market mechanism to drive buyers’ decisions. The potential buyer has no information on the quality but the seller is aware of the quality.

A class of games with incomplete information, termed as “signaling games” draws motivation from Akerlof’s work and offers models with similar context [34]. We draw inspiration from such models in articulating a hypothetical scenario where a knowledge transaction happens between two members in an organizational context. The game payoffs are as follows.

- Good quality (mint) knowledge is worth  $X_1$  to the seeker and  $Y_1$  to the provider
- Bad quality (lemon) knowledge is worth  $X_2$  to the seeker and  $Y_2$  to the provider
- $X_1 > X_2$  and  $Y_1 > Y_2$
- In a take-it-or-leave-it offer negotiation, the potential buyer makes an offer  $X$  as price for trading the knowledge

The strategic question involves how the knowledge seeker ensures that he is buying good quality knowledge?

Players            The knowledge sources and targets [45] in an organization.

Added values    Possession of complete and accurate information about the quality of knowledge stock held by the source provides added value to the

recipient, while it limits the value for the source.

- Rules            The rules are not fixed. From the knowledge target's perspective, a rule mandating certification of quality of the knowledge source is desired and organizational leadership can impose such a rule in order to address the asymmetry of knowledge.
- Tactics         The knowledge target's objective is to elicit maximum information about the quality of the knowledge stock of the provider. A knowledge source with a high quality knowledge stock would try and share as much as possible information on the value of this knowledge, whereas the source with lower quality knowledge stock would try to conceal the value.
- Scope           The scope of the game is limited to organizational members or groups, interested in acquiring or sharing their knowledge for utility or payoff.

#### 4.3.3.3 Analysis:

If the quality of the car is known to the seeker, the negotiated price  $X$  would assume a value somewhere between  $X_1$  and  $Y_1$  (i.e.  $X_1 > X > Y_1$ ). However, if the quality is not known, the maximum value of  $X$  would depend on how likely the buyer perceives that he is buying poor quality knowledge (or a lemon). With 50% probability of a lemon quality purchase, the valuation of the knowledge  $X = 0.5 * X_1 + 0.5 * X_2 = 0.5 * (X_1 + X_2)$ . This suggests that the knowledge seeker will not offer anything more than  $0.5 * (X_1 + X_2)$  as the value of the knowledge stock. The seller of lemon quality knowledge will gladly accept this price, given that the offered price exceeds his valuation  $X_2$ . Whereas the seller of mint quality knowledge will refuse given the offered price is lower than his perceived valuation  $X_1$ . In congruence with Akerlof's study, such a situation suggests that the only knowledge that gets traded is of lemon quality and accordingly, poor quality knowledge drives good quality knowledge out of the market.

To address problems of information asymmetry in knowledge exchanges, another Nobel Laureate, Michael Spence, developed “screening” and “signaling” strategies for these types of game situations [88]. In a screening strategy, the less informed player i.e. knowledge seeker in this case, tries to reduce the information disadvantage by acting in ways that makes the more informed player (knowledge provider in this case) reveal information about quality. One feasible screening technique could be offering different prices for different quality goods. A signaling strategy can be adopted by a seller to conceal information that is potentially beneficial for him. It could be details on product superiority when sharing the information may lead to an increased payoff. The seller may also possess information that could affect interest on his products, like the inferiority of his goods. In either case, he has an incentive to send signals to buyers. For the game model discussed above, one signaling mechanism by the knowledge provider could be obtaining formal endorsement or accreditation of his knowledge by a certificate authority. The “Sender–Receiver” framework for knowledge transfer has been applied by Lin et al. [58] as a game-theoretic modelling approach that identifies some key information structures related to knowledge transfer involving asymmetric and incomplete information. In the context of the game situation outlined earlier, the two key information structures are:

- i. *Sender-advantage asymmetric information structure*: The sender- advantage structure assumes that the senders (knowledge providers) have more information on the quality of knowledge than the receiver (knowledge seekers). And to avoid any “adverse selection” by the receiver, signalling can be a solution. The sender-advantage asymmetric information structure is based on the assumption that senders have more quality information than the receiver. In a separating equilibrium, the knowledge provider may send strong signals but the knowledge seeker may not imitate them as it is an expensive option. The expected reward does not justify the efforts. The seeker can hence filter out the high quality knowledge provider by deciphering the signals received from multiple senders and engage the best provider for the transaction.

- ii. *Symmetric incomplete information structure*: This structure assumes that both the seeker and the provider do not have the correct expectation of the value of knowledge. The provider has an incentive in distorting the signal (amplifying the offered quality of knowledge) and manipulating the transaction in a way that benefits him – a situation called “signal jamming”. A distorted signal can affect a naïve knowledge seeker, and allows the provider to distort the signal to an even higher degree. However, if the receiver is rational and has the ability to infer the correct signal, the disadvantage of incomplete information is greatly reduced.

#### 4.3.3.4. Implications for knowledge strategy:

In knowledge exchanges, asymmetry of information among the participants affects the effectiveness of the knowledge flows. Analysis of the game model suggests that such an issue of information asymmetry may be addressed by adopting “signaling” strategies by the provider of the knowledge. The source has better information on the quality of knowledge and has an incentive to send signals to the knowledge seeker. Since the concept of signal quality is linked with the reputation of the knowledge source, organizations can facilitate building credible sources of knowledge through the proper assessment and certification of skills and deploying official expertise directories and locator tools [3,49]. To complement such information technology based tools, organizations also need to put in place a mechanism for human mediation in connecting knowledge seekers and providers [47]. In a study involving knowledge sharing in communities of practice, it was observed that the absence of profile information of the knowledge providers adversely affects the motivations for knowledge exchanges in such virtual communities [57].

