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Research Article

Research on University Knowledge Transfer Strategy Selection based on Innovation Intermediary

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Abstract

In the era of knowledge economy, knowledge producers play an important role in economic development. How to promote knowledge transfer and commercialization of knowledge achievements has become an urgent problem for many universities which are major knowledge producers. This paper analyzes the behavior characteristics and interest relationship of innovation intermediaries and universities in knowledge transfer cooperation, constructs the evolutionary game model of innovation intermediaries and universities in knowledge transfer cooperation, analyzes the strategy choice, evolution track and influence factors of the two. On this basis, the paper puts forward some strategic suggestions to promote the transfer of university knowledge.

Keywords

Innovation Intermediary • University Knowledge Transfer • Evolution Game

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At present, university technology transfer has been the core content of most countries' innovation strategy, and the university has gradually changed its role from a single teaching and research function to an institution with both scientific and commercial missions (Huyghe, Knockaert & Piva, 2014). As an important part of the national innovation system, it has become the focus of many scholars on how to promote university knowledge transfer (KT) (Minguillo, Tijssen. & Mike, 2015). In order to achieve KT more effectively, the university has also begun a series of cooperation with third-party intermediary organizations (Howells, 2006).

Such cooperation mechanism between universities and innovation intermediaries has been studied by many scholars, and the factors affecting the KT of universities has been analysed, but most research was conducted from the perspective of enterprises, e.g., about the mutual game between subjects in the process of university KT. There have been few studied about the role of innovation intermediary in promoting KT, or the behaviour and role of universities and innovation intermediaries in KT and cooperation. For this, this paper, based on the evolutionary game theory, studies the strategic selection of universities and innovation intermediaries in KT activities from the perspective of innovation intermediary.

Related Studies

Knowledge transfer

Knowledge transfer was first proposed by Teece (1997), and it is believed that enterprises can accumulate a large amount of knowledge of transnational applications through the international transfer of technology. Knowledge contains both explicit and implicit knowledge. Explicit knowledge can be encoded and expressed into a formal, systematic language for better learning and dissemination, while implicit knowledge cannot be objectively encoded and expressed, but can only be perceived, felt and understood (Nonaka, 1994).

KT is a process in which an organization is influenced by the experience of other organizations, including the transmission of knowledge by knowledge senders, the movement of knowledge in the transfer medium, and the reception, learning, application and reconstruction of knowledge by knowledge receivers (Argote and Ingram, 2000). It is the knowledge sharing across boundaries within or between organizations, and through this process, organizations recreate and apply complex and implicit practices, processes or procedures in a new environment, emphasizing that KT is not only knowledge diffusion, but a purposeful, planned sharing across organizational or individual boundaries (Szulanski, 2015).

With the deepening of research, scholars have begun to highlight the application of knowledge and the generation of new knowledge in KT. The KT process is not only a process of reusing knowledge created by individuals or groups in an organization (Newell & Scarbrough, 2002), but also the process of organizational learning, which brings about an increase in the knowledge stock (Weidenfeld, Williams & Butler, 2010).

KT is the flow of knowledge from one party to another. This flow should include five factors: the transferor's knowledge stock value, the motivation of communication, the richness of the transmission route, the recipient's motivation and absorptive capacity (Gupta & Govindarajan, 2000). With regard to the factors affecting KT, scholars have drawn different conclusions from different perspectives. Cummings & Teng (2003) discussed nine factors affecting KT, namely, the embedding of knowledge, descriptiveness, organizational distance between transfer subjects, physical distance, knowledge distance and normative distance, learning culture and priority of recipients, and number of transfer activities, etc. Simonin (2015) extracted four influencing factors from the existing KT literature, i.e., company characteristics, knowledge characteristics, partner characteristics and situational characteristics.

