A Game Analysis of Technology Transfer

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Abstract Technology transformation is the only way to turn science and technology into the production. It can be divided into three modes: technology transfer, technology cooperation and spin-offs company. By building a game tree of technology transfer under the asymmetric information condition, the paper shows the results of different strategies combination and makes a comparison of price ranges under two conditions, and finds the buyer's price strategy is related to $P(T_h|P_h)$, so as to provide a new point of viewing technology transfer.

Key words Asymmetric information; Technology transfer; Game; Asymmetric information

1 Introduction

Technology transformation is a movement in which technology shifts from research institutes and universities to businesses and other organizations, and shapes from knowledge to material form, it can significantly improves the production efficiency and promotes the development of society. So many studies have been made on this topic, including mechanisms, policies, performances evaluation and technology transformation modes. Brain Harmon et al (1995) divided the university technology transformation into five types; Henry Etzkowit (1998) believed that university technology transformation has 3 ways according to the university's participation. In general, it is considered that there are 3 modes according to the relationship between the suppliers and demanders in the transformation process, which are technology transfer, technology cooperation and spin-offs company.

There have been a lot of theoretical and empirical researches about technology transfer. In recent years, game theory is applied to the researches of technology transfer to make qualitative and quantitative analysis and establish game models. Ye Xiaoqing et al (2003) made game analysis on the information asymmetry issues in the cooperation of university and enterprise, and gave interpretations of the adverse selection in technology transfer. Hu Junfeng applied game theory into the analysis of government conducts, and believed that the government's duty in technology transfer was building a good system environment which was conducive for technology transfer. Liu Bin et al (2001) believed that information asymmetry was widespread in society, and technology transformation was a typical game process. By analyzing the technology transformation of Chinese Academy of Science, he supposed that technology transformation was a multi-party game process, in which the information of suppliers and demanders was asymmetric.

In this paper, we will specially make a game analysis on technology transfer under asymmetric information condition, by which to reveal the strategy choices of buyers and sellers and the requirements of transfer. In this process, research institutions, universities and other technology suppliers transfer or license the technology to enterprises and other demanders with price as a return. Suppliers complete the laboratory stage independently and demanders finish commercialization stages alone, their relationship ends almost after the business, except some necessary technical support and service sometimes.

2 Asymmetric Information Problem in Technology Transfer

Under the asymmetric information conditions, the participant who is in information superiority is called "client", the participant who is in information disadvantage is called "client". Technology transfer is a process in which technology, capital, equipments, labours, management and other elements are regrouped, so the suppliers and demanders "principal - agent" relationship is not fixed. From "owning information of technology" point of view, suppliers can be seen as principals and demanders can be seen as agents; from "owning information of market and management" perspective, suppliers can be seen as agents and demanders can be considered as principals.

If the information asymmetry exists before the transaction, the game process between the suppliers and demanders is called adverse selection model; otherwise, it is called moral hazard model. For the suppliers and demanders relationship ends after one technology transfer, so the game analysis on technology transfer is adverse selection model. In the first case above, demanders are difficult to distinguish between high value and low value technology, so large number of low value technology may flood the market while the high one becomes less and less, that is the bad one drives out the good one; in

the second case, because suppliers are difficult to accurately assess the market value of the technology due to lack of business knowledge, they are cautious in selling.

3 A Game Model of Technology Transfer

The main asymmetric information in technology transfer is the value of the achievements, so we will analyze the influence of this information to transfer.

3.1 Construction of game parameters

(1) There are two participants in technology transfer: seller and buyer. N = (1,2) means the player set, 1 is on behalf of the seller (supplier) and 2 is the buyers (demander). The seller-self has a certain production capabilities and can turn knowledge achievements into business.

(2) Technology has two types: high value and low value. T_h is on behalf of the high value, T_l is the low value. The expected profit of high value and low value achievements is R_h and R_l, and $R_l <$ R_h .

(3) The seller has two price strategies: high price and low price, which is separately expressed by P_h and P_l. When $P = P_h$, there is $T = T_l$ or $T = T_h$; when $P = P_l$, there is $T = T_l$. That is to say, the technology achievements must be low value if the seller's price is P_l; otherwise, the buyer is uncertain for its type if the seller's price is P_h.

(4) Although the buyer can not know exactly the values of T, but they are aware of the following probability distribution of the values.