#### 4.3.4 *Scenario D - Lack of adoption of organizational knowledge.*

##### 4.3.4.1 Strategic situation (game model):

As the dilemma of knowledge friction suggests, management’s best interests are served by the transfer and application of organizational knowledge assets across the enterprise. However, the actions of organizational groups involved in the practice of such an

objective might not be aligned with the organizational good. Therefore, a strategic situation arises due to the sticky nature of knowledge. It is often difficult, if not impossible, for the organization to monitor and control the application of knowledge (particularly the transfer and reuse of valuable tacit knowledge and relational capital).

In game theoretic parlance, such situations with endogenous uncertainty, where one party is unable to observe the action taken by the other, are called “moral hazards” [16]. As noted by Schelling [81] and later Schelling [82], the notion of a moral hazard was originally observed in the insurance industry where coverage for risks leads to reduced level of care about the insured object; for instance, over-insured motorists may drive less carefully. This arises due to the fact that insurers are not able to monitor the behaviors of the insured players directly. The inherent conflict of collective knowledge where no individual feels responsible typifies a moral hazard. Accordingly, a game theoretic approach can help in modelling and analyzing such a scenario and in building effective incentive mechanisms that could be devised for teams to act in alignment with the ecosystem’s best interest.

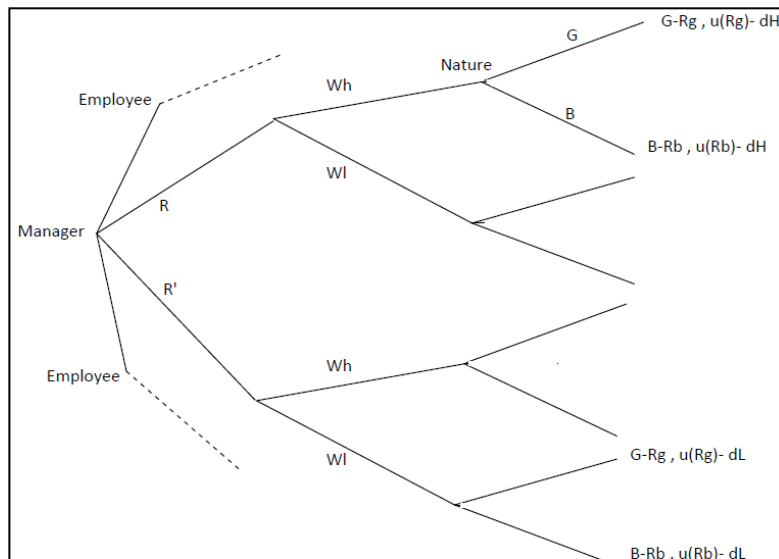
To represent such a scenario, game theory offers a model known as “Principal-Agent”, in which a manager of the firm (the principal) hires an employee (the agent) to undertake a project. Manager and employee may take two strategies and there are two consequences for each action of the employee. The game tree shown in Fig. 4 represents an enumeration of the possible outcomes.

The manager decides the level of compensation (say  $R$  and  $R_0$ ) to offer to the employee. The employee responds to the manager’s decision by applying a higher effort or lower effort,  $W_H$  or  $W_L$ . Thus, the employee decides after the manager’s decision and his choice is not clear and observable to the manager. Each choice of the employee has an impact on the profitability of the project. In a real world scenario however, the influencing factors to a similar situation are much diverse than an employee’s work effort.

This uncertainty is represented in the model through a probability distribution of the level of profits. Suppose we have two levels of profits –  $G$  (Good) and  $B$  (Bad). The probability distribution for profits when the employee puts up a high effort ( $W_H$ ) is  $G =$

0.8 and  $B = 0.2$ ; whereas the probability distribution when the employee puts up a low effort ( $W_L$ ) is just the inverse i.e.  $G = 0.2$  and  $B = 0.8$ . Game theory introduces the concept of nature that determines the profitability in addition to the employee's chosen strategy. Since the manager cannot judge the employee's effort, the incentives are to be paid based on the profitability attained. For example, the manager pays an incentive  $R_G$  when the profit level is  $G$  and  $R_B$  when the profit is  $B$ .

Therefore, the net payoffs for the manager at the two levels are  $G - R_G$  and  $G - R_B$  respectively. From the employee's perspective, the payoff utility may be expressed as a function of the incentive i.e.  $u(R_G)$  for good profit and  $u(R_B)$  for bad profit scenarios. However, the payoff should be linked to the perceived dissatisfaction (or disutility) for the level of effort that the employee needs to spend (the "hardship") to achieve the incentives. Assuming that the disutility is  $d_H$  when the employee puts high effort and  $d_L$  when the employee puts low effort, the net payoffs for the employee at the two levels are  $u(R_G) - d_H$  and  $u(R_B) - d_L$  respectively.



**FIGURE 4: GAME TREE WITH THE PAYOFFS FOR THE MANAGER AND THE EMPLOYEE.**

Players	Organizational leadership that intends to disseminate the knowledge-based practices or assets within the boundaries of the organization and the organizational members or groups involved in adopting such knowledge.
Added values	Leadership can value-add by formulating appropriate incentive schemes matching the employees' added values by tracking the status of various knowledge adoption initiatives.
Rules	Fixed rules like contractual agreements can address the organization's concern about moral hazards. However enforcing adoption of knowledge-based practices through contractual bindings is often not feasible in an organizational context.
Tactics	Players involved in adopting certain knowledge perceives the activity linked to additional effort levels and evaluates the payoff of additional effort against the incentives offered to them for such activities.
Scope	The boundaries of the game can range from small individual groups to the entire organization.

#### 4.3.4.3 Analysis:

Based on the above game tree illustrated in Fig. 4, two kinds of possible reward systems may be worked out. These systems are discussed as Cases 1 and 2.

