DOI: 10.18721/JE.14209
UDC 338.2;331.1

THE IMPORTANCE OF EFFECTIVE EXTERNALIZATION WITHIN THE SECI MODEL FOR ORGANIZATIONAL DEVELOPMENT: ANALYSIS BASED ON GAME THEORY

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In the era of knowledge economy, knowledge is gradually replacing land, labor and capital as the main resource of economic development, the source of innovation, and the foundation for forming the major competitiveness of organizations. Organizational knowledge can be divided into explicit knowledge and tacit knowledge. Explicit knowledge can be stored and transmitted through information and network technology, while tacit knowledge must rely on the interaction between people and the organization to achieve the results of transmission, sharing and effective conversion. The effective management of tacit knowledge has an important influence on sustainable development of the organization. The main goal of this article is to improve the efficiency of sharing and conversion of tacit knowledge within the organization. In the research on tacit knowledge management, the SECI model of tacit knowledge conversion proposed by Nonaka is designed to convert tacit and explicit knowledge into each other through the process of socialization, externalization, combination and internalization. This cyclical conversion has formed a spiraling process of knowledge innovation, which provides a model and theoretical basis for the effective management and utilization of tacit knowledge. Through the SECI model we can find that in the process of externalization, the members of the organization and the organization itself convert tacit knowledge into explicit knowledge. In this process, the overall major competitiveness of the organization has been enhanced, but for the members of the organization as the subject of tacit knowledge, it may mean the loss of their core value. From the economic perspective, these mutual relations essentially reflect the conflict between the interests of individuals and organizational interests. Therefore, a mathematical model can be created from the perspective of game theory to study the problem concerning knowledge conversion within the organization, which is aimed at the prisoner's dilemma, as well as to design the incentive mechanism of tacit knowledge conversion within the organization for the purpose of changing the strategic equilibrium and realizing the effective management of tacit knowledge in the organization.

Keywords: tacit knowledge, SECI model, tacit knowledge management, game theory, organizational development, incentive mechanism

Citation: Z.Yu. Taiber, Zha Shenyu, The importance of effective externalization within the SECI model for organizational development: analysis based on game theory, St. Petersburg State Polytechnical University Journal. Economics, 14 (2) (2021) 137–148. DOI: 10.18721/JE.14209

ВАЖНОСТЬ ЭФФЕКТИВНОЙ ЭКСТЕРНАЛИЗАЦИИ В МОДЕЛИ SECI ДЛЯ РАЗВИТИЯ ОРГАНИЗАЦИИ: АНАЛИЗ НА ОСНОВЕ ТЕОРИИ ИГР

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В эпоху экономики знаний, знания постепенно заменяют землю, труд и капитал в качестве основного ресурса экономического развития, источника инноваций и основы для формирования ядра конкурентоспособности организаций. Организационные знания можно разделить на явные и неявные. Явные знания могут храниться и передаваться с помощью информационных и сетевых технологий, в то время как неявные знания должны полагаться на взаимодействие между людьми и организацией для достижения результатов передачи, совместного использования и эффективного преобразования. Эффективное управление неявными знаниями оказывает важное влияние на устойчивое развитие организации. Цель этой статьи - повысить эффективность совместного потребления и преобразования неявных знаний в организации. В исследовании управления неявным знанием модель преобразования неявного знания SECI, предложенная Нонака И., заключается в преобразовании неявного знания в явное и наоборот посредством процесса социализации, экстернализации, комбинации и интернализации. Эта циклическая трансформация сформировала спиральный процесс инноваций в области знаний, который обеспечивает модель и теоретическую основу для эффективного управления и использования неявных знаний. С помощью модели SECI мы можем обнаружить, что в процессе экстернализации организация и ее члены осуществляют преобразование неявного знания в явное. В этом процессе общая основная конкурентоспособность организации повысилась, но для членов организации как объекта неявного знания это может означать потерю своей основной ценности. С точки зрения экономики, эти взаимоотношения, по существу, отражают конфликт между индивидуальными интересами и интересами организации. Таким образом, можно создать математическую модель с точки зрения теории игр для изучения проблемы преобразования неявного знания внутри организации, нацеленной на дилемму заключенного, а также для разработки механизма поощрения преобразования неявного знания, чтобы изменить стратегическое равновесие и реализовать эффективное управление неявными знаниями в организации.

