A Research of Subsidies for the Internet of Things Enterprises Based on Signaling Game Theory

Tian Chang[a] and Xingbang Zhu [b]

[1] No. 20, Chengzhong Road, Jiading District, Shanghai China

[a.] 791513040@qq.com; [b]15621327426@163.com

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Abstract. Government subsidy is critical to the rapid growth of the Internet of Things Enterprises in the future. Considering the optimal resource allocation, a Signaling Game model was used to balance between the internet of things enterprises and the government. Owing to information asymmetry and imperfection, four kinds of equilibrium including complete success, partial success ,complete failure and near failure come to existence, and efficiency of market equilibrium will be influenced by the disguised cost and expected risk cost, therefore, the key to achieve completely successful balance is to improve the camouflage cost of enterprise fraud and the expected cost of risk , and thus four targeted policies are proposed based on the results.

Introduction

The Internet of Things industry is a capital-intensive industry. The private capital and enterprise internal financing cannot support the development of the Internet of Things industry. Government subsidies are an important means to solve the shortage of R&D investment in the Internet of Thing. At present, the government's financial support for IoT enterprises mainly invests in science and technology innovation activities, basic science and technology service activities, and start-up projects to support the beginning of the transformation of scientific and technological achievements and industrialization. [1].

Subsidy policy is essentially the government's intervention in industrial economic activities. In recent years, with the development of game theory, the game research on government and enterprises has become more and more in-depth. Zhou Shaodong studied the game between enterprise technology innovation and government R&D subsidies. He believed that when policy makers have real information about the type of enterprise innovation, the improvement of subsidies can effectively encourage enterprises to increase their independent innovation investment [2]. Xu Xiaodi believes that the government chooses different support policies and has different effects on independent innovation behavior and performance. Therefore, the government should choose different subsidy methods according to the characteristics of the enterprise [3].

Although scholars at home and abroad have achieved rich results in the use of game theory to study government subsidy policies in recent years [4], as China's Internet of Things industry has just started, there are few related studies, which provides an opportunity for the research in this paper.

Model construction and analysis

In the process of the game between the government and the Internet of Things enterprises, Internet of Things enterprises have complete information on their own R&D level. The government has incomplete information. The game of enterprises applying for subsidies actually shows a special dynamic game of incomplete information: signal game [6].

Signal Game Model of Government Subsidy. In order to facilitate the research of the problem, the basic assumptions of the R&D subsidy signal game model between the Internet of Things enterprise and the government constructed in this paper are as follows:

1. The game participates are the government and the Internet of Things enterprises ignoring the differences between the upper and lower levels of government, and the differences between the IoT

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companies in addition to the R&D level and research and development willingness. Also the participating parties meet the economic man hypothesis.

2. The government determines the amount of subsidies according to the level of R&D of IoT enterprises. The higher the R&D level of enterprises, the more subsidies the government gives.

3. Internet of Things companies may adopt speculative and rent-seeking behaviors in order to obtain high subsidies, regardless of the opportunity cost of speculation and rent-seeking behavior.

In the game between the IoT enterprise and the government, the “Nuture” first gives the sender a certain type from a feasible type set according to a certain probability [7], and the sender (the Internet of Things enterprise) T observes the type, and then selects a certain signal from the feasible signal set to transmit, and the receiver (government) G observes the signal and selects its own action from the feasible action set. Assume that the type set of IoT companies is $\mathrm{L} = (t_g, t_b)$, t_g stands for high R&D level, t_b stands for low R&D level; IoT enterprise's signal set is $\mathrm{M} = (\mathrm{g}, \mathrm{b})$, and g stands for high subsidy , b represents the application for low subsidies; the government's action set $\mathrm{C} = (\mathrm{Y}, \mathrm{N})$, Y represents the grant of subsidies, and N represents the refusal to apply. Assume that the government provides high subsidies for IoT companies as L_1 and low subsidies for L_2. For both high and low R&D levels, the government's income “social welfare utility” is V_g and V_b respectively, and $V_g > L_1 > V_b > L_2$; IoT enterprises will apply for high subsidy L_1 when the R&D level is high, and the application cost is 0; if the IoT enterprise has low R&D level, it will pay the camouflage cost c when applying for high subsidy and has zero application cost when applying for low subsidy L_2; The government will review the real R&D level and investment of the IoT enterprise. The probability of the disguise behavior found in the re-examination is f. Once found, the penalty “s” will be imposed. “fs” is the expected risk cost of corporate fraud. Once the government refuses to grant enterprise subsidies, there will be no re-examination [8].

