

# The Mechanism of Sharing Tacit Knowledge Based on Multi-Agent Systems

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**Abstract.** The effective application of knowledge management in organizations is an essential factor in their successful operation. Furthermore, it is more important that how people exploit tacit knowledge, how they make tacit knowledge beneficial to the organization. Sharing tacit knowledge within an organization is critical to the organization among the individuals and between the individuals. However, there is no approach based on multi-agent systems to analyze the sharing of tacit knowledge, and to discover what kinds of methods tacit knowledge can be shared and how organizations make themselves effective and efficient based on multi-agent systems. So this paper, based on multi-agent systems, aims to present for discussion the mechanism of sharing tacit knowledge within an organization. First of all, this paper describes three main characteristics of tacit knowledge; then expands to find the games between the individuals in the organization. Finally, some conclusions and further discussions are put forward.

## 1 Introduction

The effective application of knowledge management in organizations is an essential factor in their successful operation. Furthermore, it is more important that how people exploit tacit knowledge, how they make individual knowledge and organizational knowledge easy to approach and how they make tacit knowledge beneficial to organizations.

Knowledge has been defined and has been classified into tacit knowledge (TK) and explicit knowledge (EK) [1], [2], [3], [4], [5], [6]. Knowledge is embedded in organizations and individuals [7]. Sharing tacit knowledge within an organization is critical to the cooperation among the individuals and between the individuals and the organization. However, there is no approach based on multi-agent systems to analyze the sharing of tacit knowledge and to think over how an organization creates a harmonious environment and exploit tacit knowledge, and to discover what kinds of mechanism can share tacit knowledge and how organizations make themselves effective and efficient based on multi-agent systems. So this paper, based on multi-agent systems, aims to present for discussion the mechanism of sharing tacit knowledge within an organization.

An organization is indeed a system. Most scholars who study tacit knowledge only focus on one or two key factors

that affect knowledge creation, through some specific method to solve the problems occurring in tacit knowledge management, or using limited methods to apply to the organization without thinking of the values within it. Here, we apply the multi-agent systems in order to consider the games among the individuals and between the individuals and the organization based on their different payoffs.

First of all, this paper describes three main characteristics of tacit knowledge: 1) monopolization, which means that it is not automatic for the individuals to share tacit knowledge; 2) it is quite difficult for tacit knowledge to transform or flow among the individuals or groups and between the individual and the organization; 3) the instability of the subjective benefits is caused by the deeply individual tacit knowledge, because their values can not be simply accomplished by the network platform or cultural stimulation.

According to the situation whether the participators cooperate with each other, there are two kinds of games: the cooperative game and the un-cooperative game. Time and information are the main factors which affect the equivalence of the game. In the process of the game, the information communication between the participators judges their activity space and the choice of excellent strategy. At the same time, the sequence of the participators' activities directly affects the final equivalence of the game.

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Because all the games are consisted of basic games between individuals, we focus on analyzing two kinds of basic games, one is the cooperative game and the other is un-cooperative game between individuals with some illustrations which mark the payoffs of the participators. Then, we discuss four types of tacit knowledge flows and transformations in detail under the following conditions respectively: 1) between the individuals, 2) between the individuals and the group, 3) the individuals and the organization, 4) the groups and the organization. Finally, this paper gives some conclusions and puts forward some further discussions and the future work

## 2 Tacit Knowledge and its Characteristics

### 2.1 Tacit Knowledge

According to what Polanyi analyzed, tacit knowledge refers to that "We can know more than we can tell" J.C. Spender defines tacit knowledge as "not yet explicated." [5]. Suchman observes that tacit knowledge enables us to take actions that are situated in particular social and physical circumstances, and then tacit knowledge is context bound [7]. While Polanyi addressed tacit knowledge at an individual level [3], others have suggested it exists in group settings. In fact, Richard Nedson and Sydney Winter suggested that organizations maintain their structure and coherency through tacit knowledge embedded in "organizational routines" that no single person understands completely. In this paper, tacit knowledge refers to the knowledge, which is hidden in social and physical circumstances, and which is the context bound imbedded in the individuals, groups and the organization.

### 2.2 Characteristics of Tacit Knowledge

#### 2.2.1 The Monopolization of Tacit Knowledge

Because the sharing of tacit knowledge cannot be conducted freely and automatically by the knowledge subject, the monopolization of tacit knowledge has become apparent. People who possess of tacit knowledge would not transform their knowledge, particularly tacit knowledge which can take a lot of benefit to other people. In addition, the tacit knowledge subjects have no direct exchanges and contact among themselves without the order from the organization. Individuals cannot make face-to-face communications with the restriction of working positions. The more restrict the organizational management is, the more difficult the sharing of tacit knowledge between the individuals is.