Ключевые слова: неявное знание, модель SECI, управление неявным знанием, теория игр, развитие организации, механизм поощрения

Ссылка при цитировании: Тайбер З.Ю., Чжа Ш. Важность эффективной экстернализации в модели SECI для развития организации: анализ на основе теории игр // Научно-технические ведомости СПбГПУ. Экономические науки. 2021. Т. 14, № 2. С. 137–148. DOI: 10.18721/JE.14209

Introduction

World Economic Forum held in Davos in 2016 introduced the concept of the *Fourth Industrial Revolution*. The Fourth Industrial Revolution relies on artificial intelligence, big data and the Internet, considers the development of science and technology as an important force for economic growth, formation of Industry 4.0 leads to growth of knowledge economy [1]. Knowledge-based and technology-based enterprise organizations are adapted to the needs of the Fourth Industrial Revolution and become a new growth point for the country's economic development in the future. From the perspective of knowledge management, improving the core competitiveness of organization has also become the focus of scholars. In the era of knowledge economy, knowledge has become the main production factor that promotes economic growth. There are many categories of knowledge. From the perspective of epistemology, knowledge is divided into explicit knowledge and tacit knowledge. Since Michael Polanyi proposed the concept of tacit knowledge in 1958, different scholars have carried out research on tacit knowledge from different fields. Research on tacit knowledge points out that tacit knowledge accounts for 90% of all knowledge in any organization [2], and knowledge that can be expressed in words and numbers is only the tip of the entire knowledge iceberg. At the same time, according to the modern strategic theory, the competition of enterprises has gradually evolved into competition of knowledge capital, knowledge as a strategic factor in accomplishing a sustainable competitive advantage is regarded as power [3]. Especially tacit knowledge capital, which is not only an important foundation for organization members to maintain their competitiveness, but also a core resource for organizations to create competitive advantages. A research based on externalization shows

that knowledge is the most important piece of business competitive advantage and that tacit knowledge is a key part of that knowledge [4]. It can be seen that the effective management of tacit knowledge within an organization plays a vital role in improving the core competitiveness of knowledge-based and technology-based organizations.

The purpose of this paper is to establish a game model for organizations and employees by externalizing tacit knowledge based on the summary of the different tacit knowledge characteristics. In the game process, we can simulate the behavior of the organization and employees as well as analyze the reasons for inefficient conversion of tacit knowledge into explicit knowledge within the SECI model. In response to the phenomena, the authors further propose recommendations for the organization to establish incentive mechanisms in the process of externalization, so that the SECI knowledge creation model can have more practical application value in the development of high-tech and knowledge-based organization.

Research methods

The instrumental basis of this paper is the method of literature research and game theory model. One basic condition for organization to effectively manage tacit knowledge is to externalize the tacit knowledge of employees. In this process, there is a prisoner's dilemma involving provision of public goods by private individuals. This article establishes a repeated dynamic game model on this issue, and discusses the conversion of tacit knowledge under the Nash equilibrium from the perspective of employees' personal payoffs and overall payoffs of organization.

