Technology Transfer Intermediary Mechanism Embedded in Collaborative Innovation System of Production and Research

Zhou HAN, Yuanjian QIN

School of Management, Wuhan University of Technology, Wuhan 430070, China

***Abstract* — In order to realize more reasonable technology intermediary mechanism in collaborative innovation of production and research, a game mechanism analysis method based on revenue is proposed. First, we study collaborative development and evolutionary game model to give expected gain by selecting vertical and parallel strategies during game process by enterprise and technology intermediaries. Second, we build prisoner's game model with technology adopting Fanghe technology intermediary service agency behavior, and use the above expected gain model to conduct stabilization analysis to determine the stable saddle point. Finally, we draw conclusions for meaningful guidance to practical management.**

Keywords - expected revenue; production and research; collaborative innovation; technology intermediary; game mechanism

I. INTRODUCTION

From production and research cooperation experience abroad, the production and research with technology intermediary participation has greatly improved the speed and quality of production and research. Establishment of technology intermediary organization may reduce investment risk for producing party, acquire more adequate information from researching party and promote effective transfer of technological achievements. However, their own unique characteristics of currently the only two types of technology intermediaries (profit-making technology intermediary and non-profit-making intermediary) have great influence on production and research cooperation to some extent. The Thesis conducts two rounds of game analysis on these two technology intermediaries, indicating profit-making technology intermediary gains popularity in partners on account of due diligence investigation by employees.

The difference between cooperative game and non-cooperative game lies in whether there is a binding agreement reached by parties at the time of behavior interaction among people. If there is, it can be called cooperative game. Cooperative game lays emphasis on collective rationality as well as efficiency, justice and fairness. The widely existing negotiation and contract signing in economic society indicate it is already known that cooperative game is the most effective. Therefore, only cooperative game can provide continuous and stable revenue for technology supplying party and technology intermediary. The premise of cooperative game is that both cooperative parties reach the contract to be followed by both game parties. Both parties of game shall follow in strict manner. In case one party breaches contract, though it may acquire some private revenue, it is at the price of breaching the cooperative game and even being irrationally revenged by the other party in the next round of game, thus impairing the revenue of its own eventually.

Therefore, a intermediary game mechanism analysis method for collaborative innovation system of production and research based on expected revenue is proposed to build prisoner's game model with technology from Fanghe technology intermediary service agency behavior, use the above expected gain model to conduct stabilization analysis of technology intermediary game mechanism of collaborative innovation system of production for guiding practical management.

II. COLLABORATIVE DEVELOPMENT AND EVOLUTIONARY GAME RESEARCH OF TECHNOLOGY INTERMEDIARY AND REGIONAL INNOVATION SUBJECT

TABLE 1. COLLABORATIVE GAME

Game form	Vertical	Parallel
Vertical	$(p_i - c_i, v_l - c_l)$	$\big(0.5(\lambda p - c), 0.5(v - c)\big)$
Parallel	$\big(0.5(p - c), 0.5(\lambda v - c)\big)$	$\big((p - c), (v - c)\big)$

Since enterprise is at the front line of market, it is still considered as the representative four regional innovation subjects to conduct a new round of game with technology intermediary to analyze how both of them will perform inter-level and inter-organization interaction in regional innovation system. According to direction of the activity, game strategy is simply described as vertical strategy and parallel strategy. Vertical strategy means to coordinate arrangement employees by organization from the top down and promote improvement and enhancement of system from the bottom up, laying emphasis on inter-level which is against inter-organization. Parallel means cooperation between organization and other organizations, such as forming technology alliance, laying emphasis on inter-organization, which means collaborative development between enterprise and technology intermediary. Collaborative game is shown in Table 1.

For the above game payments, they all meet $v > v_l, p > p_i$, with all revenue greater than the corresponding cost. In case one party adopts parallel strategy, it is considered the party acquires a half unilateral interest of cooperation with a half

cost paid. The other party acquires less than a half of interest even though a half cost is paid due to its negative attitude towards cooperation. Introduce parameter λ with $0<\lambda<1$, then the passive party acquires 0.5λ cooperative interest. According to seeking steps for evolutionary stable strategy, use x to represent the proportion of enterprise adopting vertical strategy and $1-x$ to represent the proportion of enterprise adopting parallel strategy; use y to represent the proportion of technology intermediary organization among the group adopting vertical strategy and $1-y$ to represent the proportion of technology intermediary organization adopting parallel strategy. Then the respective expected gain u_{E_1} of enterprise choosing vertical strategy during game process, the expected gain u_{E_2} by choosing parallel strategy and the average gain value of group are