#### 2.2.2 The Difficulties to Transform Tacit Knowledge

The flows and transform of tacit knowledge includes knowledge flows between individuals, knowledge flows between individuals and the group, knowledge flow between groups, knowledge flow between group and organization. Therefore, knowledge transforming is obviously complex and difficult.

#### 2.2.3 The Uncertainty of Subjective Benefit

One important reason for an organization to last forever is that both individuals and groups contribute to the organization or enterprise with their knowledge. The value of explicit knowledge can be calculated, but tacit knowledge owned by the individuals is very potential. It is not easy to gain value simply by establishing platform of network or stimulating organizational culture. If the tacit knowledge subjects share the knowledge, the monopolization is broken, the excess benefit and the feeling of achievement made by tacit knowledge will disappear.

### 2.3 Multi-Agent Systems

A multi-agent system (MAS) is a collection of software agents that work in conjunction with each other. They may cooperate or they may compete, or some combination of cooperation and competition, but there is some common infrastructure that results in the collection being a 'system', as opposed to simply being a disjoint set of autonomous agents.

A multi-agent system is either a closed multi-agent system or an open multi-agent system. A multi-agent system may or may not be a distributed multi-agent system. There is an alternative definition, that is: a multi-agent system (MAS) is a computational system where agents cooperate or compete with others to achieve some individual or collective task [8].

In the operation procedure, a proper way is to find out a multi-agent information system to run the systems and to achieve good performance. A multi-agent information system (IMAS) is generally composed of information agents that search, on the basis of requests that are sent to them (directly or indirectly through a database) for information on databases (local or distributed) or on Internet sites. Information agents' activities are often coordinated through coordinator agents. These agents own knowledge on information agents (such as their addresses, their search domains for example) to which they send requests (in a targeted way if they own knowledge on their competences or by broadcast techniques). Coordinator agents have to gather collected information, in order to check it, compare it or filter it. Most information multi-agents systems are directly in touch with the user, upstream (to receive new requests) and/or downstream (to display search results). In order to have a reactive interface and distribute to the users, some IMAS propose the use of

interface agents acting as interfaces between the users and the system [9].

### 3 The Game Between The Agents

As an application of analyzing and solving conflicts and cooperation, the multi-agent systems study the maximization of the subjects' function at a certain information structure so as to balance the decisions of different subjects. The game includes three parts: one is decision subject, which means participators; the second is the certain information structure, that is the strategies and action space that the participators can choose; the third is payoff, which is the participator's benefit that can be defined and quantified. The participators, strategies and payoff function form a basic game.

According to the completeness of information, games can be divided into four types: complete information static game, complete information dynamic game, incomplete information static game and incomplete information dynamic game. They can also be divided into cooperative game and uncooperative game, and the difference rests with whether the participators reach a restricted agreement in the process of gaming. If no, the game is an uncooperative game that is the main research focus for modern game. In the uncooperative game, participators firstly consider how to sustain their own benefit. The cooperative game emphasizes the collectivism, group rationality, which is efficiency, fairness and justification. However, uncooperative game emphasizes individual rationality, individual optimized decision, and the result is that it is sometimes efficient, but sometimes not.

Multi-agent systems extremely emphasizes the time and information, and considers time and information are the main factors to affect equilibrium of the game. In the process of the game, the action space and the most optimized strategy selection are decided by the information transform between the participators; at the meantime, there exists a sequence of the game process, and the sequence of participator's action directly affect the final result of the game.

Because all the games are consisted of basic games between individuals, we focus on analyzing two kinds of basic games, one is the cooperative game and the other is uncooperative game between individuals with some illustrations of payoff matrix and payoff function.

	A Sharing	A Non-sharing
B Sharing	(10, 10)	(0, 10)
B Non-sharing	(10, 0)	(0, 0)

Fig. 1. Cooperative Game.

#### 3.1 Cooperative Game

On the condition of good incentives, among all the individuals, there maintains basic cooperative game, and this makes knowledge sharing smoothly between individuals.

We establish the game as follows:

If individuals select sharing, then the benefit will be 10; otherwise, the benefit will be 0 (without lose anything);

If A selects sharing, then B definitely selects sharing

If A selects not sharing, then B definitely selects not sharing;

If A knows that B will not select sharing, then A definitely selects not sharing.