##### 4.3.4.3.1. ***Case 1: Fixed salary based compensation for the employee***

If we consider a fixed salary for the employees, then  $R_G = R_B = R$  and  $u(R_G) = u(R_B) = u(R)$ . In this case the employee's payoff is derived as  $u(R) - dH$  (for high effort) and  $u(R) - dL$  (for low effort). Since  $dH > dL$ , the perceived payoff for the employee will always be high when he puts low effort. Thus, the employee's dominant strategy will be to expend the minimal effort (having no incentive for putting additional effort). This is in fact the rational for free-riding which results in a tragedy of the commons.

##### 4.3.4.3.2. ***Case 2: Incentive based compensation for the employee (salary plus incentive)***

Under this arrangement, the manager will pay a fixed salary plus an incentive linked with the profitability of the project. That implies that the risk is shared by the manager and the employee. The respective payoffs for the employee under situations of routine and high efforts are:

Payoff P1 =  $0.8 * u(R_G) + 0.2 * u(R_B) - dH$  (when the employee spends high effort)

Payoff P2 =  $0.2 * u(R_G) + 0.8 * u(R_B) - dL$  (when the employee spends routine effort)

For the employee to work at a higher effort level i.e. for  $P1 \geq P2$ ,

$$0.8 * u(R_G) + 0.2 * u(R_B) - dH \geq 0.2 * u(R_G) + 0.8 * u(R_B) - dL$$

Or  **$0.6 [u(R_G) - u(R_B)] \geq dH - dL$**

Now, for the manager to devise an ideal incentive model there are two further sub-scenarios.

***Case 2a: When there is no Moral Hazard***

Here the employee's efforts are observable by the manager and the incentives offered by the manager for low and high efforts are  $R_L$  and  $R_H$  respectively

Expected payoff for the manager when the employee works hard ( $W_H$ ),  $P1 = 0.8 * G + 0.2 * B - R_H$

Expected payoff for the manager when the employee makes low effort ( $W_L$ ),  $P2 = 0.8 * B + 0.2 * G - R_L$

For the manager to pay incentives for higher work,  $P1 \geq P2$

i.e.  $0.8 * G + 0.2 * B - R_H \geq 0.8 * B + 0.2 * G - R_L$

i.e.  **$0.6 (G - B) \geq R_H - R_L$**

***Case 2b: When there is clear Moral Hazard***

Here the employee's efforts are not observable by the manager and the incentives offered by the manager for low and high efforts are  $R_G$  and  $R_B$  respectively.

Expected payoff for the manager when the employee works hard ( $W_H$ )  $P1 = 0.8 * (G - R_G) + 0.2 * (B - R_B)$

Expected payoff for the manager when the employee makes low effort ( $W_L$ )  $P2 = 0.8 * (B - R_B) + 0.2 * (G - R_G)$

For the manager to pay incentives for higher work,  $P1 \geq P2$

i.e.  $0.8 * (G - R_G) + 0.2 * (B - R_B) \geq 0.8 * (B - R_B) + 0.2 * (G - R_G)$

thus,  $G-B \geq R_G - R_B$

#### 4.3.4.4 Implications for knowledge strategy

Organizations find it difficult to monitor and control the application of tacit knowledge by their employees. Analysis of the game model suggests that a moral hazard aggravates the problem and demands additional initiatives. To combat such an event, changes in the behavior of employees are necessary so that they are incentivized to put higher effort on knowledge initiatives. Incentives help in reinforcing positive behaviors and culture [98]. However, motivation crowding theory has pointed out that extrinsic incentives like monetary rewards may undermine intrinsic motivation such as peer recognition [37]. Such a view is further strengthened by an empirical study in organizations which found that expected associations and contributions supersede the expectation of rewards, as determinants of employees' knowledge sharing behaviors [8]. A study by Zhang et al. [104] on incentive-based sharing relationships in an information technology driven organizational KMS indicated that high task visibility positively impacts the knowledge contribution behaviors of employees. Accordingly, organizations need to design a balanced incentive mechanism incorporating both extrinsic and intrinsic incentives. Another empirical study by Yang and Wu [100] suggested that incentive design that rewards each knowledge contribution action is more effective than the periodic organizational performance review to encourage actors' knowledge behaviors.

Embedding informal coaching and mentoring of employees in the routine behavior of executives can foster a corporate "gift culture", promoting collaboration [44]. As Snowden [87] opined, organizations should not over-emphasize codifying knowledge into artefacts and building best practices. He suggested that the organic elements such as tacit empowerment need to be facilitated and the serendipity in knowledge creation to deal with the uncertainty and complexity of decision making should be cultivated [87]. Informal networks within the organization such the communities of practice can promote exchange of tacit knowledge and collaborative knowledge sharing [97].

#### 4.3.5 *Scenario E – Improper usage of knowledge (or knowledge mis / ab –use).*

5 Strategic situation (game model):

An indispensable reality of organization life is competition among the members, groups and units. Some scholars have observed that competition is not necessarily bad and can be an effective means in stimulating innovation, increasing task focus, generating high-quality problem solving and building group cohesion in certain situations (c.f. [91,74,42]). However, the established notion associating possession of knowledge with power is instrumental in driving competitive agendas and intra-organizational rivalry. In such situations, discriminatory use of knowledge is made by organizational members for running “political” or other unethical agenda [72]. These forms of organizational conflict situations typify “zero-sum” nature of the competitive posture impairs the flow of knowledge across the enterprise.

From a game theoretic perspective, such situations may be modelled using a two-person zero sum game where a gain of one player implies loss of the other and vice-versa. Accordingly, such a game can be presented through the payoff table for each one of the players. The other player’s payoff values would be identical but in the negative. Such a game model assumes that the number of strategies available to each player might differ but both players have a common knowledge of the strategies. To illustrate such a game scenario, assume that two players X and Y are engaged in simultaneous decision making and player X enjoys a superior position in the situation either as a senior or manager. Using mathematical notations, the game can be described as:

$p$  = No of available strategies for player X

$q$  = No of available strategies for player Y

Total number of game outcomes =  $p * q$

$S_X$  = Strategy profile for X, can be expressed as  $\{X_1, X_2, \dots, X_p\}$

$S_Y$  = Strategy profile for Y, can be expressed as  $\{Y_1, Y_2, \dots, Y_q\}$ .

