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Game Analysis on Economic Risks of Lack of Innovation in Industrial Transferring Regions

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Abstract: By using the model of game analysis, we find it is necessary for government to inject certain subsidies in the enterprise technology innovation in the industrial transferring regions. However, because of the information asymmetry, it is difficult to find the right subsidy strength for the governments in practice. After further analysis of subsidies incentive efficiency, the paper tries to put forward some policy recommendations to promote enterprise innovation and to reduce the economic risk.

Keywords: lack of innovation, industrial transferring regions, economic risks, game analysis

1. INTRODUCTION

It has become an indisputable fact that the industrial upgrading is fatigue in China's relative developed regions where is also industry-transferring regions. The paper transfer government intervention into concrete government subsidies, trying to find the specific reason for the lack of technical innovation in those enterprises which have received the financial support from local government, which finally leads to the weakness of industrial upgrading in those relatively developed regions.

There are two problems when the government give indirect or indirect subsidies to enterprises to excite the technological innovation: one is how to determine the subsidies strength for the technological innovation. Too much government subsidies will lead to the great finacial pressure, while insufficient subsidies can not to form an effective incentive to the enterprise. The other one is the efficiency of the resource allocation of the government subsidy. Because the process of technological innovation includes all aspects of R&D, trial production, production, marketing, diffusion, one policy measures may have a greater incentive to certain link while the other parts is not obvious. In addition, when the government encourage the enterprises to increase investment in a link , the enterprises will weaken invest in other sectors. We will explain the process and reasons by using game model.

2. ANALYSIS ON THE STRENGTH OF GOVERNMENT SUBSIDIES

According to the principal-agent theory, it is a function relationship between the principal and agent. The principal goal is to choose a rule which can bring him the maximum expected utility in the following two conditions: one, it is a voluntary act to sign a contract. The client must ensure that the agent is willing to accept the contract. The other, the agent will select actions that should be the best for him under this contract once he signs it, that is, in his chosen action the agents marginal revenue should equal the marginal cost. Therefore, to satisfy the above two conditions and to bring the client maximum expected utility, the contract has to be designed to let the agent bear part of the risk results of uncertainty and get the corresponding compensation so that the agents have enough incentives to take actions which will also favor the principal. Holmstrom and Milgrom have proved that the linear contract can achieve optimal. Therefore, we can design the incentive model as follows:

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$$\max EV = \int V(\lambda - A(\lambda)) f(\lambda, \pi) d\lambda$$

s.t. $$(\mathrm{IR}) \int U(A(\lambda)) f(\lambda, \pi) d\lambda - c(\pi) \geq \overline{U}$$

$$(\mathrm{IC}) \int U(A(\lambda)) f(\lambda, \pi) d\lambda - c(\pi) \geq \int U(A(\lambda)) f(\lambda, \pi') d\lambda - c(\pi') \quad \forall \pi' \in M$$

H 1: Since the government inject subsidies in enterprise technology innovation in two ways, including direct and indirect subsidies subsidies, the government can design a linear incentive contract: $s(\lambda) = \alpha + \beta\lambda$

Type: α for direct government investment, β for the ratio of tax preference given by government on the basis of technological innovation profit size, λ for the output of the technological innovation.

H 2: The level of enterprise technology innovation efforts is directly related to the profit of technology innovation. So assuming that margins and the degree of effort has a linear relation: $\lambda = a\pi + \theta$

Type: π for the effort of enterprise innovation, which is integrated determined by the enterprises using internal, external resources and the input of innovation. Parameter a for a conversion constant between level of effort π and the actual income of the enterprise, which comes from expert evaluation or the empirical data. θ for the normal distribution random variables with zero mean and σ variance, which express uncertainty of external factors, such as market uncertainty etc. Therefore $E(\lambda = a\pi), \mathrm{Var}(\lambda) = \sigma^2$

That is, the effort of enterprise determines the expected profit, but can not change the external uncertainty.

H 3: The government is risk neutral, the enterprise is risk averse, the utility function of the government is equal to its expected income:

$$E[V(\lambda - A(\lambda))] = E(\lambda - \alpha - \beta\lambda) = -\alpha + (1 - \beta)E(\lambda) = -\alpha + (1 - \beta)a\pi$$

H 4: The enterprise's utility function has the invariant characteristics of avoiding risk, i.e. $U = -e^{-rm}$, r for a measure of the degree of absolute risk aversion, m for the enterprise's actual monetary income.

