

# Knowledge Sharing: An Evolutionary Game

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Knowledge sharing in R&D teams is a dynamic process, and the strategic behaviors of sharing parties are interactive. The realization of sharing behavior and the achievement of collective goals require sharing parties to work together. While obtaining benefits, the involved parties also assume possible risks and related costs. This often leads to a knowledge sharing dilemma: sharing personal insights with coworkers may carry a cost for the sharing individuals which consequently leads to, at the aggregate level, a co-operation dilemma, similar to a public-good dilemma. As a result, knowledge sharing is by nature an evolutionary game scenario, a calculated, dynamic, give-and-take process. The evolutionary game theory is the emerging theory developed from the traditional game theory that combines game theory analysis with a dynamic evolution process in order to develop a more holistic understanding of a dynamic interaction process. Therefore, the evolutionary game theory provides an appropriate perspective to understand the dynamic knowledge-sharing process within R&D teams.

evolutionary gaming theory

innovation performance

knowledge sharing

R&D team

## 1. Knowledge Sharing in R&D teams

Knowledge sharing among R&D team members is a process to develop and utilize knowledge resources, and further to promote R&D team performance. Members of R&D teams with heterogeneous characteristics in knowledge, skills, and work experiences can stimulate creative solutions, thereby effectively increasing the depth and breadth of knowledge sharing [1]. Team rewards and profit sharing can also promote the exchange and creation of internal knowledge among team members [2]. However, there are also risks associated with knowledge sharing. If team members share too much of their key knowledge, they may worry that their unique contribution to the organization will be reduced and thus lose their power position in the team. In addition, if some knowledge is improperly handled by other members, the losses suffered by them are immeasurable [3]. This is particularly true for R&D personnel because most of them have tacit knowledge, and its characteristics such as vagueness, stickiness, and implicitness will hinder effective knowledge sharing [4].

Knowledge exists at different levels within an organization and is shared spontaneously in various environments [1]. Knowledge management requires companies to manage organizational knowledge as corporate assets and make full use of knowledge creation and knowledge sharing as key organizational capabilities [2]. Since Nonaka proposed the concept of knowledge sharing in 1991, academics and industry have paid increasing attention to the research and management of knowledge sharing among individuals, teams, organizations, and cross-organizations. Davenport and Prusak [3] defined knowledge sharing as a voluntary behavior. They defined

knowledge sharing as the conscious exchange of knowledge by individuals, not involving routine or structured information exchange. Wang [4] believed that knowledge sharing refers to providing task information and skills, helping others and cooperating with others to solve problems, and developing new ideas and implementing policies or procedures. Bartol and Srivastava [5] defined knowledge sharing as the sharing of information, ideas, suggestions and expertise related to the organization between individuals. Ipe [6] argued that knowledge sharing between individuals refers to the process by which individuals transform their knowledge into a form that other individuals can understand, absorb, and use. Huang et al. [7] divided knowledge sharing into tacit knowledge sharing and explicit knowledge sharing. The process of tacit knowledge sharing includes the process of team members sharing personal experiences, elaborating background knowledge and professional knowledge, and the characteristics of explicit knowledge sharing are that team members exchange ideas and knowledge in coded form. These studies show that while knowledge sharing has been examined from different perspectives and thus their definitions of knowledge sharing are different, there are some key elements in common: the type of knowledge shared, the method or channel, and the level wherein the knowledge is shared (individual, team and organization) [8]. Individual knowledge needs to be transferred into team knowledge and then into organization knowledge through various methods so as to promote the achievement of organizational objectives [6].

Knowledge sharing has a wide range of influencing factors. Many scholars have examined the behavior and process of knowledge sharing around social psychology, organizational and team characteristics, knowledge characteristics, motivation elements, and cultural characteristics [9][4]. A variety of studies have suggested improving organizational culture and atmosphere, management support, rewards and incentives, team diversity, social networks, knowledge of intellectual property, perceived benefits and costs, interpersonal trust and justice, individual attitudes, and others in order to help improve knowledge sharing effectiveness [10][9]. For example, Masa'deh [11] believed that creating an atmosphere of mutual trust, openness, and sharing is a key success factor in creating a knowledge-sharing environment. Transformational leadership and transactional leadership also have an important ability to promote the knowledge-sharing process within an organization [12]. Cabrera and Cabrera [13] proposed that the establishment of a good incentive system and the improvement of employees' self-efficacy are powerful measures to promote knowledge-sharing behaviors. Staples and Webster [14] found that for teams of different structures (local, mixed and distributed), there is a strong positive correlation between trust and knowledge sharing. However, when the degree of task interdependence is low, this relationship is stronger. That is, trust plays a stronger role in a weakly structured team. Liu and Liu [15] argued that individual self-efficacy perception can effectively promote knowledge sharing among R&D personnel. The research by Akhavan and Mahdi [16] showed that social interaction relationships (structural capital factors), trust, reciprocity, and team identity (relationship capital factors) are significantly related to the willingness to share knowledge, and the willingness to share knowledge is further significantly related to knowledge-sharing behaviors (collecting knowledge and donating knowledge). Wu [17] proposed that when employees are more satisfied with their knowledge-sharing environment, more knowledge-sharing behaviors will occur, and when the main driving force of knowledge sharing is economic (external motivation), employees may be more reluctant to share their knowledge. This line of research has thus generated an impressive array of literature on knowledge and knowledge sharing.