University knowledge transfer

Knowledge production is a major target and function of the university. With the development of the times, the functions of the university have begun to change, especially after the “second academic revolution” (Etzkowitz & Leydesdorff, 1999), through knowledge transformation by universities, the knowledge and technology transfer has been applied to economic activities, promoting knowledge flow, and transforming it into a source of technological innovation. Then, the market value of technology can be further realized through technology transfer so as to serve the society.

The object of university knowledge transfer is usually the enterprise. In the process of R&D cooperation with enterprises, the characteristics of researchers are more influential than that of research institutions (D Este & Patel, 2007), and the reputation of scientific research may also have a certain impact on the structure of KT (Elfenbein, 2007).

Through analysing the data from 141 universities in the United States, Chevalier, Allen, O'Shea & Roche, (2005) found that employee quality, R&D funding scale, funding science or technology trends, and business abilities all affect corporate derivatives, but with the maximum successful KT experience. In order to encourage researchers to commercialize research results, many colleges and universities have begun to set up knowledge transfer organizations (KTO) or technology transfer organizations (TTO), which will become the most effective way for universities and enterprises to transfer knowledge. Chapple, Lockett, Lockett & Siegel, (2005) found that the performance of each TTO vary greatly by evaluating the relative performance of the 122 University Technology Transfer Offices (TTO) in Britain. Arvanitis, Kubli & Martin, (2008) concluded that research institutions that focus on applied research, less teaching tasks, and cooperation experience with enterprises prefer to knowledge technology transfer (KTT).

With more emphasis on knowledge transfer in various universities, the number of school-enterprise cooperative research and development projects has increased, and the relevant KT research has gradually begun. Ziss (1994) first proposed a classic two-stage R&D bilateral game model for technology spillover. Sakakibara (2003) studied the KT system in cooperative R&D, and regarded knowledge resources as the source of income generated by enterprises; then, by measuring the KT cost and transferring income, a principal-agent model was established to accurately define the functional form of knowledge resources.

The role of innovation intermediary in knowledge transfer

The term “intermediary” can be traced back to the middlemen of the British agricultural and wool textile industry in the 16th and 18th centuries. At that time, the middlemen engaged in trade, were also important informal communicators of agriculture garment, and wool sorting improvement technologies (Howells, 2006). In the late 20th century, with the advent of knowledge economy era, innovation intermediary as an important part of the innovation system has attracted the attention of academic circles. Many scholars have defined it from different angles. Deck (2010) believes that the main role of innovation intermediaries in the commercial environment is to help companies solve product problems, and also find customers for developers. Winch (2007) emphasized on the promotion of innovation intermediaries. Howells (2006) defines innovation intermediaries as organizations or institutions that undertake the role of agency in the innovation process between two or more participants. In addition, Bendis, Seline & Byler, (2008) focuses more on the role of innovation intermediaries in resource integration, and believes that innovation intermediaries are at the centre of innovation, combining technology, capital and resources to promote technological innovation. Dalziel (2012) conceptually expands the scope of innovation intermediary activities, arguing that innovation intermediaries not only help to improve the innovation ability of one or more enterprises, but also promote the innovation ability of countries, regions or industries.

The knowledge transfer system consists of four parts: knowledge source, knowledge receptor, transferred knowledge and transferring context, and innovation intermediary is an important part of transferring context (Cummings & Teng, 2003). Successful technology transfer involves the absorption and digestion of new technology, and innovation intermediaries can bridge the management gap by changing the nature and scope of services and using technology policies (Bessant and Rush, 1995). Innovation intermediaries can accelerate the transaction of technology patent buyers and sellers by saving the evaluation cost of technical patent value, and promote technology dissemination and transfer (Ullberg, 2012). Through the case study of technology transfer in the UK's bio-industry, Shohet (2010) believes that the main role of innovation intermediaries is to formalize informal cooperation through contracts and permits etc., thereby strengthening cooperation and facilitating transfer. Hoppe (2005) taking the creation and use of inventions as an example, proposes that innovation intermediaries can provide efficient investment decisions, identify the profitability of inventions, and thus reduce the uncertainty of technology transactions. Ahsan (2015) based on the empirical research of the Bangladesh film industry, pointed out that the lack of effective innovation intermediary for the transfer of foreign digital technology is an important reason for the failure of the country's film industry technology transformation.