$x_{ij}$  = Payoff which player X gains from player B if he choose a strategy  $i$  and player Y chooses strategy  $j$ , where  $i = 1, 2, 3, \dots, q$  and  $j = 1, 2, 3, \dots, p$

The payoff table for player X is shown in figure 5 below:

		Player Y’s Strategies			
		Y <sub>1</sub>	Y <sub>2</sub>	.....	Y <sub>q</sub>
Player X’s Strategies	X <sub>1</sub>	a <sub>11</sub>	a <sub>12</sub>	.....	a <sub>1q</sub>

$X_2$	$a_{21}$	$a_{22}$	.....	$a_{2q}$
$X_p$	$a_{p1}$	$a_{p2}$	.....	$a_{pq}$

**FIGURE 5: PAYOFF MATRIX FOR PLAYER X.**

Players	Organizational members or groups engaged in application of knowledge, with agendas that severely hurt each other’s interests
Added values	Possession and subsequent application of knowledge that has strategic importance in the organization can provide better utility for one player while limiting the value of others.
Rules	Rules are typically not fixed and can be manipulated by the player with higher position, power or influence in the organization, creating an advantage for him.
Tactics	Players perceive the scenario as pure competition where only wins and losses are possible outcomes.
Scope	The boundaries of the game can range from individual groups to organizational departments.

**4.3.5.3 Analysis:**

Such a situation can be solved for Nash equilibrium by the “minimax – maximin” principle or simply “minimax” method of game theory. This principle suggests that since player X is deemed to be in a superior position or the perceived winner, he would try to maximize his payoff  $x_{ij}$  while Y tries to minimize the loss to secure a minimum guaranteed payoff.

For player X, the minimum value in each row represents the least gain to him if he chooses that particular strategy. These are represented in the matrix by row minima. It is obvious that player X will then select the strategy that gives him maximum gain among the row minimum values. This choice of player X is known as the maximin criterion and the corresponding gain is known as the maximin value of the game. Similarly, for player Y who is assumed to be the loser, the maximum value in each column represents the

maximum loss to him if he chooses his particular strategy. These are written as column maxima. He will select that strategy which gives the minimum loss among the column maximum values. This choice of player Y is known as the minimax criterion, and the corresponding loss is the minimax value of the game. Assuming the value of the game as  $V$ ,

Maximin value ( $V^{\wedge}$ ) = maximum {row minima} = max [min { $x_{ij}$ }]

Minimax value ( $V^{\vee}$ ) = minimum value {column maxima} = min [max { $x_{ij}$ }]

Typically, value of the game ( $V$ ) exists somewhere between the maximin value ( $V^{\wedge}$ ) and the minimax value ( $V^{\vee}$ ). In case both Maximin and Minimax values are equal to zero, the game is considered to be fair. The equilibrium condition for such games is referred to as the “saddle point”. The game is considered to be strictly determinable and has a saddle point if and only if the condition  $V^{\wedge} = V^{\vee} = V$  is met. The corresponding strategies at the saddle point are called optimal strategies and the amount of payoff at this point is the value of the game.

#### 4.3.5.4. Implications for knowledge strategy:

Zero-sum situations in an organization embody absolute conflict of interest among its members. The game theoretic analysis provides a good understanding of motivations and possible interaction patterns for the individuals and groups involved in such conflict situations. The organizational members become risk averse and behave in ways to safeguard only personal or group interests even if the actions are not in the best interest of the organization. As several KM researchers have suggested, cultural elements such as trust, concern, shared values and commitment are most important preconditions for knowledge exchange in an organization (cf. [67,56,77,95]). Hence, a highly political environment with zero-sum conflict situations would severely impede organizational knowledge flow.

Organizations strive to avoid such situations in the workplace through mechanisms such as creating “win-win” opportunities for all, fostering collaboration, establishing shared business goals and devising an inclusive reward strategy [49,64]. Organizations also implement robust HR policies and processes that can act as a protection against potential

zero-sum situations such as abuses of power by higher authority and discriminations against employees at workplace [93,98,104].

<b>Scenario E: Improper usage of knowledge in unhealthy competitive situation</b>	
Players	Organizational members or groups engaged in application of knowledge, with an agenda that severely hurts each other's interests
Added Values	Possession and subsequent application of knowledge that has strategic importance in the organization can provide better utility for one player while limiting the value of others.
Rules	Rules are typically not fixed and can be manipulated by the player with higher position, power or influence in the organization, creating advantage for him.
Tactics	Players perceive the scenario as pure competition where only wins and losses are possible outcomes.
Scope	The boundaries of the game can range from individual groups to organizational departments.
Impact on organizational knowledge ecosystem	Zero-sum situations in an organization embody absolute conflict of interest among its members and lead to weakening the organizational knowledge flows. Organizations should strive to avoid such situations in the workplace through mechanisms such as creating "win-win" opportunities for all, fostering collaboration, establishing shared business goals and devising an inclusive reward strategy (Hinds and Pfeffer, 2003). Organizations can implement robust HR policies and processes to address zero-sum situations.

## 5. Findings and Implications

This paper began with and the investigation of how common dilemmas which endanger the knowledge ecosystem of an organization may be analyzed and interpreted using a game theoretic approach. After a critical review of literature on both knowledge management and game theory, four key knowledge dilemmas were identified as useful for modelling. The analysis of five different scenarios in the preceding section has revealed some useful design rules for knowledge strategies. Though some may argue that the goal of game theoretic reasoning should be primarily "predictive", the strategic insights derived from the game modelling and analysis can be leveraged in answering our research question.

