Externality of Internet Companies' Scientific and Technological Innovation in the Complete Information Static Game

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Abstract. The purpose of this study was to explore in Internet industry whether a company’s R&D choice is affected by other companies’ choices and point out the scope it matters, futher, determine the best R&D strategy on different occasions. The paper established a rectified Cournot model. Based on the traditional model, the paper added two parameters: knowledge spillover effect and knowledge absorptive capacity. The paper argues that the externality of R&D doesn’t exist when the above parameters changes within a certain range. Thus, the paper put forward that the government should strengthen patent protection and supply financial support to encourage R&D. This study innovatively applied rectified Cournot model, and discussed R&D from the microscopic perspective.

Introduction

Put forward with the development of society, our country's demographic dividend is gradually disappearing, original extensive labor intensive economic development mode has been unable to adapt to the social development [1]. In addition, scientific and technological innovation has become key support to improve the comprehensive national strength, and powerful leads to social mode of production and life style changes and progress. Therefore, the Chinese government is also actively promoting enterprise's scientific and technological innovation. General secretary Xi Jinping in 2015 proposed “The foundation of the enterprise's sustainable development and the way to win the market lies in innovation."

The current China’s Internet industry is booming, but there exists some problems: most small Internet companies lack of R&D, which result in shortage of competence and serious homogeneity. So, take appropriate efforts and explore what have influence on R&D of Internet companies matters. Lots of researchers pay attention to this, often analyzing by building models or empirical research from perspective of Enterprise Cluster. However, All in all, on externality of R&D, current research concentrate on collaborative cluster, and hardly discuss the situation under non-cluster collaboration. So, we apply to the Complete information static game theory, optimizing the Cournot Model to analyze the impact externality have on R&D. Furthermore, put forward the advice on how government promotes the R&D.

Literature Review

By reading the relevant literature and data, we found that the influence of Internet innovation of small and medium-sized enterprises is divided into external factors and internal factors, external factors including host clusters, social environmental factors, cultural and historical traditions, customs and so on. [2] think that internal factors of product innovation, including the enterprise’s decisive board of leader, product information and management organization. [3], through empirical analysis, pointed out that the internal R&D capital stock contribute most to scientific and technological innovation performance.
There are several conceptions about cluster collaboration: Agglomeration effect fails to promote R&D, on the contrary plays a negative role. [4] draw a conclusion through questionnaire in Jiang Su Province. [5] argues that only the cooperation and interaction can improve innovation performance. [6] [7] [8] [9] further pointed out that the gathering to generate knowledge spillovers, and to benefit the third party companies. [10] study the technology spillover impact on Enterprise R&D investment, they think that knowledge spillovers can enable enterprises to access to the results of research and development of other R&D companies at no cost, but this disadvantage to the long-term development of enterprises, enterprises should still adhere to the independent research and development. [11] further through theoretical analysis pointed out that independent research and development is a necessary way to enhance the competitiveness of enterprises.

R&D decision-making are mainly analyzed by the Game of Theory. [12] supposes that SMEs should make full use of the advantages competing with large enterprises. [13] build Game Matrix Model of duopoly enterprises adding absorptive capacity and Knowledge Spillover, explore whether R&D and what R&D mood to choose. 

However, there is a corresponding analysis of knowledge spillover, scholars mainly research and discuss from the angle of cluster, which in the study of non-cluster enterprise knowledge spillovers have certain limitations. When analyzing the game of R&D between enterprises from the perspective of game theory, there is no corresponding policy suggestions about the results of the study. In summary, from the angle of two non-cluster of Internet companies, we analyze their R&D game with the aid of the game theory, and put forward the corresponding policy recommendations.

Model Assumptions

There are a lot of High-tech Industry markets which are oligopoly, such as communications industry, where market share is mainly dominated by oligarchs. The knowledge spillover generated when the China Mobile innovate technically have an impact on the China Unicom. We abstract a duopoly market, where two companies are in the same conditions and have the same product.