## 2. Knowledge Sharing as an Evolutionary Game

Evolutionary game theory is a theory developed from the traditional game theory by combining game theory analysis with the dynamic evolution process. It is the application of traditional game theory to the dynamic process in evolving populations [18]. The traditional game theory emphasizes a static equilibrium or a comparatively static equilibrium of participants with an assumption that all participants are completely rational. In the process of decision-making, all participants can make rational judgments and decisions because they can obtain complete information. However, due to the complexity of a dynamic system or a society, no individual can be completely rational, let alone the assumption that every individual can remain completely rational and make perfect decisions at all times [19]. In other words, the traditional game theory has its own challenges in dealing with social interaction processes, the dynamic processes. During these processes, participants could change, and the purpose of their interactions could also change. These changes can affect the whole system, thereby changing the results and direction of the game. The evolutionary game perspective, however, combines the traditional game theory with the dynamic evolving process and thus can better explain the process of knowledge sharing among R&D team members thanks to its integration of traditional game theory with the evolution process.

Within the R&D teams and with common group performance goals, R&D personnel work together with each other to form a dynamic group. In the process of knowledge sharing, every team member has a dynamic cooperative and also competitive relationship with each other. Because of the limited rationality of participating individuals in such teams, the process of knowledge sharing tends to be a slow evolution process. In other words, knowledge sharing is a dynamic evolutionary game, and it should be analyzed with a dynamic evolutionary model, rather than a static approach. In this gaming process, the knowledge obtained by each participant is limited. Participants constantly adjust and improve their own future interests according to the obtained benefits, and constantly pursue a more satisfactory state in order to achieve a state of equilibrium. In this balanced state of equilibrium, if the opponents do not change their strategies, no individual will unilaterally adjust their strategy. The strategy at this time is called an evolutionarily stable strategy.

Literature on knowledge sharing has begun to adopt the game theory to explore the dynamic interaction process and related influencing factors of knowledge sharing. For example, Chua [20] used the framework of multiplayer game theory to investigate the dynamic process of knowledge sharing. He found that the tendency of individual knowledge sharing is driven by a series of situational concerns and interests, and the choice of knowledge-sharing/retention strategy depends on the level of perceived rewards. Shih et al. [21] also studied the interactive behavior of knowledge sharing among high-tech employees in combination with the evolutionary game theory, and found that factors such as commitment, trust, reciprocity, and long-term relationships can drive employees to adopt sharing and cooperative behaviors. In addition, the introduction of agency competition and reward mechanisms can solve the “free-riding” phenomenon that is prone to collective cooperation. Bandyopadhyay and Pathak [22] used the evolutionary game analysis to analyze the interaction between the employees of the “host” company and the outsourcing company. Their results showed that when the degree of knowledge complementarity between employees is high, employees are more likely to engage in cooperative behaviors. Liu et al. [23] also applied the evolutionary game analysis to analyze the knowledge-sharing mechanism between firms in supply chain

collaborative innovation, and they decomposed it into two stages of knowledge mining and knowledge transfer. Their results showed that mutual trust, property rights protection, and corporate culture integration can promote knowledge-sharing behaviors. In a similar study, Du et al. [24] pointed out that the factors that affect team knowledge sharing include knowledge stock, knowledge ratio, knowledge absorption coefficient, synergy coefficient, and knowledge-sharing cost.

However, while contemporary research has adopted the game theory or even an evolutionary perspective to explore the process of knowledge sharing, it has largely focused on the macro level, i.e., firms or organizations, and relatively less attention has been paid to the knowledge-sharing process at the individual level [25]. Research at the individual level within R&D teams is relatively rare. Given that the nature of the team environment and the level of analysis can affect the evolutionary results with different evolution paths and evolutionary stability strategies, it is essential to explore what affects knowledge-sharing behaviors within R&D teams when treating the knowledge-sharing process as a dynamic evolutionary game.

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