$P(T_h|P_h) = p$， $P(T_l|P_h) = 1\text{-}p$, that means the probability of high value is p and low value is $1-p$, when the seller's price is P_h.

$P(T_l|P_l) = 1$, $P(T_h|P_l) = 0$, that means the probability of high value is 0 and that of low value is 1, when the seller' price is P_l. In other words, seller will never sell the high value technology with a low price.

(5)There are two strategy choices for seller: transfer or not transfer. The second choice means choosing spin-offs company and the profits of seller in this mode are $R_h^{'}$ and $R_l^{'}$（$R_h^{'} > R_l^{'}$）, which is decided by the value of technology. Facing the seller's transfer choice, the buyer has two options: accept or reject. In the second cases, seller takes spin-offs company mode, buyer produces using original technology and has an expected profit of R_0, and $R_0 < R_l <$ R_h.

(6) Assuming that the cost of R&D and technology transfer is zero.

3.2 Game tree

By establishing game tree, we can show the income portfolios in different strategies combinations as following figure 1 shows.

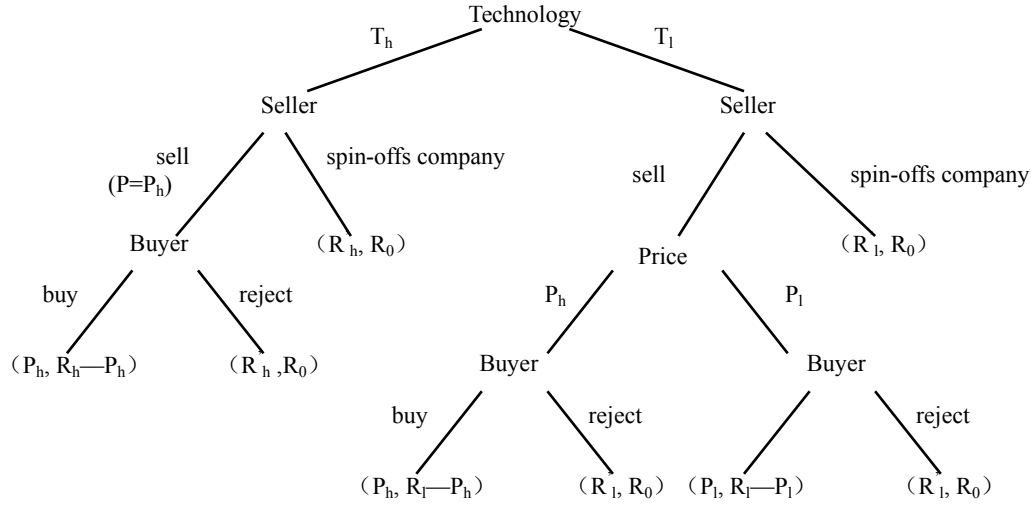

Figure 1 Game Tree of Technology Transfer

1) The technology is of high value and buyer's price must be P_h. Because of asymmetric information, buyer cannot know exactly the true value of technology and can only expect his profits according to probability distribution of the value.

When the buyer considers that the technology is of high value, his expected profit from purchase is $R_h - P_h$. When the buyer considers that the technology is of low value, his expected profit from purchase is $R_l - P_l$.

As we have known $P(T_h|P_h) = p$, $P(T_l|P_h) = 1\text{-}p$; $P(T_l|P_l) = 1$, $P(T_h|P_l) = 0$.

Based on these assumptions and profits, we can get that buyer's expected profit at a price of P_h is $E_2^h = P(T_h|P_h)(R_h - P_h) + P(T_l|P_h)(R_l - P_h) = p(R_h - R_l) - (P_h - R_l)$, and seller's expected profit is $E_1^h = P_h$. Next, we continue to analyze the requirement of transfer.

When $E_1^h = P_h > R_h^{'}$, seller will choose transfer instead of spin-offs company. When $E_2^h = p(R_h - R_l) - (P_h - R_l) > \mathrm{R}_0$ which also is $P_h < p(R_h - R_l) + R_l - R_0$, buyer will choose to buy.

So, when there is $R_h^{'} < P_h < p(R_h - R_l) + R_l - R_0$, the technology transfers successfully. That is to say, at the price of P_h , the range of transfer equilibrium price is $P_h \in (R_h^{'}, p(R_h - R_l) + R_l - R_0)$ when the technology is of high value.