Drawing on the discussions from game theoretic modelling, a prescriptive knowledge policy framework may be developed as shown in Fig. 6. The framework suggests six categories of organization strategic focus areas in formulating its knowledge strategy and accompanying policies. While these areas are a generalization of the findings derived from the game theoretic analysis performed on the five scenarios (and sub-cases) in the previous paper, they are by no means claimed as comprehensive.

At a granular level, each category comprises of several strategy and policy dimensions. The major finding of our modelling approach to resolving knowledge dilemmas is that knowledge strategies and policies may be formulated to promote equilibria in

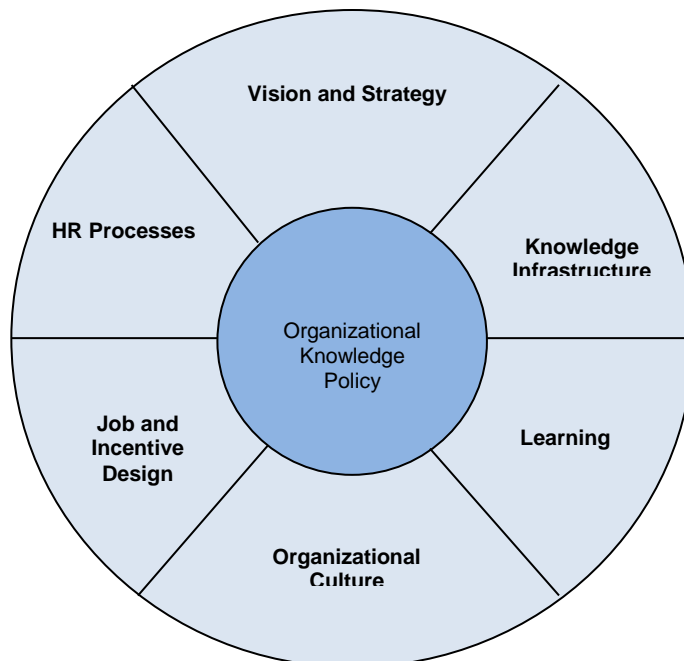
the organizational knowledge eco-system. Table 4 highlights some of the key knowledge dimensions suggested in the research literature. While not entirely similar in scope nor approach to the empirical findings (cited in Table 4) of numerous scholars on the specific factors that contribute to knowledge flows within an organization, the analysis of game situations made in this paper provide us with some insights into how organizational interventions and incentives could promote more effective outcome of knowledge initiatives. In short, Table 4 may be viewed as the areas of application of game theoretic reasoning in managing the knowledge ecosystem.

The relevance of game theoretic reasoning has been questioned with the view that the theory is grounded on a simplistic assumption on human predictability in terms of being perfectly rational and risk neutral; whereas in reality, human decisions are guided by bounded rationality and risk considerations. Additionally, analytic game theory does not consider the existence of the “soft” factors like emotions, altruism, fairness, randomness into human decision making. Hence, instead of a pure analytic approach backed by mathematical calculations, the perspective from behavioural game theory and lessons from practical game experiments have been introduced. Behavioral game theory has complemented the rationality driven analytic approach of game theory, by extending human aspects into analytic consideration [71]. Contemporary views on the role of learning, social, cultural and psychological aspects that expands the concept of Nash equilibrium are taken into consideration. It may also be noted that though there have been modifications, generalization and refinements of the Nash equilibrium

but the study of the basic equilibrium still remains the place to begin an analysis of strategic interactions [50]. It is hoped that the game theoretic reasoning presented in this paper, would benefit knowledge strategists and policy-makers with a better understanding and interpretation of conflict situations in their organizations.

At this point, some limitations of the current research need to be acknowledged. The scope of the research is limited to studying intra-organizational knowledge flows. In today's complex business environment, organizations simultaneously compete and cooperate in a "value net", a phenomenon branded as "co-opetition" [12]. Further research can extend the boundary of the organizational knowledge ecosystem to include such value net and bring additional game theoretic modelling perspectives for the identified dilemma situations. Additionally, for reasons outlined earlier we could not perform empirical experiments and obtain field measurements. However, a retrospective management analysis of key decisions, policies and outcomes, perhaps as part of a formal After Action Review (AAR), could possibly strengthen the understanding of the links between human behavior in form of best responses and knowledge strategies that produce equilibrium outcomes.

This paper concludes with the considered view that solving real-life conflict situations demands combining the rigor of science powering game theory with the art of playing the game. Game theoretic reasoning of strategic dilemmas can be instrumental as a guide for the organizations in applying effective strategies and achieving their desired outcome. We therefore find resonance with Polak's [75] assertion that game theory should not seek to predict phenomena of interest but give a perspective of the possibilities so that decisions may be so framed.



**Figure 10: Prescriptive organizational knowledge policy framework.**

**Table 4: Dimensions of Organizational Knowledge Policy.**

No	Category	Strategy and Policy Dimensions
1	Organizational Culture	Trust [28, 77]
2	Design	Work climate [19, 95]
3		Risk tolerance [35]
4		Cohesion [66]
5		Open communication [74]
6		Complexity of Structure [59]
7	Vision and Strategy	Organizational purpose and espoused values [68]
8		Knowledge strategy [101]
9		Shared context [45]
10	Job and Incentive	Incentive design for knowledge [8]
11	Design	Team-based goal setting [47]
12		Redundancy and Shadowing [68]
13	Knowledge	Expertise locator [49]
14	Infrastructure	Knowledge repositories and collaboration tools [3]
15		Facility for face-to-face interactions [24]
16	HR Processes	Retention policy [25]
17		Mentoring by experts [44]
18		Community building [97]
19	Learning	Employee absorptive capacity [21]

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at <http://dx.doi.org/10.1016/j.knosys.2013.02.011>.