Proposition 1: When the enterprise innovation effort π is observable, preferential policies that the government give the enterprise are independent of the innovation output of the enterprises.

Proof: When the enterprise innovation effort is observable, any effort level π can realize by meeting participation constraint (IR) of the compulsory contract. Therefore, the government's problem is to choose (α, β) and to optimize π:

$$\max_{\alpha,\beta,\pi} E[V(\lambda - A[\lambda])] = -\alpha + (1 - \beta)a\pi$$

s.t. $$(\mathrm{IR})\alpha + \beta a\pi - 1/2r\beta^2\sigma^2 - 1/2b\pi^2 \geq \overline{k}$$

Because enterprise effort levels can be observed, the government need not give enterprises more preferential policies, so in the best case, constraint equation is set up, so

$$\max_{\alpha,\beta,\pi}\left(a\pi - 1/2r\beta^2\sigma^2 - 1/2b\pi^2 - \overline{k}\right)$$

Because $\overline{k}$ is given, the type said the government actually reduce the incentive cost of enterprise technology innovation. From the first-order condition optimization, we have $\pi^* = a/b \quad \beta^* = 0$, then substitute into the constraints, we can obtain:

$$A^*(\lambda) = a^* + \beta^*\lambda = \overline{k} + a^2/2b = \overline{k} + 1/2b\pi^2$$

This is the optimal incentive policy, which realizes the Pareto optimal risk sharing, namely, in the conditions of principal risk neutral and the agent risk aversion $\beta^* = 0$, namely, the government incentive payment is independent of the innovation output of the enterprise, which is just equal to the retained earnings and the cost of effort.

Proposition 2: When the enterprise innovation effort can not be observed, the optimal government policies is to let the enterprise take certain level of risks when it obtain the government preferential policies.

Proof: When the level of effort can not be observed, the agent's incentive compatibility constraint (IC) is to work, because no matter how the agent place rewards and punishment on the principal, the agent will choose a certain action to maximize their own utility level, i.e. the principal can not use 'force contract' to force the agent do what the principal want, but can let the agent choose an expected action way of an incentive contract. So the principal objective is to establish an incentive contract which realize the compatibility between the participation constraint and the compatibility constraint of the agent so as to realize the maximization of expected utility function. Because the marginal cost is equal to marginal revenue principle of the enterprise, the incentive compatibility constraint of the enterprise means $\pi = a\beta / b$, so the problem evolute into:

$$\max_{\alpha,\beta,\pi} E[V(\lambda - A[\lambda])] = -\alpha + (1-\beta)\pi$$

s.t. $(\mathrm{IR})\alpha + \beta a\pi - 1/2r\beta^2\sigma^2 - 1/2b\pi^2 \geq \bar{k}$

$$(\mathrm{IC})\pi = a\beta / b$$

Therefore, the optimum conditions for $a^2 / b - r\beta\sigma^2 - a^2\beta / b = 0$. The solution is

$$\beta = a^2 / \left(a^2 + br\sigma^2\right) > 0$$

This shows that, when the enterprise innovation effort level can not be observed, the government should take indirect incentives. Enterprises enjoy the preferential tax rate β to r, σ^2, b is a decreasing function. The enterprise more risk averse, variance profit is more big, which causes the enterprise to be the more afraid of hard work, so the enterprise should bear less risk. This shows that the enterprise must assume certain risks at the same time it enjoys the benefits of tax incentives in technology innovation. In particular, if the enterprise is risk neutral, $r = 0$, then the optimal incentive mode is that the enterprise take all the risk, i.e. $\beta = 1$.

Proposition 3: In the asymmetrical information condition, when the agent is risk aversion, agency costs will rise with the increase of enterprise risk aversion and the increase of the variance of the natural state, but agency costs will decrease with the increase of enterprise innovation effort cost.

Proof: In general, if the government can not observe the efforts of enterprises, there are two kinds of agency cost which can't be found under symmetric information. One is that risk sharing can't achieve the risk cost in the Pareto optimal requirements. The other is the saving of net profit of loss minus the effort cost. This saving is called incentive cost in the information economics. Because the government is risk neutral, so when the level of effort can be observed, the government assumes all risk, which means the risk cost is zero. On the contrary, enterprise risk cost is the net loss of its welfare. It can be expressed as follows:

$$\Delta RC = 1/2r\beta^2\sigma^2 = ra\sigma / 2\left(a^2 + br\sigma^2\right)^2 > 0$$