Therefore, once the government accepts the application, when the IoT enterprise applies for high subsidy, if the enterprise has a high level of R&D, the income of the enterprise and the government are (T_1, G_1), $T_1 = L_1$, $G_1 = V_g - L_1$, respectively; if low, the income of the two is (T_3, G_3), $T_3 = L_1 - c - fs$, $G_3 = V_b - L_1$. When the IoT enterprises apply for low subsidies, the income of the two is (T_5, G_5), $T_5 = L_2$, $G_5 = V_b - L_2$; if the government refuses to apply, the income of the enterprise and government when the enterprise with low R&D level fails to apply for high subsidy is(T_4, G_4), $T_4 = -c$, $G_4 = 0$. In other cases, both sides have a return of 0. The above game process can be expressed as an extended type as shown in Fig. 1:

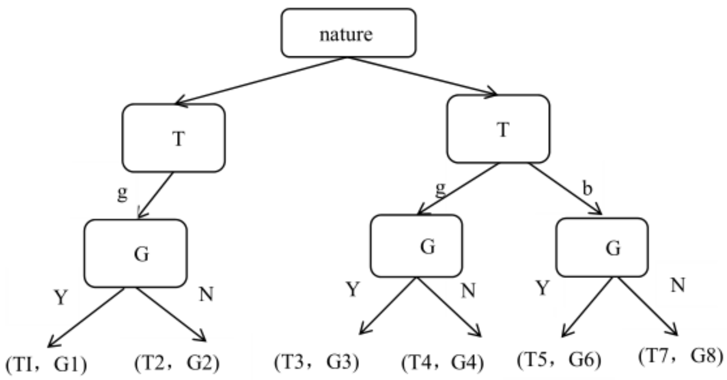

Figure 1. Signal transmission game tree under government subsidies

Assume that the government is a risk-neutral player and the distribution probability of the level of R&D of IoT enterprises is $P_g$and P_b where $P_g + P_b = 1$.

The expected benefits when the government chooses to grant subsidies:

$$E_1 = p(g|h)\left(V_g - L_1\right) + p(b|h)(V_b - L_1) + p(g|1)\left(V_g - L_2\right) + p(b|1)(V_b - L_2) \quad (1)$$

The expected benefits when the government refuses to apply:

$E_2 = 0$ (2)

In Eq. 1,$p(g|h)$ and $p(b|h)$ are the conditional probabilities of high/low R&D level when IoT companies apply for high subsidies, similarly, $p(g|1)$, $p(b|1)$ are the conditional probability of high/low R&D level when when IoT companies apply for low subsidies, where $p(g|h) + p(b|h) = 1$, $p(g|1) + p(b|1) = 1$ and $p(g|1) = 0$, $p(b|1) = 1$. These four conditional probabilities represent the judgment for the type of the signal senders IoT enterprise, which is made by the government as the signal receiver, and its size is directly related to the equilibrium and efficiency of the game.The section headings are in boldface capital and lowercase letters. Second level headings are typed as part of the succeeding paragraph (like the subsection heading of this paragraph).

Game Equilibrium Analysis between Government and Internet of Things Enterprises.

1. The separation equilibrium with completely successful market

When $L_1 - c - fs < L_2$, the game will achieve a perfect Bayesian equilibrium with complete market separation. And this equilibrium's strategic combination and corresponding judgments are as follows:

(1) Enterprises with high R&D level apply for high subsidies, and enterprises with low R&D levels apply for low subsidies;

(2) The government will issue subsidies in accordance with the application;

(3) The government's judgment is $p(g|h) = 1$, $p(b|h) = 0$, $p(g|1) = 0$, $p(b|1) = 1$.

Then using the inverse inductive method to prove that the above two strategic combinations and corresponding judgments constitute a perfect Bayesian equilibrium [9]. For the government, if the IoT enterprise applies for high subsidies, the expected return of the government to grant subsidies is $E_1 = (V_g - L_1) > 0$; if the IoT enterprise applies for low subsidies, the expected income that the government chooses to issue is $E_2 = (V_b - L_2) > 0$; In both cases, the government will have zero expected return when chooses reject. So granting the subsidy is the best strategy against the rejection of the application for the government. For IoT enterprises, if the R&D level is high, the return L_1 for applying for high subsidies must be higher than the return L_2 with low subsidy. If the R&D level is low, it is reasonable to apply for low subsidies for that$L_1 - c - fs < L_2$. Therefore, the above strategy combination and the judgment are "perfect Bayesian equilibrium".

According to the classification of market types, the resource allocation is optimal under the separation equilibrium of market's complete success.