## References

- [1] Aitken-Turff, N. Jackson, A mixed motive approach to lobbying: applying game theory to analyze the impact of cooperation and conflict on perceived lobbying success, *Journal of Public Affairs* 6 (2) (2006) 84–101.

- [2] G.A. Akerlof, The market for “lemons”: quality uncertainty and the market mechanism, *The Quarterly Journal of Economics* 84 (3) (1970) 488–500.
- [3] M. Alavi, D.E. Leidner, Review: knowledge management and knowledge management systems: conceptual foundations and research issues, *MIS Quarterly* 25 (1) (2001) 107–136.
- [4] S. Alter, Goals and tactics on the dark side of knowledge management, in: *Proceedings of the 39th Hawaii International Conference on System Sciences (HICSS’06)*, Hawaii, USA, January 4–7, 2006.
- [5] L. Argote, P. Ingram, Knowledge transfer: a basis for competitive advantage in firms, *Organizational Behavior and Human Decision Processes* 82 (1) (2000) 150–169.
- [6] R. Axelrod, *The Evolution of Cooperation*, rev. ed., Basic Books, New York, 2006.
- [7] S. Bandyopadhyay, P. Pathak, Knowledge sharing and cooperation in outsourcing projects—a game theoretic analysis, *Decision Support Systems* 43 (2) (2007) 349–358.
- [8] G.W. Bock, Y.G. Kim, Breaking the myths of rewards: an exploratory study of attitudes about knowledge sharing, *Information Resources Management Journal* 15 (2) (2002) 14–21.
- [9] N.-I. Boer, H. Berends, P. van Baalen, Relational models for knowledge sharing behavior, *European Management Journal* 29 (2011) 85–97.
- [10] M. Boisot, *Knowledge Assets: Securing Competitive Advantage in the Information Economy*, Oxford University Press, New York, 1998.
- [11] G.E. Bolton, A. Ockenfels, ERC: a theory of equity, reciprocity, and

- competition, *The American Economic Review* 90 (1) (2000) 166–193.
- [12] A.M. Brandenburger, B.J. Nalebuff, The right game: use game theory to shape strategy, *Harvard Business Review* 73 (4) (1995) 57–71.
- [13] Bryant, Knowledge management – the ethics of the agora or the mechanisms of the market? in: *Proceedings of the 39th Annual Hawaii International Conference on System Sciences (HICSS'06)*, Hawaii, USA, January 4–7, 2006.
- [14] Cabrera, E.F. Cabrera, Knowledge-sharing dilemmas, *Organization Studies* 23 (5) (2002) 687–710.
- [15] C.F. Camerer, Progress in behavioral game theory, *The Journal of Economic Perspectives* 11 (4) (1997) 167–188.
- [16] C.F. Camerer, *Behavioral Game Theory: Experiments in Strategic Interaction*, Princeton University Press, Princeton, NJ, 2003.
- [17] P.R. Carlile, A pragmatic view of knowledge and boundaries: boundary objects in new product development, *Organization Science* 13 (4) (2002) 442–455.
- [18] C.-J. Chen, S.-W. Hung, To give or to receive? Factors influencing members' knowledge sharing and community promotion in professional virtual communities, *Information & Management* 47 (4) (2010) 226–236.
- [19] S.-S. Chen, Y.-W. Chuang, P.-Y. Chen, Behavioral intention formation in knowledge sharing: examining the roles of KMS quality, KMS self-efficacy, and organizational climate, *Knowledge-Based Systems* 31 (2012) 106–118.
- [20] A. Chua, Knowledge sharing: a game people play, *Aslib Proceedings: New Information Perspectives* 55 (3) (2003) 117–129.

- [21] W.M. Cohen, D.A. Levinthal, Absorptive capacity: a new perspective on learning and innovation, *Administrative Science Quarterly* 35 (1) (1990) 128–152.
- [22] B. Cruver, *Anatomy of Greed: The Unshredded Truth from an Enron Insider*, Carroll and Graf, New York, 2002.
- [23] T.H. Davenport, Ten principles of knowledge management and four case studies, *Knowledge and Process Management* 4 (3) (1997) 187–208.
- [24] T.H. Davenport, L. Prusak, *Working Knowledge: How Organizations Manage What They Know*, Harvard Business School Press, Boston, MA, 1998.
- [25] D. De Long, *Building the Knowledge-Based Organization: How Culture Drives Knowledge Behaviors*, Center for Business Innovation, Ernst and Young, New York, 1997.
- [26] D.W. De Long, L. Fahey, Diagnosing cultural barriers to knowledge management, *Academy of Management Executive* 14 (4) (2000) 113–127.
- [27] X. Ding, R. Huang, Effects of knowledge spillover on inter-organizational resource sharing decision in collaborative knowledge creation, *European Journal of Operational Research* 201 (3) (2010) 949–959.
- [28] K.T. Dirks, D.L. Ferrin, The role of trust in organizational settings, *Organizational Science* 12 (4) (2001) 450–467.
- [29] A.K. Dixit, B. Nalebuff, *The Art of Strategy: A Game Theorist's Guide to Success in Business and Life*, first ed., W.W. Norton and Company, New York, 2008.
- [30] A.K. Dixit, S. Skeath, *Games of Strategy*, Norton, New York, 1999.
- [31] D. Dougherty, Interpretive barriers to successful product innovation in large