Then we have the payoff matrix illustrated in figure 1. It is obvious that this cooperative game is not accord with daily motivated action. There must be something forcing people to behave "abnormal". This kind of thing could be a series of supporting systems, such as the organizational structure, organizational environment, and incentive mechanism. If there are no supporting systems, the game in organization is belonging to uncooperative game. We can see that in the situation of protecting individual benefit and making individuals competitive, the final result is that A and B share their own knowledge with each other because of the effect of various of factors.

#### 3.2 Uncooperative Game

In the non-incentive situation, if people do share their own tacit knowledge with others in an organization, they will lose their competition and there exists some potential threat or crisis for the organization. Therefore, nobody will voluntarily share their special knowledge with others. Thus, in the organization, there is a harmful circulation; the more secret (tacit knowledge) people own, the more they can constrain others' development, the more they can plan only for themselves. This makes all the individuals not share knowledge with others and leads to the unfaithfulness of sharing knowledge or destructs the sharing environment. Eventually, it evolves to a long-term battle which makes the organization dysfunctional and loses their competition. The payoff matrix of uncooperative game is illustrated in figure 2.

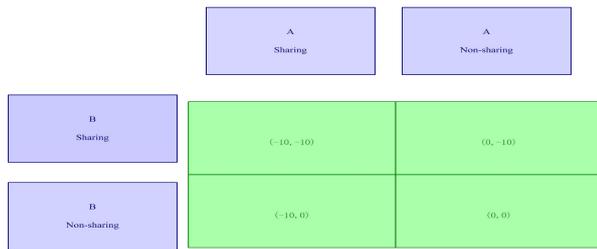


Fig. 2. Uncooperative Game

### 3.3 The Sharing Mechanism in Mathematic Support

In most interactive decision situations, organizations may have strong incentives to modify the information structure by sharing some of their knowledge. That is, when distributed knowledge is not common knowledge, predicted outcomes should be biased by communication possibilities. In this paper we use the model of strategic knowledge sharing presented in Koessler to investigate different classes of Bayesian games where it is possible to characterize endogenous information structures generated by voluntary and direct communication [8].

More precisely, we elaborate sufficient conditions for the initial game to become common knowledge or, on the contrary, for the information structure of the initial Bayesian game to remain unchanged, even if a first stage game of information revelation is added. Several examples and economic applications are also examined. In general terms, the idea is that a set of individuals are involved in a game with uncertain payoffs, where each individual has some piece of knowledge. An individual might perfectly know the game, another might completely ignore the real state of Nature, another might know who has some piece of knowledge that can complement his own knowledge, another might not know if others have some relevant information, etc.

We briefly define an equilibrium concept close to the sequential equilibrium, called knowledge equilibrium, for Bayesian games in which we add a first stage of strategic information revelation. Several useful definitions and properties of such equilibrium are also elaborated [9].

We consider an initial Bayesian game

$$G \equiv \langle N, \Omega, p, h, A, (u_i)_{i \in N} \rangle \quad (1)$$

Where

$N = \{1, \dots, n\}$  is a finite set of players;

$\Omega$  is a finite set of states of the world;

$p$  is a full-support probability distribution on  $\Omega$ ;

$h = (h_i)_{i \in N}$  is the initial information structure on  $\Omega$ ;

$A_i$  is player  $i$ 's set of effective or payoff-relevant actions, and  $A = \prod_{i \in N} A_i$ ;

$u_i : A \times \Omega \rightarrow R$  is player  $i$ 's von Neumann Morgenstern utility function. The payoff-relevant partition  $P$  is the partition of  $\Omega$  generated by the vector of utility functions  $u = (u_i)_{i \in N}$ . Write  $P(\omega)$  for the element of  $P$  containing  $\omega$ .

For any information structure  $h' = (h'_i)_{i \in N}$  on  $\Omega$ , we denote by

$$G(h') \equiv \langle N, \Omega, p, h', A, (u_i)_{i \in N} \rangle \quad (2)$$

Then, player  $i$ 's expected utility when he is at his information set  $h_i(\omega)$  and the strategy  $\phi \in \Phi$  is used is given by

$$\begin{aligned} U_i(\phi | h_i(\omega)) &\equiv E_p(u_i(\phi, \bullet) | h_i(\omega)) \\ &= \sum_{\omega' \in \Omega} p(\omega' | h_i(\omega)) u_i(\phi, \omega') \end{aligned} \quad (3)$$

For two individuals, the game can function can be very simple. However, for many individuals, the game becomes more and more complicated and complex.