In summary, the innovation intermediary plays an extremely important role in promoting KT. Scholars have also conducted in-depth research on the its role orientation and functional role. However, as an important supply subject of KT, there is still lack of the research on the innovation decision-making strategies in the process of KT by combining the innovation intermediary with universities. Therefore, according to research literatures and the characteristics of innovation intermediaries, this paper constructs an innovation intermediary-based evolutionary game model of university KT, and obtains the evolutionary stability strategy through calculation. On this basis, it also analyses the strategy selection of each subject, and provides related suggestions on university KT.

Evolutionary game model of university knowledge transfer based on innovation intermediary

Evolutionary game theory originated from the theory of biological evolution and grew from the theory of behavioural ecology. It is a theory that combines game analysis (Barichard & Stéphan, 2017; Koriche, Lagrue, Piette, & Tabary, 2017; Sigmund & Nowak, 2001). Through the survival of the fittest, the behaviour of game participants will tend to certain stable strategy (ESS). In this paper, the evolutionary game theory was used to study the strategy selection of university knowledge transfer based on innovation intermediary, and analyse the factors affecting KT.

Model construction

The model hypothesises are as follows:

Hypothesis 1: Innovation intermediaries and universities cooperate to achieve resource sharing and knowledge appreciation. It is assumed that innovation intermediaries and universities as behaviour subjects are bounded rational, and make decisions that maximize their own interests under given conditions.

Hypothesis 2: The model involves two types of participants: innovation intermediary and university. In the dynamic game between the two, universities have two strategic choices: transferring knowledge and non-transferring knowledge; while the innovation intermediary also two choices: active cooperation and negative cooperation. Assuming that the probability of an active cooperative strategy in the innovative intermediary to be x, the probability of choosing a negative cooperative strategy is 1-x. Similarly, the probability that a university chooses to transfer knowledge through an innovation intermediary is y, and the probability of choosing not to transfer knowledge through an innovation intermediary is 1-y. It's given that $x, y \in [0, 1]$.

Hypothesis 3: It's assumed that r1 represents the revenue obtained by the positive cooperation of the innovation intermediary, r2 is the revenue by the negative cooperation of the innovation intermediary, and r1>r2; c1 is the cost of active cooperation strategy, c2 is the cost of negative cooperation for innovation intermediary, and c1>c2; α indicates the university's income from the transfer of knowledge under the active cooperation strategy of the innovation intermediary, while that under the negative cooperation strategy is zero; β is the university's cost of innovation intermediary services.

Hypothesis 4: U and V represent the benefits of innovation intermediaries and universities, respectively. U1 is the benefit of the innovative intermediary active cooperation strategy, and U2 is the benefit of the innovation intermediary negative cooperation strategy. V1 is the benefit of the university transfer knowledge, and V2 is the benefit of the university without transferring knowledge.

According to the game process analysis and model construction above, the evolutionary game payoff matrix of innovation intermediary and university KT can be obtained (Table 1):

Table 1
Payoff Matrix

Utility function		Universities	
		Transferring knowledge	Non-transferring knowledge
Innovation intermediary	Positive cooperation	r_1-c_1, α-β	-β, 0
	Negative cooperation	r_2-c_2, -β	-c_2, 0