- firms, *Organization Science* 3 (2) (1992) 179–202.
- [32] P.F. Drucker, *The Age of Social Transformation*, The Atlantic Monthly, New York, 1994.
- [33] M. Dufwenberg, G. Kirchsteiger, A theory of sequential reciprocity, *Games and Economic Behavior* 47 (2) (2004) 268–298.
- [34] P.K. Dutta, *Strategies and Games: Theory and Practice*, MIT Press, Cambridge, MA, 1999.
- [35] L. Fahey, L. Prusak, The eleven deadliest sins of knowledge management, *California Management Review* 40 (3) (1998) 265–276.
- [36] E. Fehr, K.M. Schmidt, A theory of fairness, competition, and cooperation, *Quarterly Journal of Economics* 114 (3) (1999) 817–868.
- [37] B.S. Frey, R. Jegen, Motivation crowding theory, *Journal of Economic Surveys* 15 (5) (2001) 589–611.
- [38] D. Fudenberg, D. Levine, Learning in games, *European Economic Review* 42 (3–5) (1998) 631–639.
- [39] S. Gächter, G. von Krogh, S. Haefliger, Initiating private-collective innovation: the fragility of knowledge sharing, *Research Policy* 39 (7) (2010) 893–906.
- [40] J. Gao, Uncertain bimatrix game with applications, *Fuzzy Optimization and Decision Making* 11 (2012) 1–14.
- [41] R. Garud, A. Kumaraswamy, Vicious and virtuous circles in the management of knowledge: the case of Infosys Technologies, *MIS Quarterly* 29 (1) (2005) 9–33.
- [42] S. Ghobadi, J. D’Ambra, Coopetitive knowledge sharing: an analytical review of literature, *The Electronic Journal of Knowledge Management* 9 (4) (2011)

- 307–317.
- [43] R. Goffee, G. Jones, What holds the modern company together? *Harvard Business Review* 74 (6) (1996) 133–148.
- [44] L. Gratton, T.J. Erickson, Eight ways to build collaborative teams, *Harvard Business Review* 85 (11) (2007) 100–109.
- [45] A.K. Gupta, V. Govindarajan, Knowledge flows within multinational corporations, *Strategic Management Journal* 21 (4) (2000) 473–496.
- [46] G. Hamel, C.K. Prahalad, The core competence of the corporation, *Harvard Business Review* 68 (3) (1990) 79–91.
- [47] M.T. Hansen, N. Nohria, How to build collaborative advantage, *MIT Sloan Management Review* 46 (1) (2004) 22–30.
- [48] G. Hardin, The tragedy of the commons, *Science* 16 (1) (1993) 1243–1248.
- [49] P.J. Hinds, J. Pfeffer, Why Organizations Don't "Know What They Know": Cognitive and Motivational Factors Affecting the Transfer of Expertise, MIT Press, Cambridge, MA, 2003.
- [50] C.A. Holt, A.E. Roth, The Nash equilibrium: a perspective, *Proceedings of the National Academy of Sciences of the United States of America* 101 (12) (2004) 3999–4002.
- [51] Z. Jiang, L. Hu, K. Chen, Decisions of knowledge transfer in technology innovation alliance: a Stackelberg leader–followers model, *Operational Research* 10 (2) (2010) 231–242.
- [52] N.C. Karunatillake, N.R. Jennings, I. Rahwan, P. McBurney, Dialogue games that agents play within a society, *Artificial Intelligence Journal* 173 (9–10) (2009) 935–981.

- [53] P. Kollock, Social dilemmas: the anatomy of cooperation, *Annual Review of Sociology* 24 (1) (1998) 183–214.
- [54] J.P. Kotter, *Leading Change*, Harvard Business School Press, Boston, MA, 1996.
- [55] L. Lessig, *The future of ideas: The fate of the commons in a connected world*: Vintage, 2002.
- [56] D.Z. Levin, R. Cross, The strength of weak ties you can trust: the mediating role of trust in effective knowledge transfer, *Management Science* 50 (11) (2004) 1477–1490.
- [57] Y.-M. Li, J.-H. Jhang-Li, Knowledge sharing in communities of practice: a game theoretic analysis, *European Journal of Operational Research* 207 (2) (2010) 1052–1064.
- [58] L. Lin, X. Geng, A.B. Whinston, A sender–receiver framework for knowledge transfer, *MIS Quarterly* 29 (2) (2005) 197–219.
- [59] W.B. Lin, The effect of knowledge sharing model, *Expert Systems with Applications* 34 (2) (2008) 1508–1521.
- [60] C. Loebecke, P.C. Van Fenema, P. Powell, Co-opetition and knowledge transfer, *ACM SIGMIS Database* 30 (2) (1999) 14–25.
- [61] M.L. Markus, Toward a theory of knowledge reuse: types of knowledge reuse situations and factors in reuse success, *Journal of Management Information Systems* 18 (1) (2001) 57–93.
- [62] R. McDermott, C. O’Dell, Overcoming cultural barriers to sharing knowledge, *Journal of Knowledge Management* 5 (1) (2001) 76–85.
- [63] M. Minsky, Negative expertise, *International Journal of Expert Systems* 7 (1) (1994) 13–18.

- [64] R.M. Muller, M. Spiliopoulou, H.J. Lenz, The influence of incentives and culture on knowledge sharing, in: Proceedings of the 38th Annual Hawaii International Conference on System Sciences (HICSS'05), Los Alamitos, CA, USA, January 3–5, 2005.
- [65] R.B. Myerson, Nash equilibrium and the history of economic theory, *Journal of Economic Literature* 37 (3) (1999) 1067–1082.
- [66] J. Nahapiet, S. Ghoshal, Social capital, intellectual capital, and the organizational advantage, *The Academy of Management Review* 23 (2) (1998) 242–266.
- [67] I. Nonaka, N. Konno, The concept of “Ba”: building a foundation for knowledge creation, *California Management Review* 40 (3) (1998) 40–54.
- [68] I. Nonaka, H. Takeuchi, *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*, Oxford University Press, London, 1995.
- [69] C. O’Dell, C.J. Grayson, If only we knew what we know, *California Management Review* 40 (3) (1998) 154–174.
- [70] M.J. Osborne, *An Introduction to Game Theory*, vol. 3, Oxford University Press, New York, 2004.
- [71] U.F. Ott, International business research and game theory: looking beyond the prisoner’s dilemma, *International Business Review*, in press. <http://dx.doi.org/10.1016/j.ibusrev.2012.07.004>.
- [72] J. Parviainen, M. Eriksson, Negative knowledge, expertise and organizations, *International Journal of Management Concepts and Philosophy* 2 (2) (2006)