## 4 The Analysis of Knowledge Flows and Transform

Because there are different levels and different groups in an organization and both the knowledge system and the organization system are complicated, we mainly focus on four kinds of knowledge flows between the individuals, groups and the organization.

### 4.1 Tacit Knowledge Flows between Individuals

The tacit knowledge flows and transform between individuals are the base and creation source to form organizational knowledge. There are two kinds of approaches of tacit knowledge flows: one is the flows from tacit to tacit knowledge that is individuals can exchange and transform some tacit knowledge, such as technique, knack and the mode of thinker by social communication; The other is that flows from tacit knowledge to explicit knowledge, that is tacit knowledge can be externalized as explicit knowledge by mining, clearing up and concluding.

### 4.2 Tacit Knowledge Flow between Individuals and Group

The tacit knowledge flows between individuals and group is bidirectional. For the tacit knowledge flow from the individuals to the group, one approach is making individual tacit knowledge explicit to the group through social communication, such as technicians or experts instructing the group work; another approach is codifying some tacit knowledge; For the tacit knowledge flow from the group to the individuals, some tacit knowledge which is hard to be made explicit can be transformed into individual tacit

knowledge through the impact of the group and the feeling of individuals.

#### **4.3 Tacit Knowledge Flows between the Individuals and the Organization**

This individual tacit knowledge which is hard to be made explicit can be transformed to organizational tacit knowledge by socialization and effective integration. Some can be made organizational explicit knowledge, and some can be transformed into individual tacit knowledge, and eventually, forms organizational culture, view of valuation and the mode of thinker [10].

#### **4.3 Tacit Knowledge Flows between the Groups and the Organization**

For knowledge itself, there are four kinds of flows: from tacit to tacit, from tacit to explicit, from explicit to explicit, and from explicit to tacit. The game process is comparatively complicated when knowledge is hidden in the groups and the organization. It needs more and more cooperative works, highly ordered organizational structure and harmonious environment.

### **5 Discussion and Future Research**

System focus is a philosophy rather than a specific technique, one that reinforces the importance of technology integration. The advantages of knowledge integration do not come without investment and commitment from top management. It also takes time to develop the skills of integrating teams. There exists value of system focus in an environment that is both complex and changeable. An integration team can build a solid and powerful base of knowledge about the interactions between the most critical decisions in new product design[11].

In knowledge-intensive organizations, one should expect randomness, chaos, and disorderliness that are inherent to innovation process. Those who accept chaos and try to manage it are likely to be far more successful than those who try to pretend it can be orderly if one can introduce more structure to the process. Knowledge-intensive organizations have to be driven by vision that attract superb people and motivate them to contribute in desired directions so that people are not "loose to innovate". Also, the organization has to capture its systematic and managerial knowledge in its information systems.

Knowledge-intensive organizations need not to follow blindly the competitive or partnership models, mixing cooperation and competition, trust and flexibility. An interesting agenda for future research should include how small and medium sized knowledge-intensive organizations and developing regions can react, where the focus is on imitation, absorption and incremental improvement rather

than the development of radical new products or processes. Some discussions are as follows.

I. This paper mainly aims to establish managerial mechanism, which can develop the ability of public knowledge department. Therefore, based on transforming the organizational function, simplifying the institution, it is important to complete the operational rules and to execute strictly.

II. Rectifying the external effect. To the beneficial externality, it is necessary for the organization to encourage the individuals to share their knowledge by several of incentive policy, and to expand the effect to the most efficient level to the organization by intellectual property right.

III. Improving the efficiency of the sharing of tacit knowledge. The effective way is to set up the competitive and incentive mechanism between the individuals, groups and the organization, and to introduce market competition to the organization. Another way is to form the inner knowledge sharing network, which can enhance the tacit knowledge exchange between individuals and organization, and maintain the organization efficient [12].

IV. Focusing on harmonious environment and relationship within the organization. To maintain competitiveness, organizations need both a sense of stability and continuity. At the same time, as there is a potential in human resource, tacit knowledge plays a crucial part in the successful process of continuous improvements. An emphasis on building bridge between colleagues and create suitable environment to promote this.

V. Focusing on social competence. Develop complementary relations within the company, based on apprenticeship, trust and a helping attitude. We have argued that organizing companies around process teams may be a viable solution. Effective systems for sharing tacit knowledge presuppose a focus on social competence.

VI. This paper based on the analysis of two kinds of basic game explains the tacit knowledge sharing mechanism between individuals and the organization. However, there are much more works to do in the near future, such as how to establish games for some other different level in the organization, how to simulate the knowledge flows, how to do some empirical research and so on.

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