Evolutionary game equilibrium analysis

According to the above payment/payoff matrix, for the two types of innovation intermediaries, namely the positive cooperation strategy and negative cooperation strategy, their expected income values U_1, U_2 and the average income value $\overline{U}$ are given as:

$$U_1=y(r_1-c_1)+(1-y)(-c_1)=yr_1-c_1 \quad (1)$$

$$U_2=y(r_2-c_2)+(1-y)(-c_2)=yr_2-c_2 \quad (2)$$

$$\overline{U}=xU_1+(1-x)U_2=xyr_1-xc_1+yr_2-c_2-xyr_2+xc_2 \quad (3)$$

Similarly, for the two types of games in which the university chooses to transfer knowledge and not transfer knowledge, the expected income values V_1 and V_2 and their average expected income value $\overline{V}$ are given as respectively:

$$V_1=x(\alpha-\beta)+(1-x)(-\beta)=x\alpha-\beta \quad (4)$$

$$V_2=0 \quad (5)$$

$$\overline{V}=yV1+(1-y)V_2=xy\alpha-y\beta \quad (6)$$

According to formulas (1) and (3), the replicator dynamic equation of the innovation intermediary is expressed as:

$$F(x)=\frac{dx}{dt}=x(U_1-\overline{U})=x(1-x)[(r_1-r_2)y-(c_1-c_2)] \quad (7)$$

According to formulas (4) and (6), the university's replicator dynamic equation is expressed as:

$$G(y)=\frac{dy}{dt}=y(V_1-\overline{V})=y(1-y)(x\alpha-\beta) \quad (8)$$

Let $F(x)=\frac{dx}{dt}=0$, then the critical value is calculated as: $x_1=0$, $x_2=1$, $y^*=\frac{c_1-c_2}{r_1-r_2}$. At this time, there is no difference in the positive and negative strategy selection for innovative intermediaries. Based on the replicator dynamic equation (7) of the innovation intermediary, it's concluded that at $y=\frac{c_1-c_2}{r_1-r_2}$, then $\frac{dx}{dt}=0$, and all $0\leq x\leq 1$ are stable; at $y\neq\frac{c_1-c_2}{r_1-r_2}$, $x_1=0$, $x_2=1$ are two stable states; at $y>\frac{c_1-c_2}{r_1-r_2}$时, $x_2=1$ is an evolutionary stable strategy; at $y<\frac{c_1-c_2}{r_1-r_2}$, $x_1=0$ is an evolutionary stable strategy.

Let $G(y)=\frac{dy}{dt}=0$, then the critical value is calculated as: $y_1=0$, $y_2=1$, $x^*=\frac{\beta}{\alpha}$. At this time, it makes no difference whether the university chooses to transfer knowledge or not transfer knowledge strategy. Based on the university's replicator dynamic equation (8), it's concluded that at $x=\frac{\beta}{\alpha}$, then $\frac{dx}{dt}$=0, and all $0 \le y \le 1$ is steady; at $x \neq \frac{\beta}{\alpha}$, then $y_1 = 0$, $y_2 = 1$ are two stable states; at $x > \frac{\beta}{\alpha}$, $y_2=1$ is an evolutionary stable strategy; at $x < \frac{\beta}{\alpha}$, $y_1 = 0$ is an evolutionary stable strategy.

Therefore, five partial equilibrium points for the behavioural game between the innovation intermediary and the university have been derived as: (0,0), (0,1), (1,0), (1,1), $(\frac{\beta}{\alpha}, \frac{c_1-c_2}{r_1-r_2})$.

Evolutionary equilibrium asymptotic stability analysis

The equilibrium point obtained by replicator dynamic equations is not necessarily the system's evolutionary stable strategy (ESS). According to Friedman's (1998) method, the ESS can be achieved by analysing the local stability of the Jacobian matrix. The Jacobian matrix can be expressed as:

$$J = \begin{bmatrix} \frac{dF(x)}{dx} & \frac{dF(x)}{dy} \\ \frac{dG(y)}{dx} & \frac{dG(y)}{dy} \end{bmatrix} = \begin{bmatrix} (1-2x)[(r_1-r_2)y-(c_1-c_2)] & (r_1-r_2)x(1-x) \\ (-\beta)y(1-y) & (1-2y)(x\alpha-\beta) \end{bmatrix}$$