2. The consolidation equilibrium with partially successful market

If $L_1 - c - fs < L_2$ and $p(g|h)$ is large enough, the following stategic combination and judgments constitutes a perfect Bayesian equilibrium for a partially successful market:

(1) Regardless of the level of R&D, IoT companies choose to apply for high subsidies;

(2) The government grants subsidies according to application of the Internet of Things enterprises;

(3) The government's judgment is that $p(g|h)$ is large enough.

For the government, the expected return of subsidies is $E_1 = p(g|h)(V_g - L_1) + p(b|h)(V_b - L_1) > 0$, so that the government will inevitably choose to issue subsidies. On the other hand, given the government's countermeasures, for IoT enterprises, when the enterprise's R&D level is high, the return L_1 for applying for high subsidies is higher than the return $L_2$for applying for low subsidies, so that the company will apply for high subsidies. When the R&D level is low. the company's income applying for high subsidy is still higher than applying for low subsidy income, for that $L_1 - c - fs > L_2$. So companies will also choose to apply for high subsidies. This kind of market situation is partially successful. The behavior of IoT companies cannot fully transmit the information of their R&D level where there exists a "free rider" behavior of "spoken-up".

3. The consolidation equilibrium with completely failed market

If $L_1 - c - fs > L_2$, considering the extreme situation, that is, the camouflage cost and the expected risk cost are close to 0, and the subsistence does not require cost, all IoT companies will apply for high subsidies, and the high subsidy will not reflect the R&D level of the enterprise. In addition, $p(g|h)$ is small enough, $p(b|h)$ is large enough, then the government chooses to pay the expected return of subsidies: $E_1 = p(g|h)(V_g - L_1) + p(b|h)(V_b - L_1) < 0$, so the government refused to give corporates subsidies, the subsidy mechanism could not be operated, and finally forming the "lemon market" that the policy makers did not expect to see [10].

4. The mixed strategy equilibrium with closely failed market

If the government and IoT companies are allowed to adopt a hybrid strategy, there is still a mixed strategy equilibrium that is close to failure: IoT companies with low R&D levels randomly choose to apply for high subsidies or low subsidies, and enterprises with high R&D levels choose to apply for high subsidies. while the government randomly chooses to issue or reject subsidies with a certain probability. It can be proved that the corresponding strategies and judgments are in line with Bayes' rule, but this equilibrium is not an ideal market situation.

Recommendations

Improving information transparency. The cost of corporate camouflage depends to a certain extent on the difficulty of camouflage. The difficulty of camouflage is affected by the degree of transparency of information. In order to improve information transparency, on the one hand, in the process of applying for R&D subsidies by IoT enterprises, the government should formulate clear application standards and publish them to all IoT companies, on the other hand, in the subsidy review session, the government should engage professionals with industry experience to solve the problem of incomplete government staff information.

Strengthening awareness of efficiency and increasing punishment. The expected risk cost is determined by the probability of inspection, the efficiency of inspection, and the intensity of punishment. To this end, the government must ensure that all IoT subsidized companies are treated equally, and random, uncompromised sampling inspections must first ensure the quantity and frequency of sampling inspections. Secondly, the efficiency of inspections should be effectively improved. Finally, increasing the degree of punishment, such as high fines, forced withdrawal, etc., so that the damage caused by camouflage is far greater than the proceeds of its disguise.

References

[1] J.L. He: Journal of Central University of Finance and Economics, (2012) No.9,p. 12. (In Chinese)

[2] S.D. Zhou: Review of Industrial Economics, Vol. 7(2008) No.3,p.38. (In Chinese)

[3] X.D. Xu: Industrial Technology&Economics, Vol. 29(2010) No.6,p.107. (In Chinese)

[4] G.X. Zhang, X.T. Zhang, S.J. Cheng, G.R. Chai, and L.L. Wang: Chinese Journal of Management Science, Vol. 21(2013) No.4,p.131. (In Chinese)

[5] L.F. Xu and G.H. Chen: Chinese Journal of Management Science, Vol. 20(2012) No.4,p.74. (In Chinese)

[6] Robert gibbons: Fundamentals of Fame Theory Beijing Translated by F. Gao (Social Sciences Publishing House, China, 1999).

[7] S.Y. Xie: Economic Game Theory (Fudan University Press, China, 2002). (In Chinese)

[8] T.Y. Zhong and R. Du: Chinese Journal of Management Science, Vol. 23(2015) Special Issue,p. 818. (In Chinese)

[9] H.X. Wang and X.M. Miao: Soft Science, Vol. 27(2013) No.6,p. 29. (In Chinese)

[10] Lerner J: Research Policy, (2010) p. 61.

[11] Weiss D,Falk H and Ben Zion: Accounting and Finance, (2013) p. 37.