Assumption: the yield of A is \(q_1\), the yield of B is \(q_2\), market output is \(Q = q_1 + q_2\). Market-clearing price \(P\) the function of market output \(P = P(Q) = b - Q, b > 0\). The initial unit cost of the two are \(a, b > a > 0\). We suppose R&D exists Knowledge Spillover, that is the new knowledge not only promote itself, but also suppress other companies’ innovation, Knowledge spillover coefficient is \(\alpha\). We assume that the system of Knowledge Spillover is determined by surroundings. We assume absorptive capacity and innovation fund of A are \(k_1\) and \(\gamma_1\), which of B are \(k_2\) and \(\gamma_2\). And absorptive capacity is function of innovation fund, \(y = 0, k = 0\), that is \(k_2(\gamma_2) = 0\).

If both company innovate: \(0 \leq q_1, q_2 \leq a < b, 0 < k_2, k_1 < 1, a_1 = a + (1 - a)k_1, a_2 = a + (1 - a)k_2\). And they decide on their output simultaneously. 

Cournot Model of Two Companies

If A companies choose not to research and development, then \(y_1 = 0, k_1(\gamma_1) = 0, a_1 = a\).

In this case, if B companies also choose not R&D, then \(y_2 = 0, k_2(\gamma_2) = 0, a_2 = a\).

According to the Cournot model, in this game, A and B enterprises are two players, due to the limitation of production capacity, they have an upper limit of production, so the benefit of the game is two manufacturers of their own interests of course, that their sales revenue minus the cost of each, according to the set of circumstances. They are:

\[
\begin{align*}
&\{u_1 = q_1P(Q) - a_1q_1, \quad \frac{\partial u_1}{\partial q_1} = 0\} \\
&\{u_2 = q_2P(Q) - a_2q_2, \quad \frac{\partial u_2}{\partial q_2} = 0\}
\end{align*}
\]

\[
\begin{align*}
u_1 &= \frac{1}{9}(b - a)^2 \\
u_2 &= \frac{1}{9}(b - a)^2
\end{align*}
\]
Above formulas are net income of two enterprises.
In this case, if B companies choose R&D, then \( y_2, k_2 > 0, \ a_2 = a + y_2 \). At this point the benefit functions of the two enterprises are:

\[
\begin{align*}
\{ u_1 &= q_1P(Q) - a_1q_1, \ u_2 = q_2P(Q) - a_2q_2 \} \\
\frac{\partial u_1/\partial q_1}{\partial u_2/\partial q_1} &= \left\{ \begin{array}{l}
\frac{1}{9}(b - a + y_2)^2 \\
\frac{1}{9}(b - a - 2y_2)^2
\end{array} \right.
\end{align*}
\]

Above formulas are net maximum profit of two enterprises.
If A companies choose to research and development, then \( y_2 > 0, k_2(y_2) > 0, \ a_2 = a + (y_1 - a_2k_1y_2) \). In this case, if B companies choose not R&D, maximum net profit of two enterprises at this point are:

\[
\begin{align*}
\{ u_1 &= \frac{1}{9}(b - a - 2y_1)^2 \\
\{ u_2 &= \frac{1}{9}(b - a + y_1)^2
\end{align*}
\]

In this case, if B companies also choose R&D, then \( b > a > y_1, y_2 > 0, u_1 = a + y_1 - a_2k_1y_2 \), so:

\[
\begin{align*}
\{ u_1 &= [b - (q_1 + q_2) - a]q_1 \\
\{ u_2 &= [b - (q_1 + q_2) - a_2]q_2
\end{align*}
\]

To order \( u_{u_1}/u_{u_2} - v \), we get the maximum profit functions when two enterprises both research and development:

\[
\begin{align*}
\{ u_1 = \frac{1}{9}[(b - a) - (2 + a_2k_2)y_1 + (2a_2k_1 + 1)y_2]^2 \\
\{ u_2 = \frac{1}{9}[(b - a) - (2 + a_2k_2 + 1)y_1 + (2 + a_2k_1)y_2]^2
\end{align*}
\]