The concept and characteristics of tacit knowledge

Based on the problems covered in this article, we mainly focus on Polanyi's knowledge classification, namely explicit knowledge and tacit knowledge. Polanyi believed that explicit knowledge is a type of knowledge that can be expressed with various explicit symbols, i.e., in words, diagrams, and mathematical formulas. Tacit knowledge can be defined as skills, ideas and experiences that people have, it is non-codified and is difficult to express [5]. Explicit knowledge is information that can be expressed in language and it can be transferred and communicated in a formal, systematic and structured manner, such as organizational procedures, rules, scientific equations, manuals, etc. Compared with explicit knowledge, tacit knowledge is an unconventional form of knowledge, so it is not perceivable. Tacit knowledge is personal knowledge. It is rooted in actions, procedures, commitments, values, and emotions. In other words, special experience is needed in order to communicate tacit knowledge through observation and imitation. Drucker believes that tacit knowledge cannot be explained by words, and can only be demonstrated to prove that it exists. The only way to learn tacit knowledge is to comprehend and practice [6]. He also believes that tacit knowledge is derived from experience and skills and must be acquired through practice.

According to the literature research, tacit knowledge has the following characteristics:

1. The individuality and embodiment of tacit knowledge

Tacit knowledge has characteristics unique to individuals [7], cannot be used to communicate with others, and is embedded in personal behavior in special situations. Nonaka and his colleague believe that tacit knowledge is a form of personal knowledge [8].

2. The tacitness of tacit knowledge

Tacit knowledge is closely related to actions. For example, apprentices can only rely on practice to explore the master's operating know-how and experience. Technological tacit knowledge is created through personal behavior and direct experience "here and now" [9]. Tacit knowledge is a process of intelligence and cognition. It can neither be expressed nor publicly shown, but it can be implied or simply understood. Specifically, work involving highly tacit knowledge tends to involve practical, action-oriented know-how that is difficult to articulate, that is acquired only through personal experience, and is seldom expressed openly [10].

3. The empirical nature of tacit knowledge

Tacit knowledge is a term referring to knowledge gained based on experience, characterized by the fact that it is not formal and is process-based in nature [11]. Tacit knowledge is created in experience and stored in the form of individual ability. Although tacit knowledge is past experience, unconscious application of tacit knowledge by the individual does not require long-term thinking. In the context of emerging public health incidents, tacit knowledge as individual's past experience has a wide-ranging impact for building resilient and responsive health systems [12]. Since tacit knowledge is obtained through practical experience and observation in various environments, it is often called empirical knowledge.

4. The difficulties in spreading and sharing tacit knowledge

Tacit knowledge is difficult to obtain, transfer, share and manage. An incentive mechanism can make the enterprise employees share their inner individual tacit knowledge, which in turn, makes the shared knowledge explicit, transfers the explicit knowledge into assets, and finally translates the asset knowledge into incomes [13]. In practice, tacit knowledge sharing between employees is rare, firms should employ various methods to facilitate the intrinsic motivations to promote sharing [14]. Tacit knowledge is not only the most difficult to share and keep in organizations, but also rightly perceived to be the most valuable knowledge asset owing to its contextualized and experience-based nature [15].

5. The monopolization of tacit knowledge

The monopoly of tacit knowledge is evident in that it is obtained not through words, images or other knowledge [16]. It is accumulated in long-term practice by individuals who have invested time, experience, material, etc. Therefore, tacit knowledge has value, the individuals within an organization may have a strong monopoly on some kinds of rarer tacit knowledge [17], especially when monopoly knowledge can bring core competitiveness and additional economic returns, the same is true for organizations with tacit knowledge.

The influence of tacit knowledge on the core competitiveness of organizational development