On the condition of symmetric information, when the technology is of high value, the range of transfer equilibrium price is $P_h \in (R_h^{'}, R_h - R_0)$. (According to author's analysis at other places, which is omitted here)

Make a comparison between the two price ranges under different information conditions, we will find that their lower limits are equal and there are $p(R_h - R_l) + R_l - R_0 < R_h - R_0$ between their upper limits.

2) The technology is of low value and buyer's price is P_h . Buyer can only expect his profits according to probability distribution of the value.

When the buyer considers that the technology is of high value, his expected profit from purchase is $R_h - P_h$. When the buyer considers that the technology is of low value, his expected profit from purchase is $R_l - P_h$.

Based on these assumptions and profits, we can get that the buyer's expected profit at a price of P_h is $E_2^h = P(T_h|P_h)(R_h - P_h) + P(T_l|P_h)(R_l - P_h) = p(R_h - R_l) - (P_h - R_l)$, and the seller's expected profit is $E_1^h = P_h$.

The analysis is the same as (1), we can get that buyer's expected profit at a price of P_h is $E_2^h = P(T_h|P_h)(R_h - P_h) + P(T_l|P_h)(R_l - P_h) = p(R_h - R_l) - (P_h - R_l)$, while the buyer's expect profit is $E_1^h = P_h$.

Next, we continue to analyze the requirement of transfer.

When $E_1^h = P_h > R_l^{'}$, the seller will choose transfer instead of spin-offs company.

When $E_2^h = p(R_h - R_l) - (P_h - R_l) > R_0$ which also is $P_h < p(R_h - R_l) + R_l - R_0$, buyer will choose to buy。

So, when there is $R_l^{'} < P_h < p(R_h - R_l) + R_l - R_0$, the technology transfers successfully. That is to say, at the price of $\mathrm{P_h}$, the range of transfer equilibrium price is $P_h \in (R_l^{'}, p(R_h - R_l) + R_l - R_0)$ when the technology is of low value.

On the condition of symmetric information, when the technology is of low value, the range of transfer equilibrium price is $P_l \in (R_l^{'}, R_h - R_0)$. (According to author's analysis at other places, which is omitted here.)

Make a comparison between the two price ranges under different information conditions, we will

find that their lower limits are equal and there are $p(R_h - R_l) + R_l - R_0 > R_l - R_0$ between their upper limits.

3) Since the seller will never sell the high value technology at price of P_l, so the buyer's expected benefit of the technology at P_l is: $E_2^l = P(T_l|P_l)(R_l - P_l) = R_l - P_l$.

As we have known, the buyer's expected profit of technology at a price of P_h is: $E_2^h = P(T_h|P_h)(R_h - P_h) + P(T_l|P_h)(R_l - P_h) = p(R_h - R_l) - (P_h - R_l)$.

Put E_2^h and E_2^l into the formula $E_2^h > E_2^l$, we can get $p > \dfrac{P_h - P_l}{R_h - R_l}$.

It means when there is $p > \dfrac{P_h - P_l}{R_h - R_l}$, the buyer's expected profit at a price of P_h is greater than that at a price of P_l and then the buyer is willing to pay a high price for the technology; In turn, when there is $p < \dfrac{P_h - P_l}{R_h - R_l}$, the buyer's expected profit at a price of P_l is greater than that at a price of P_h, then the buyer is willing to pay a low price for the technology. So we can get that the buyer's price strategy is related to $P(T_h|P_h)$.

4 Conclusion

From the comparison of prices on condition (1) and (2), we get such results as following: Firstly, asymmetric information influences the price range of transfer, it lowers the transfer price when the technology is of high value which is not benefit for seller and raises the transfer price when the technology is of low value, which is not benefit for the buyer. So, high value technology will gradually withdraw from the market and low value technology will be more and more, this phenomenon is called "adverse selection" which means an expulsion of low-quality products to high-value products. Secondly, the buyer's price strategy is closely related to $P(T_h|P_h)$ which will change the expected profits at the price of P_l and P_h. So how to raise the buyer's expected probability of T_h is important to technology transfer, it influences the technology markets scale and then its R & D by affecting the buyer's willing pay.

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