The determinant and trace of the matrix J can be derived as:

$$\det J=(1-2x)[(r_1-r_2)y-(c_1-c_2)](1-2y)(x\alpha-\beta)-(r_1-r_2)x(1-x)(-\beta)y(1-y)$$

$$tr\ (1-2x)[(r_1-r_2)y-(c_1-c_2)]+(1-2y)(x\alpha-\beta)$$

Table 2
Stability Analysis of Local Equilibrium Points

Equilibrium points	|J|	Tr|J|	Results
(0,0)	+	−	ESS
(0,1)	+	+	Unstable
(1,0)	+	+	Unstable
(1,1)	+	−	ESS
(x*,y*)	−	0	Saddle point

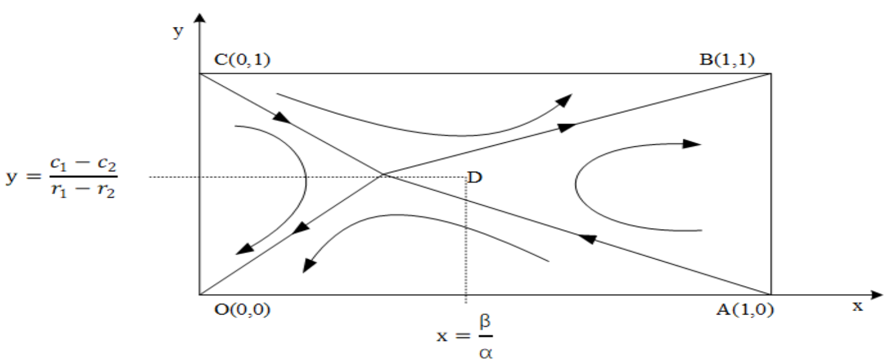

Figure 1. Dynamic evolution process of the system

For discrete dynamic systems, if and only if detJ>0 and trJ<0, the corresponding equilibrium point can be the evolutionary stable strategy. Thus, it depends on the size relationship between r_1-c_1 and r_2-c_2 and between α and β about whether the equilibrium point is an evolutionary stabilization strategy. However, due to x, y∈[0, 1], the constraint condition should be increased according to the actual situation, that is, at r_1-c_1>r_2-c_2, and α>β, only when the innovation intermediary and the university make KT, the benefits obtained by both parties are greater than the cost paid, both parties shall have the willingness to transfer knowledge. Table 2 lists the results of its evolution stable analysis.

Table 2 shows that A(1,0) and C(0,1) are unstable points, D(x*,y*) is the saddle point, and O(0,0) and B(1,1) are evolution equilibrium points. At this time, the system consists of two evolutionary stable strategies: (active cooperation, transfer of knowledge); (negative cooperation, no transfer of knowledge). The dynamic evolution process of the system that satisfies this condition is shown in Fig.1.

Analysis of evolutionary game results

According to Fig. 2, the evolutionary dynamic process of both sides in the game was analysed. The broken line connecting the saddle point D with the two unstable points of A and C is the critical line for the system evolution to different strategies. When the initial state of the system is in the upper right part of the broken line (ABCD), the system converges to the B(1,1) point, and the stability strategy combination at this time is (active cooperation, transfer knowledge). When the initial state of the system is in the lower left part of the line (AOCD), the system converges to the O(0,0) point, and the strategy combination at this time is (negative cooperation, no transfer of knowledge). The changes in the saddle point D(x*, y*) result in a change in the long-term evolution of the system, which is related to the position of the saddle point D(x*, y*). If the area of ABCD is larger than AOCD, the probability for choosing the strategy combination of active cooperation and transfer knowledge shall be higher; otherwise, the probability for the strategy of transfer knowledge shall be smaller.

Therefore, in the game process, the parameter variation of the revenue function on the two sides can cause the change of the saddle point D(x*, y*), resulting in the system converging to different equilibrium points.