In the field of economics and management, research on the interconnection between tacit knowledge and the core competitiveness of organization has also attracted widespread attention of scholars. Lubit proposed the importance of tacit knowledge in enterprises, and believed that the competitive advantage of enterprises does not come from resources and markets but from the tacit knowledge of enterprises [18]. The importance of tacit knowledge has been pointed out in relation to decision-making, time-management, quality and competitiveness in organizations. Tacit knowledge is the most strategically important resource of an organization [19]. Okuyama believes that tacit knowledge plays an important role in incremental innovation through the study of drug discovery cases, and companies should pay more attention to the contribution of tacit knowledge in problem solving related to incremental innovation [20]. Many studies have shown that when explicit knowledge is identified by other competitors, an organization can only gain its competitive advantage by evaluating its tacit knowledge. The organizations should be conscious about the importance of the tacit knowledge the employee possesses for the development of the organizations [21]. In his book, Nonaka described in details the importance of tacit knowledge for the company's success [22]. He believes that in a dynamic and rapidly changing environment, the ability of an enterprise to gain a competitive advantage depends on its ability to continuously examine various factors in its internal and external environments. The only way to do this is to focus on the knowledge created by the individuals in the organization. Knowledge creation leads to continuous innovation, and continuous innovation brings competitive advantages. The creation and conversion of organizational knowledge becomes a necessary condition for the survival and development of enterprises. Therefore, Nonaka proposed a SECI model, the core content of which is how companies can establish an organization based on knowledge innovation through the process of mutual conversion between tacit knowledge and explicit knowledge. This article focuses on the conversion process of externalization. The externalization process is mainly the explicit description of tacit knowledge and conversion of it into an easy-to-understand form. Through metaphors,

analogies, diagrams, concepts and models, the tacit knowledge that can be made explicit is clearly expressed in concepts, etc., so as to implement the conversion of tacit knowledge into explicit knowledge. Externalization is an important way to expand the scope of tacit knowledge flow and conversion, as well as to realize enterprise knowledge creation.

Implementation of tacit-to-explicit knowledge conversion

By developing a semantic web platform, it can capture the domain experts' tacit knowledge and allow collaboratively annotating experts' knowledge in a computer interpretable format to form common explicit knowledge that can be shared and reused by human and machines [23]. Olaisen and Oivind conducted a longitudinal survey study of two teams of staff employed with a Norwegian manufacturer. Through rotating role mechanism and socialization process they successfully encouraged the team members to convert their tacit knowledge into collective explicit knowledge, and the innovation results have been achieved within a certain period of time. The authors prove that the conversion of tacit knowledge into explicit knowledge helps increase efficiency and effectiveness in knowledge-intensive corporations [24]. Some scholars had proposed to build a knowledge base to replace human expert query system with the use of intelligent search technologies and chatbots, thereby increasing the efficiency of tacit knowledge externalization [25].

Knowledge management and game theory

Game theory was proposed by Von Neumann and Morgenstern in 1944. It mainly studies the game subject behavior, i.e., how each subject selects strategies to maximize its utility and an effective way to reach equilibrium [26]. Game theory is the method of studying the phenomenon of struggle or competition, and it is widely used in biology, economics, international relations, computer and political science, military strategy and in many other disciplines. The research method of game theory is to abstract basic elements from complex phenomena, analyze the mathematical model composed of these elements, and then gradually introduce other factors that influence the development of this phenomenon for reanalysis, and finally obtain the corresponding research results. In the application of knowledge management, Jiang and Xu established a nonlinear evolutionary dynamic game model to explore the impact of structural changes on the tacit knowledge sharing behavior of IT R&D team. They believe that managers can only strengthen the reward system or reduce sharing costs, and only when a certain critical threshold is reached, the effectiveness of knowledge sharing will be significantly improved [27]. Li set up a dynamic cooperative game model to reveal the strategic characteristics of knowledge sharing between knowledge transferors and knowledge recipients, and evaluates the role of institutional constraints and incentives in promoting knowledge sharing [28]. Qin and Wang regard the organization as a system, applying the multi-agent systems to consider the games among individuals and between the individuals and the organization based on their different payoffs, and explain the tacit knowledge sharing mechanism between individuals and organization. They believe that individual tacit knowledge can be converted into an organization's explicit knowledge through socialization and effective integration, and some can be converted into individual tacit knowledge, and eventually, forms organizational culture [29]. Based on the constituent elements of the psychological contract when members participate in knowledge collaboration, some scholars use game theory to establish a cost game model and profit-sharing game model for practical knowledge collaboration [30].