To sum up, the R&D investment strategy of A and B enterprises benefit matrix is shown in Table 1, and we will make Equilibrium Analysis:

| A enterprise | R&D
|--------------|----------|
| Non-R&D | Non-R&D | R&D
| \( \frac{1}{9}(b - a)^2 \), \( \frac{1}{9}(b - a)^2 \) | \( \frac{1}{9}(b - a) + y_1 \), \( \frac{1}{9}(b - a - 2y_1)^2 \) | \( \frac{1}{9}(b - a + (2a_2k_2 + 1)y_1 - (2 + a_2k_1)y_2)^2 \) | \( \frac{1}{9}[(b - a) - (2 + a_2k_2)y_1 + (2a_2k_1 + 1)y_2]^2 \) |
**Equilibrium Analysis**

Case 1: A choose not to innovate
Assuming B earns \( A_1 \) when do not innovate, otherwise, earns \( A_2 \).

\[
\begin{align*}
A_1 &= \frac{1}{9} (b - a)^2 \\
A_2 &= \frac{1}{9} (b - a - 2y_2)^2
\end{align*}
\]

- \( A_1 > A_2 \): the best strategy for B is not to innovate
- \( A_1 < A_2 \): the best strategy for B is to innovate
- \( a - b + y_2 > 0 \): B should choose to innovate
- \( a - b + y_2 < 0 \): B should not choose to innovate

It can be calculated from the front: \( y_2 < \frac{1}{2} (b - a) \)
So, B choose not to innovate

Case 2: A choose to innovate
Assuming B earns \( A_4 \) when do not innovate, otherwise, earns \( A_5 \).

\[
\begin{align*}
A_4 &= \frac{1}{9} (b - a + y_1)^2 \\
A_5 &= \frac{1}{9} [(b - a) + (2ak_2 + 1)y_1 - (2 + ak_1)y_2]^2
\end{align*}
\]

- \( A_4 > A_5 \): the best strategy for B is not to innovate
- \( A_4 < A_5 \): the best strategy for B is to innovate

Hypothesis: A, B innovate is a Nash Equilibrium, meeting the following conditions:

\[
\begin{align*}
(2 + ak_1)y_2 &< 2ak_2y_1 \\
(2 + ak_2)y_1 &< 2ak_1y_2
\end{align*}
\]

When \( a, k_1, k_2, y_2 \) are fixed, \( y_2 \) should follow:

\[
\frac{(2 + ak_1)y_2}{2ak_2} < y_1 < \frac{2ak_1y_2}{2 + ak_2}
\]

Similarly, when \( a, k_1, k_2, y_2 \) are fixed, \( y_1 \) should follow:

\[
\frac{(2 + ak_2)y_2}{2ak_1} < y_2 < \frac{2ak_2y_2}{2 + ak_1}
\]

**Conclusion**

The article analyzes the principles of economics about R&D decision-making on the foundation of the duopoly model. The phenomenon that company may not innovate because of other companies’ R&D does not happen. Two companies decide simultaneously. R&D renders the technology of products higher. To some extent, it proves the necessity of development of society. Whether a company choose to innovate depends on contrast of revenue under different occasions, also is concerned with absorptive capacity and Knowledge Spillover which are assumed previously.
By solving the model, we think: When Knowledge Spillover and absorptive capacity in itself reaches a certain situation, the free rider phenomenon is not a key factor that influences technology innovation of small and medium-sized enterprises in our country, so it also provides some suggestions for our government to promote the innovation of science and technology of Internet small and medium-sized enterprises: on the one hand, the government can improve the corresponding policies and laws, such as strengthening the patent protection, strengthen the punishment of illegal use of others patent, the control of knowledge spillover and self-absorption capacity in the range of free rider phenomenon can be prevented., so as to improve the enthusiasm of independent research and development of Internet small and medium-sized enterprises; on the other hand, considering the pressure in the economic aspects of the enterprise R&D, may be appropriate to increase support in the economy, alleviate the economic burden of enterprises for research and development, such as increased extra deductions for businesses’ R&D expenses. The establishment of small and medium enterprises tends to support the development of science and technology special funds, etc.

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