Analysis of university knowledge transfer strategy selection based on innovation intermediary

Through analysis for the dynamic game evolution process of innovation intermediary and university knowledge transfer above, it's found that KT can only be achieved successfully when the revenues obtained by both innovation intermediary and the university are greater than the cost, i.e., r_1-c_1>r_2-c_2, and α>β. The local equilibrium points O and C are game stable points, and the corresponding strategies are (positive cooperation, transfer knowledge), (negative cooperation, no transfer of knowledge). Besides, the local equilibrium point D ($x^*=\frac{\beta}{\alpha}$, $y^*=\frac{c_1-c_2}{r_1-r_2}$) is the saddle point, which is the critical point of the game.

From Fig.1, the area of ADBC can be calculated as: $S=1-1/2\left(\frac{\beta}{\alpha}+\frac{c_1-c_2}{r_1-r_2}\right)$.

(1) For the knowledge transfer cooperation between Innovation intermediary and universities, there exist two strategy choices, namely the revenue of positive cooperation r_1 and that of negative cooperation r_2. The larger r_1-r_2 is, the greater the ADBC area is, and the higher the probability that the system converges to the C(1,1) point, that is, the final evolutionary equilibrium strategy of the system is (active cooperation, transfer knowledge). At this time, the KT activities of the university and the innovation intermediary can proceed smoothly, so as to promote the university's scientific and technological achievements and achieve its commercial value. Therefore, with the larger r_1 and the smaller r_2, it's more conductive to the KT activities of universities and innovation intermediaries.

(2) The greater the benefit α obtained by the active cooperation between the universities and innovation intermediary, the larger the ADBC area, and the higher the probability that the system converges to the point C(1,1), that is, the final evolutionary equilibrium strategy of the system is (active cooperation, transfer knowledge), and at this time, the KT activities of universities and innovation intermediaries can proceed smoothly. On the contrary, the smaller the α and ADBC area, the higher the probability that the system converges to the O(0,0) point, that is, the final evolutionary equilibrium strategy of the system is (negative cooperation, no transfer of knowledge), at this time, the KT between university and the innovation intermediary cannot go smoothly.

(3) In the KT activities, according to different strategies, the cost paid by innovation intermediaries is c_1, c_2, and the cost by the university is β. As β and c1-c2 increase more, the area of ADBC becomes smaller, and the probability that the system converges to the equilibrium point O(0, 0) is higher. Therefore, during the KT between the university and the innovation intermediary, the two parties can communicate with each other to reduce unnecessary human and material costs. Besides, the government can also consider covering part of the cost through subsidies, to encourage the smooth transfer of knowledge.

Conclusion

Based on the relevant research, this paper firstly affirms the positive role of innovation intermediaries in university knowledge transfer, and then constructs one innovation intermediary-based evolutionary game model of university KT using the evolutionary game analysis method. Finally, it obtains the evolutionary game equilibrium point between the innovation intermediary and the university in the process of KT, and by analysing the stability of the equilibrium point, achieves the evolutionary stable strategy. In the choice of analytical methods, taking the actual situation of university KT into consideration, the limited rationality of decision makers was introduced into this paper for further research, so as to draw more accurate conclusions, and further propose constructive and targeted countermeasures.

Through the use of evolutionary game model, the KT behaviour strategy between innovation intermediary and university was analysed to conclude that the cost and benefit of KT activities determine the evolution trend of university KT behaviour. In order to ensure the continuity and stability of KT activities between innovation intermediaries and universities, it can be carried out from the following aspects: strengthen the institutional construction of innovation intermediaries, improve the supervision and management system, and establish a standardized performance evaluation system; improve the KT and absorptive capacity of innovation intermediaries; clarify the functions of innovation intermediary, making it a bridge for KT and information communication between schools and enterprises; actively carry out value-added services, provide personalized services for the needs of university KT. Besides, the innovation intermediary can expand service partners to form regional KT service alliances, improve KT efficiency, reduce KT costs, encourage interaction among innovation intermediaries, and maximize the synergy of KT.

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