Game Model of the Externalization

According to the characteristics of tacit knowledge, the process of externalization is not necessarily sufficient, which will ultimately affect the efficiency of knowledge creation in the organization. Members of the organization choose confrontation or cooperation in the conversion of tacit knowledge depending on whether the interests of all participants are consistent. This article suggests that it is necessary to establish an effective incentive mechanism from the perspective of game theory to take advantage of the tacit knowledge of organization members.

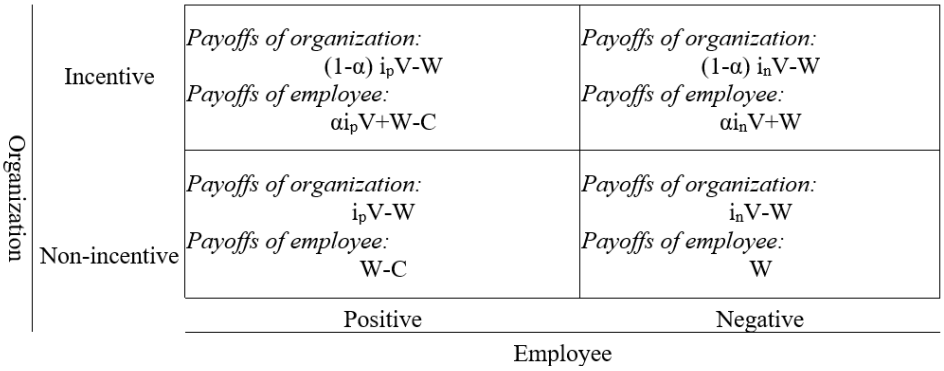

Fig. 1. Game Matrix of Externalization within organization

Due to the fact that the knowledge of employees in the organization is inseparable from them, and most of it is invisible and uncoded personal knowledge, experience and skills are accumulated by employees in long-term work practices. If their tacit knowledge can successfully be converted into explicit knowledge of the organization through externalization, it can increase the overall knowledge stock of the organization, and then enable the organization to obtain continuous innovation capabilities and competitive advantages. Therefore, the smooth conversion of employees' personal tacit knowledge into the organization's explicit knowledge is the key to the improvement of organizational knowledge stock, which in its turn depends on the aspiration of employees. Through the dynamic game analysis between the organization and its employees, this paper establishes a dynamic analysis model and incentive factor based on employee incentive and restraint mechanisms as shown in the Fig. 1. The two players of the game are: organization and employee. There is information asymmetry between the two parties, and the employee is the player which captures the information advantage; the employee's actions are based on the organizational behavior; the organization has two strategies in terms of employees' aspiration to convert knowledge: incentive and non-incentive strategies; according to the organization's strategy, employees can choose one out of two strategies, namely, positive or negative conversion of tacit knowledge.

i_n and i_p — the probabilities of converting tacit knowledge when employees are negative and positive, $0 \le i_n < i_p \le 1$;

C — the cost of employees converting tacit knowledge, $C > 0$;

V — the value created by employees for the organization after their own tacit knowledge is externalized, $V > 0$;

α — the incentive factor when the organization motivates employees, i.e., a part of the value V created by employees for the organization, $0 < \alpha < 1$;

W — the basic income of employee.

When the organization's strategy is non-incentive, because $W - C < W$ is constant, employee will choose to be negative at this time, and the final equilibrium is non-incentive, negative. It is an inefficient Nash equilibrium.

When the organization's strategy is incentive, whether employee will positively convert tacit knowledge depends on the size of his or her own benefits: if $\alpha i_p V + W - C > \alpha i_n V + W$, employee will choose to be positive, and the equilibrium is incentive, positive. It is an ideal Nash equilibrium. If $\alpha i_p V + W - C < \alpha i_n V + W$, employee will not positively convert tacit knowledge even under incentive conditions. At this time, the equilibrium is incentive, negative, which is also an inefficient Nash equilibrium. In this model, the game between the organization and employee is regarded as one game behavior. The game between the two players should be a continuously repeated process.