Due to the expected profit $E(\lambda = a\pi)$, expected net loss of the enterprise will be

$$\Delta E(\lambda) = \Delta a\pi = a\left(\pi^* - \pi\right) = a^2 / b - a^4 / \left(b\left(a^2 + br\sigma^2\right)\right) = a^2 r\sigma^2 / \left(a^2 + br\sigma^2\right)$$

The save of the effort cost will be

$$\Delta C = c\left(\pi^*\right) - c(\pi) = a^2 / 2b - a^4 / 2b\left(a^2 + br\sigma^2\right) = 2a^4 r\sigma^2 + br^2a^2\sigma^4 / 2\left(a^2 + br\sigma^2\right)^2$$

The incentive cost will be

$$IC = \Delta E(\lambda) - \Delta C = 2br^2a^2\sigma^4 / 2\left(a^2 + br\sigma^2\right)^2$$

Then the total cost will be

$$AC = \Delta RC + \left[\Delta E(\lambda) - \Delta C\right] = ra^2\sigma^2 / 2\left(a^2 + br\sigma^2\right) > 0$$

Thus we can get the following conclusions:

The agency cost will reduce government subsidies utility. In the information asymmetry, it is very difficult for the government to control the effort of the innovation enterprise, which will increase the new agency cost. Based on this understanding, we can draw a conclusion about the cause of ecnomic risk in the industrial transferring regions:

The cause of economic risk: it is necessary for the government to inject subsidies in the enterprise undergoing technology innovation. However, because of the information asymmetry, it is difficult to find the right strength of subsidies in practice, and both inadequacy and excess won't be conducive to technology innovation of the enterprise.

In reality, the more intense the government look forward to enterprise technological innovation, the greater subsidy the enterprise will be received. When in the asymmetric information environment, the optimal policy of the government is to allow enterprises to assume certain risks. Discount rate β that the enterprises enjoy is a decreasing function for r. The greater degree of risk aversion, the smaller risks they should bear. Because of the information asymmetry, it is a very difficult thing for the government to grasp r or the effort of the enterprise, which means more cost for the government who should pay. As a rational economic person, the enterprise often try various ways to strive for the excess of government subsidies, which not only increase the pressure on government finances but also reduce the power of innovation of enterprises, resulting in inadequate enterprise innovation after government massive investment. So it is difficult to achieve industrial upgrading.

3. ANALYSIS ON THE INCENTIVE EFFICIENCY OF GOVERNMENT SUBSIDIES

In reality, the agent is often engaged in more than one job , and even one job is always involved in many dimensions. Then it is hard for the agent to decide how to allocate energy in different jobs, and for the client it is also a problem to implement the incentive. Technology innovation is a continuous process composed of multi links. Because technological innovation is a system in space and is a process in time which is a spatio-temporal continuous system consisting of design, research and development, mass production and commercialization. Now governments subsidy policy almost covered every link the innovation activities in many countries. But method used and intensity of the intervention are not the same in each link of the innovation process. The government should choose certain incentive mode and intensity subsidy policy according to the relationship between nodes of innovation. For the convenience of analysis, here we only select two key activities in the innovation chain, and simplify the innovation process as two activities: R&D and commercialization.

Assume the enterprise is engaged in the two innovation activities: R&D and commercialization, then facing two innovation activities of different correlation degree. The government optimal design of incentive model is:

$$\max EV = B(\pi_1, \pi_2) - E[A(\lambda)] = B(\pi_1, \pi_2) - \alpha - \beta^T U(\pi_1, \pi_2)$$

s.t. $$(\mathrm{IR})\alpha + \beta^T U(\pi_1, \pi_2) - 1/2r\beta^T \sum \beta - C(\pi_1, \pi_2) \geq \bar{k}$$

$$(\mathrm{IC})(\pi_1, \pi_2) \in \arg \beta^T U(\pi_1, \pi_2) - C(\pi_1, \pi_2)$$

H 1: A firm is engaged in only two innovation activities. $\pi = (\pi_1, \pi_2)$ π is for the effort vector of a innovation enterprise. π_1 is for the enterprise effort in the commercialization link, π_2 is spent on R&D efforts.

The two innovation of a enterprise can decide the information vector observed below:

$$\lambda = \mu(\pi_1, \pi_2) + \theta$$

θ is to obey the normal random vectors with zero mean and E covariance matrix.

H2: Assume $\mu(\pi_1, \pi_2) = (\pi_1, \pi_2)^T$, here λ 1 for the profit of innovation, λ 2 for the results number of R&D. When θ 1and θ 2 is related, λ 1 and λ 2 is also related.