$$u_{E_1} = y(v_l - c_l) + 0.5(1-y)(\lambda v - c) \tag{1}$$

$$u_{E_2} = 0.5y(v-c) + (1-y)(v-c) \tag{2}$$

$$\bar{u}_E = xu_{E_1} + (1-x)u_{E_2} \tag{3}$$

The respective expected gain u_{E_1} of technology intermediary organization choosing vertical strategy during game process, the expected gain u_{E_2} by choosing parallel strategy and the average gain value of group are:

$$u_{I_1} = x(p_i - c_i) + 0.5(1-x)(\lambda p - c) \tag{4}$$

$$u_{I_2} = 0.5x(p-c) + (1-x)(p-c) \tag{5}$$

$$\bar{u}_I = yu_{I_1} + (1-y)u_{I_2} \tag{6}$$

III. GAME MODEL ANALYSIS OF TECHNOLOGY INTERMEDIARY SERVICE AGENCY BEHAVIOR

A. Model Assumption

We will build a prisoner' dilemma, namely a game model with technology adopting Fanghe technology intermediary service agency behavior. During the analysis, we will not study how technology adopting Fanghe technology intermediary service agency behavior is affected by all the influence factors. We only study the probability by which they adopt different behaviors and the results brought to them. So assumptions are made as follows:

(1) The probability for technology adopting party to choose betrayal is p, then obviously the cooperation probability is $1-p$. The probability for technology intermediary service agency to choose betrayal is q and the probability for technology intermediary service agency to choose cooperation is $1-q$.

(2) The revenue of choosing cooperation by both parties is r and that of choosing betrayal is $1-r$.

(3) It is rational to consider revenue from common cooperation is the highest and revenue from common betrayal is the lowest.

(4) Distribution proportion of technology adopting party is α; the proportion of technology intermediary service agency is $1-\alpha$; and revenue proportions of technology intermediary service agency and technology supplying party are β and $1-\beta$ respectively.

Based on the assumption, strategy choices and revenue of technology adopting party and technology intermediary service agency and revenue of technology supplying party are shown in Table 3.

B. Stabilization Analysis of Game Model

Apply replicated dynamic equation to two groups participating in the game respectively, then the replicated dynamic equation of type proportion of game parties of enterprise is:

$$\begin{aligned}\frac{dx}{dt} &= x\left(u_{E_1} - \bar{u}_E\right) = x(1-x)[y(v_l - c_l) + 0.5(1-y)(\lambda \mathrm{v} - \mathrm{c}) \\ &\quad -[0.5y(v-c) + (1-y)(v-c)]\end{aligned} \tag{7}$$

According to equation (7), $x=0.1$ or $y=\dfrac{(1-0.5\lambda)v-0.5c}{(v_l-c_l)+v-0.5v(1+\lambda)}$ is stable strategy for enterprise participation in the game, then the replicated dynamic equation of type proportion of game parties of technology intermediary organization is:

$$\begin{aligned}\frac{dy}{dt} &= y\left(u_{I_1} - \bar{u}_I\right) = y(1-y)[y(p_i - c_i) + 0.5(1-x)(\lambda p - c) \\ &\quad -[0.5x(p-c) + (1-x)(p-c)]\end{aligned} \tag{8}$$

According to (8), $y=0.1$ or $x=\dfrac{(1-0.5\lambda)p-0.5c}{(p_i-c_i)+p-0.5p(1+\lambda)}$ is stable strategy for technology intermediary organization participation in the game. By analyzing stability of its equilibrium point by local stability of jacobian matrix of evolution system, the jacobian matrix of the system composed of equation (7) and equation (8) is:

$$J\begin{pmatrix}(1-2x)[[(v_l-c_l)+v-0.5v(1+\lambda)]y & x(1-x)[(v_l-c_l)+v-0.5v(1+\lambda)] \\ -[(1-0.5\lambda)v-0.5c]] & \\ y(1-y)[(p_i-c_i)+p-0.5p(1+\lambda)] & (1-2y)[(p_i-c_i)+p-0.5p(1+\lambda)]x \\ & -[(1-0.5\lambda)p-0.5c]\end{pmatrix} \tag{9}$$

According to analysis by replicated dynamic equation:

$$0<\frac{(1-0.5\lambda)v-0.5c}{(p_i-c_i)+p-0.5p(1+\lambda)}<1 \tag{10}$$

$$0<\frac{(1-0.5\lambda)v-0.5c}{(v_l,-c_l)+v-0.5v(1+\lambda)}<1 \tag{11}$$

In case the above equations (10)-(11) are workable, equilibrium points of the system are five point, namely $(0,0),(0,1),(1,0),(1,1)$ and $\left(\frac{(1-0.5\lambda)v-0.5c}{(p_i-c_i)+p-0.5p(1+\lambda)},\frac{(1-0.5\lambda)v-0.5c}{(v_l,-c_l)+v-0.5v(1+\lambda)}\right)$.