Assume that the decision and behavior of the organization and employee are to maximize the sum of the present value of their future payoffs. The payoffs of the two players not only depend on how to allocate the value created by the employees for the organization in the current period, but is also related to the existing knowledge stock accumulated by the employee through the conversion of tacit knowledge in the early stage, the knowledge stock consists of the knowledge, skills, and abilities of employees [31]. The more positive the conversion in the early stage is, the larger the accumulated knowledge stock will be, and the more value is created for the organization in this period of time.

The following notations have been added to the new repeated dynamic model:

n — the expected working time of the employee in organization;

r_t — the current discount factor;

Q_t — the current explicit knowledge stock;

V_t — the current value created by employee in converting own tacit knowledge;

E_t — the current positive degree of employee in converting tacit knowledge;

θ_t — the contribution coefficient of the organization's explicit knowledge stock to the current payoffs;

Ω — the employee's opportunity cost of working in the enterprise, which is equivalent to the employee's social average personal income;

C_t — the current cost of converting tacit knowledge by employee;

φ — the employee's degree of risk aversion (risk tolerance), $\varphi > 0$;

ω^2 — the variance of the benefits obtained by the organization using new explicit knowledge.

In long-term cooperation, the objective function of the organization related to maximization of the payoffs by determining the basic income of employee W and the incentive factor α is:

$$\max \sum_{t=0}^{n} r_t \left[(1-a)\left(V_t\left(E_t(\alpha)\right) + \theta_t Q_t\left(E_{t-1}(\alpha)\right)\right) - W \right]. \tag{1}$$

In long-term cooperation, the employee takes appropriate actions according to the incentive factor α to achieve the objective function of maximizing payoffs:

$$\max \sum_{t=0}^{n} r_t \left[\alpha V_t\left(E_t(\alpha) + \theta_t Q_t\left(E_{t-1}(\alpha)\right)\right) + W - \frac{1}{2}\alpha E_t^2 - \frac{1}{2}\varphi\alpha^2\omega^2 \right]. \tag{2}$$

The constraint condition for employee to participate in this game is:

$$\max \sum_{t=0}^{n} r_t \left[\alpha V_t\left(E_t(\alpha) + \theta_t Q_t\left(E_{t-1}(\alpha)\right)\right) + W - \frac{1}{2}\alpha E_t^2 - \frac{1}{2}\varphi\alpha^2\omega^2 \right] \geq \sum_{t=0}^{n} r_t \Omega. \tag{3}$$

The incentive constraint condition for employee to participate in this game is:

$$E_t(\alpha) = \frac{\alpha}{C_t}. \tag{4}$$

Substituting (3) (4) into (1), and then seeking the first derivative of α, the optimal solution is:

$$\alpha^* = \frac{\sum_{t=0}^{n} r_t \left(V_t' + \theta_t Q_t'\right)}{\sum_{t=0}^{n} r_t \left(1 + \varphi C_t \omega^2\right)} > 0.$$

The results of research and their discussion

In this Nash equilibrium state, the incentive factor α is an increasing function of the accumulated amount of explicit knowledge of the previous organization Q, its influence coefficient on organizational revenue θ, and the marginal revenue V of the organization generated by the employee's marginal conversion of tacit knowledge. In other words, the level of incentives for employee in each period is positively correlated with θ and V. When the marginal payoffs of the organization generated by the positive conversion of the employee marginal conversion of tacit knowledge rises, the payoffs of the organization also increase. In order to further motivate the employee to positively convert tacit knowledge, the organization will increase the incentive factor α, accordingly, the payoffs of the employee will also grow, thus forming a virtuous circle. In addition, the positive conversion of tacit knowledge by employees will increase the quantity and quality of the organization's knowledge stock, which will affect the organization's subsequent competitiveness. The level of incentive factor α stipulated by the organization will change the quantity and quality of the organization's knowledge stock by influencing employees' enthusiasm, and will ultimately affect its long-term operating activities. This shows that the incentives for employees should not only be linked to the actual payoffs of the organization in the current period, but also should be linked to the increase in the quantity and quality of knowledge stock within the organization.