- 140–153.
- [73] A. Perrin, N. Rolland, T. Stanley, Achieving best practices transfer across countries, *Journal of Knowledge Management* 11 (3) (2007) 156–166.
- [74] J. Pfeffer, R.I. Sutton, *The Knowing-Doing Gap: How Smart Companies Turn Knowledge into Action*, Harvard Business School Press, Cambridge, MA, 1999.
- [75] Polak, Ben, Econ 159: Game Theory, Open Yale University Course, 2007, <<http://oyc.yale.edu/economics/game-theory>> (retrieved 31.08.11).
- [76] J. Raelin, Finding meaning in the organization, *MIT Sloan Management Review* 47 (3) (2006) 64–68.
- [77] N. Rolland, D. Chauvel, Knowledge transfer in strategic alliances, *Knowledge horizons: The present and the promise of knowledge management* (2000) 225–236.
- [78] R. Ruggles, The state of the notion: knowledge management in practice, *California Management Review* 40 (3) (1998) 80–89.
- [79] S. Samaddar, S.S. Kadiyala, An analysis of interorganizational resource sharing decisions in collaborative knowledge creation, *European Journal of Operational Research* 170 (1) (2006) 192–210.
- [80] H.M. Samieh, K. Wahba, Knowledge sharing behavior from game theory and socio-psychology perspectives, in: *Proceedings of the 40th Hawaii International Conference on System Sciences (HICSS'07)*, Hawaii, USA, January 3–6, 2007.
- [81] T.C. Schelling, The strategy of conflict prospectus for a reorientation of game theory, *The Journal of Conflict Resolution* 2 (3) (1958) 1–63.
- [82] T.C. Schelling, Dynamic models of segregation, *The Journal of Mathematical*

- Sociology 1 (2) (1971) 143–186.
- [83] A.K. Sen, Rational fools: a critique of the behavioral foundations of economic theory, *Philosophy & Public Affairs* 6 (4) (1977) 317–344.
- [84] P.M. Senge, *The Fifth Discipline: The Art and Practice of the Learning Organization*, Currency, New York, 1990.
- [85] A. Shapiro, *Creating Contagious Commitment. Applying the Tipping Point to Organizational Change*, Strategy Perspective, Hillborough, North Caroline, 2003.
- [86] B.L. Simonin, Ambiguity and the process of knowledge transfer in strategic alliances, *Strategic Management Journal* 20 (7) (1999) 595–623.
- [87] D. Snowden, Organic knowledge management, *Knowledge Management* 3 (7) (2000) 14–17.
- [88] M. Spence, Job market signaling, *The Quarterly Journal of Economics* 87 (3) (1973) 355.
- [89] J.C. Spender, Competitive advantage from tacit knowledge? Unpacking the concept and its strategic implications, in: B. Moingeon, A. Edmondson (Eds.), *Organizational Learning and Competitive Advantage*, Sage Publications, Thousand Oaks, CA, 1996, pp. 56–73.
- [90] G. Szulanski, Exploring internal stickiness: impediments to the transfer of best practice within the firm, *Strategic Management Journal* 17 (1996) 27–43 (winter special issue).
- [91] D.J. Teece, Capturing value from knowledge assets: the new economy, markets for know-how, and intangible assets, *California Management Review* 40 (3) (1988) 55–79.

- [92] P. Trkman, K.C. Desouza, Knowledge risks in organizational networks: an exploratory framework, *Journal of Strategic Information Systems* 21 (1) (2012) 1–17.
- [93] W. Tsai, Social structure of “coopetition” within a multi-unit organization: coordination, competition, and intraorganizational knowledge sharing, *Organization Science* 13 (2) (2002) 179–190.
- [94] E. von Hippel, “Sticky information” and the locus of problem solving: implications for innovation, *Management Science* 40 (4) (1994) 429–439.
- [95] G. von Krogh, Care in knowledge creation, *California Management Review* 40 (3) (1998) 133–153.
- [96] J. von Neumann, O. Morgenstern, *Theory of Games and Economic Behavior*, Princeton University, Princeton, NJ, 1947.
- [97] E.C. Wenger, W.M. Snyder, Communities of practice: the organizational frontier, *Harvard Business Review* 78 (1) (2000) 139–146.
- [98] K.Y. Wong, Critical success factors for implementing knowledge management in small and medium enterprises, *Industrial Management and Data Systems* 105 (3) (2005) 261–279.
- [99] Y. Xu, J. Liu, X. Zhong, S. Chen, Lattice-valued matrix game with mixed strategies for intelligent decision support, *Knowledge-Based Systems* 32 (2012) 56–64.
- [100] H.L. Yang, T.C.T. Wu, Knowledge sharing in an organization, *Technological Forecasting and Social Change* 75 (8) (2008) 1128–1156.
- [101] M.H. Zack, Developing a knowledge strategy, *California Management Review* 41 (3) (1999) 125–145.

- [102] F.C. Zagare, *Game Theory: Concepts and Applications*, vol. 41, Sage, Newbury Park, CA, 1984.
- [103] X. Zhang, Z. Chen, D. Vogel, M. Yuan, C. Guo, Knowledge-sharing reward dynamics in knowledge management systems: game theory-based empirical validation, *Human Factors and Ergonomics in Manufacturing and Service Industries* 20 (2) (2010) 103–122.
- [104] X. Zhang, P.O. Pablos, Z. Zhou, Effect of knowledge sharing visibility on incentive-based relationship in Electronic Knowledge Management Systems: An empirical investigation. *Computers in Human Behavior*, in press. <<http://www.sciencedirect.com/science/journal/aip/07475632>> (Corrected Proof, retrieved 17.03.12).