According to analysis result, $x=0,y=0$ and $x=1,y=1$ are the two evolutionary stable strategies. The former corresponds to the situation where both technology intermediary organization and enterprise adopts parallel strategy and the latter corresponds to the situation where both technology intermediary organization and enterprise adopts vertical strategy. In addition to the two points corresponding to evolutionary stable strategy within values area of x and y, there are three other special points, inducing two unstable points of $A(0,1)$, $B(1,0)$ and a saddle point:

$$C\left(\frac{(1-0.5\lambda)v-0.5c}{(p_i-c_i)+p-0.5p(1+\lambda)},\frac{(1-0.5\lambda)v-0.5c}{(v_l,-c_l)+v-0.5v(1+\lambda)}\right) \quad (12)$$

The groups participating in game have two different differentiation tendencies, evolving towards two different evolutionary stable strategies. The broken line ACB by connecting the above two points divide the evolution region into two regions containing one evolutionary stable strategy respectively, shown in table 1.

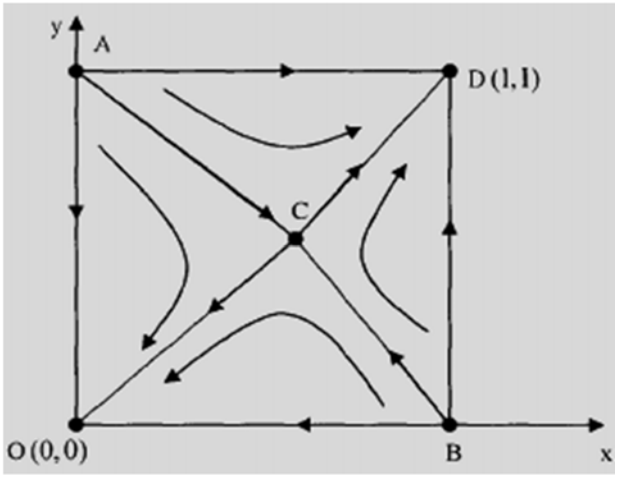

Figure 1. The dynamic evolution of the system

In the top right region of ACB, it converges to evolution stable strategy (1,1), which means both enterprise and technology intermediary organization choose vertical strategy while in the bottom left region, it converges to evolution stable strategy (0,0), which means both enterprise and technology intermediary organization choose evolution stable strategy in parallel strategy. As the boundary of two different evolution tendencies, the points on ACB can not be determined with possibility to develop towards both directions. To realize evolutionary stable strategy requires long-term evolution. Game research objects will adopt vertical and parallel strategies simultaneously in the long term, that is, to conduct organic combination between inter-level development and inter-organization contact.

IV. GAME CONCLUSION

According to the above analysis, whether to apply profit-making technology intermediary to production and research cooperation mainly depends on the balance and comparison between expected revenue of production and research cooperation after producing party conducts independent communication and revenue from profit-making technology intermediary. In case the expected revenue of production and research cooperation after producing party conducts independent communication is higher, producing party will communicate on its own rather than with the help of profit-making technology intermediary; in case revenue from production and research cooperation by profit-making technology intermediary is higher, producing party will make use of the sufficient information provided by profit-making technology intermediary to improve expected revenue of production and research cooperation, even with high information expense. The game analysis of production and research cooperation by non-profit-making technology intermediary by producing party is similar to the method of making use of profit-making technology intermediary by producing party, except for the information expense payment which is not required to be paid by producing party to non-profit-making technology intermediary for production and research cooperation. However, producing party may undertake the loss caused by non-due diligence investigation made by intermediary, which is not further stated here.

Therefore, during third party cooperation, the best behavior of technology intermediary service agency, technology adopting party and supplying party is to stick to their duty and maintain common interest. While in case of information asymmetry, for technology supplying party, its revenue mainly depends on cooperation condition between technology adopting apart and technology intermediary service agency. In order to protect interest of technology supplying party, it may investigate history record of related technology intermediary service agency to conduct due diligence investigation for technology intermediary service agency, understand its honesty and capacity to reduce information asymmetry. For technology adopting party, item with greater cooperative revenue utility than cooperative cost utility shall be adopted to fully ensure technology adoption party to be free from interest impairment. For technology intermediary, it shall shoulder the mission of maintaining social interest while pursing economic interest. Technology intermediary shall maintain common interest of the three parties by seeking for proper technology adopting party and develop it to promote three parties' cooperation.

V. CONCLUSIONS

A technology intermediary game mechanism analysis method for collaborative innovation system of production and research based on revenue is proposed to study collaborative development and evolutionary game model of technology intermediary organization and regional

innovative subject. Build prisoner's game model with technology from Fanghe technology intermediary service agency behavior. Finally, based on the game model built, discuss technology intermediary game model of collaborative innovation system of production and research and give rationalization proposal to maintain multilateral interest.

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