H3: The government (the principal) is risk neutral, while the enterprise (the agent) is risk aversion and has a utility function of constant absolute risk aversion. Effort cost is strictly increasing convex function. The government will design the compensation contract:

$$A(\lambda) = \alpha + \beta_1\lambda_1 + \beta_2\lambda_2 = \alpha + \beta^T \pi \text{，Among them } \beta^T = (\beta_1, \beta_2)$$

H4: $B(\pi_1, \pi_2)$ represents an effort to expected income, and is strictly increasing concave function. So the certainty equivalent income of the enterprise is:

$$CE = A(\lambda) - 1/2r\beta^T \sum \beta - C(\pi_1, \pi_2) = \alpha + \beta^T \mu(\pi_1, \pi_2) - 1/2r\beta^T \sum \beta - C(\pi_1, \pi_2)$$

R for the measure of absolute risk, $\beta^T \sum \beta$ for income variance, $1/2r\beta^T \sum \beta$ for risk cost.

So the government expected profit is:

$$B(\pi_1, \pi_2) - E[A(\lambda)] = B(\pi_1, \pi_2) - \alpha + \beta^T \mu(\pi_1, \rho_2)$$

Thus incentive model of the government's is:

$$\max E(V) = B(\pi_1, \pi_2) - E[A(\lambda)] = B(\pi_1, \pi_2) - \alpha - \beta^T \mu(\pi_1, \pi_2)$$

s.t. $$(\mathrm{IR})\alpha + \beta^T \mu(\pi_1, \pi_2) - 1/2r\beta^T \sum \beta - C(\pi_1, \pi_2) \geq \bar{k}$$

$$(\mathrm{IC})(\pi_1, \pi_2) \in \arg\max \beta^T \mu(\pi_1, \pi_2) - C(\pi_1, \pi_2)$$

Proposition 1: If the cost function of two kinds of innovation activities are related, the government should take corresponding measures according to its relevance.

Proof: because $C_{ji} \neq 0$, $\beta\pi_1 > 0$

Then $$\beta_1 = \frac{B_1 - B_2 C_{12} / C_{22}}{1 + R\sigma_1^2 (C_{11} - C_{12}^2 / C_{22})}$$

(1) if $C_{12} < 0$, the bigger $|C_{12}|$ is , the biger β 1 is. This shows that: if the cost of a commercial activity and the cost of R&D are complementary, the commercial activities will promote the innovation of a enterprise, the government should strengthen the commercial activity of the enterprise.

(2) if $C_{12} > 0$, the bigger $|C_{12}|$ is , the smaller β 1 is. This shows that: Higher β 1 will induce

enterprises will put much more effort (such as investment) into commercial activities, and ignore the R&D activities. So the government should weaken the incentive of commercial activities of the enterprise.

4. THE SUBSIDY POLICY RECOMMENDATIONS FOR THE GOVERNMENT IN THE INDUSTRIAL TRANSFERRING REGIONS

4.1 To improve the system of innovation incentive policy

First, to provide innovation security policy, which can ensure a stable economic and social infrastructure, and then to lower financing costs and entrepreneurial threshold. Second, to promote the power of innovation policy. The establishment of competitive encouraging system, information disclosure system and ownership system, can provide the expected benefits and incentives for innovation enterprises. Third, to adjust R&D subsidy structure. The government can gradually improve the status and role of indirect measures(such astax relief) in enterprise technology innovation, so as to let the enterprise more sensitive to internal mechanism of technology innovation.

4.2 The government subsidy policy should be combined with property policy.

Government subsidies and property right system of technical innovation are both direct ways to internalize the externalities of technical innovation, which play a different role on technology innovation incentive of the enterprise. The government subsidies try to internalize technical spillover effect on tax regulation of innovative products, which can be the effective supplement of market failure. The property rights system is the most economical and effective persistent means of encouraging innovation, but implementation of property right system is quite difficult. Therefore, the complement of government subsidies and technology innovation property will play an important role to eliminate the negative effect of externality in technology innovation.

4.3 To establish a long-term, predictable government procurement policies to support the technology innovation enterprises in the region of industrial transferring.

Government procurement is an important policy tool to guide the investment direction and scale, which can reduce the risk of innovation enterprises to enter the market. The object products of government procurement is the innovation products in the early stages of product life cycle, or the innovation projects that government is the ultimate users. The government subsidies of industrial transferring regions should focus on to the technology which have great mareket prospects. The government should also make corresponding adjustment in the funds, personnel allocation and relevant policies.

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