At the same time, the incentive factor α is a decreasing function of the employee's risk aversion degree φ, the cost of converting tacit knowledge C, and the variance of the benefits obtained by the organization using new explicit knowledge ω^2. For employees, when the process of converting tacit knowledge is more difficult, the uncertainty of the additional income brought by the conversion process is greater, and the risk aversion degree of employees is higher, they are willing to take less risks. This means that employees will require higher risk-free income when signing an incentive contract with the organization, but due to the fact that organization is at an information disadvantage position concerning the cognition of tacit knowledge, and the influence of explicit knowledge generated by externalization on the profit of the organization needs to be verified by time, organization can truly understand its value only after the application of new explicit knowledge. It is unfair for organization to pay high risk-free income to employees from the beginning. This phenomenon shows that it is difficult to reach an effective incentive contract between the organization and employees at this time. Therefore, an effective incentive mechanism design should not only connect employees' income with the organization's new benefits, but should also consider such factors as employees' risk tolerance and costs.

Conclusion

Based on the above analytical results of the tacit knowledge conversion game, managers can take a set of effective incentive measures to ensure the smooth progress of tacit knowledge conversion.

1. Developing salary payment mechanism based on knowledge conversion contribution. The system refers to linking the knowledge achievements that can determine the benefits in a short time with the current income of the employees, and can motivate the employees through the issuance of salary and provision of bonuses. It is also possible to link the long-term income of employees with knowledge achievements that are difficult to determine and are mainly realized in a long-term period, and to motivate the employees by giving stock rights and options to achieve the effect of extrinsic motivation.

2. Developing position promotion mechanism based on knowledge conversion contribution. The promotion system means that employees who have not only achieved beneficial knowledge results, but also have management capabilities, and are loyal to the organization can be motivated by promotion methods. Employees who attach importance to fame can be motivated by the method of knowledge signature. For example, a particular technology or marketing knowledge can be named after an employee in order to inspire him/her. Employees can also be sent to high-level research institutes and universities for undergoing knowledge training. Through these methods, the effect of intrinsic motivation to employees can be achieved.

Tacit knowledge always exists depending on the subject of knowledge, and the subject's willingness determines the efficiency and results of tacit knowledge sharing and conversion. An effective incentive mechanism is the driving force for the flow of sharing and conversion of tacit knowledge within the organization. Based on the analysis of the repeated dynamic game model of externalization by the SECI model, this paper establishes the incentive factor, and proposes corresponding incentive mechanisms from the perspective of intrinsic and extrinsic motivation. It is aimed at eliminating obstacles in the process of tacit knowledge sharing and conversion among employees, maximizing personal and organizational benefits, providing guarantees for the organization's innovation and sustainable development, as well as at consolidating the core competitiveness of the organization on the basis of effective management of tacit knowledge.

Directions for further research

Due to the many different working groups in the organization, the authors will further use the evolutionary game theory to examine the behavior of tacit knowledge sharing between different groups in the framework of the dynamic process. The good tacit knowledge sharing within the organization (i.e., the SECI model socialization process) is a prerequisite for further conversion of tacit knowledge into explicit knowledge. The evolutionary game theory is based on the new theory of biological evolution, and its basic content is that in a group of certain size the players are constantly engaged in repeated gaming activities. Because of the presence of limited rationality, the players cannot find the best equilibrium point in each game, so the best strategy is to imitate and improve the optimal strategy of itself and of others. Through this long-term imitation and improvement, all players will tend to achieve a stable strategy balance. With the help of evolutionary game theory, we can identify the reasons which affect strategical evolution during the tacit knowledge sharing process within the organization, and continuously improve the systemic incentive mechanism for organizational members.

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Статья поступила в редакцию 13.02.2021.

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