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WHICEB 2015 Proceedings | Wuhan International Conference on e-Business

Summer 6-19-2015

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Abstract: In the competitive market of B2B E-commerce platform, the former entrant has the advantage of switching cost while the later entrant has the advantage of declining IT cost. Considering the variable investment cost due to the improvement of platform quality, the paper develops an IT investment model to investigate the best investment strategy for B2B E-commerce platform under the impact of switching cost, declining IT cost, user price-sensitive coefficient and quality-sensitive coefficient. The results show that, switching costs helps former entrant increase investment in platform quality, assume an aggressive investment strategy. Declining IT cost helps later entrant increase investment in platform quality and assumes an aggressive investment strategy only when user switching costs are lower. With the increase of user price-sensitive coefficient, former entrant and later entrant should both decrease investment in platform quality. With the increase of user quality-sensitive coefficient, former entrant and later entrant should both increase investment in platform quality.

Keywords: B2B E-commerce platform, IT investment, variable cost, consumer sensitivity, decision model

1. INTRODUCTION

According to the market detecting data reported by Chinese Electronic Research Center, the number of B2B e-intermediary has reached 11400 until Jun 2013. The rapid development of B2B e-commerce industry has made the competition between B2B e-intermediaries more and more serious [1]. In the competitive environment of B2B e-commerce, former entrants of the market always have opportunity to get its consumer scale in advance, and this part of consumer will give the former entrant some competition advantages. But in the practical case of the market, there exists some latter entrants that catch up the former entrants. Take the *cn.toocle.com* as a practical example, applying information technology investment, it developed a cross-platform searching tools and a consumer recommendation platform in 2007. This IT investment made *cn.toocle.com* more competitive with higher platform quality, which made *cn.toocle.com* the 7th market share of B2B e-commerce in 2013. This case shows that the use of information technology has become a primary factor for e-commerce platforms in the B2B competitive environment.

In the competitive market of B2B e-commerce, there exist both first mover's advantages and latter mover's advantages. The early entrants may enjoy the advantage of consumer scale. There are several factors that could provide an advantage to the first mover like strong brand recognition, network effects, switching cost and the opportunity to set standards [2]. The switching cost refers to the efforts and expense involved in switching from one B2B platform to another platform, the efforts and expense include the time to get familiar with the platform and maybe the money paid for using the platform [3]. While the former entrants have the advantage of switching cost, the latter entrants have the advantage of information technology. This advantage refers to that the cost of information technology declines over time for IT assets such as hardware, software and telecommunications [4]. The development and operation of B2B platform depend mainly on the investment of information technology [5]. Generally, the information technology investment refers to the human capital, hardware assets and software assets caused by the IT research and development. Now the qualities of the B2B platforms are always

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influenced by the cost of IT investment. Former research shows that the service quality level of B2B platform could affect the consumers' behavior and influences the consumer scale of the platform [6]. So, in this situation of competitive market, the latter entrants can utilize an advanced information technology with lower costs and higher quality. And the higher quality could provide latter entrants advantage to attract more consumers [7]. With the intersection of fist-mover advantage and latter-mover advantage in this market, it would be extremely important how the platform make the IT investment decision.

Former researchers have studied IT investment issue under the perspective of different market structures, different cost structures and different consumer selection preference. Considering the sequential entry of platforms, Tyagi [8] examined the product position decisions of different firms that enter a market sequentially. It showed that the uncertainty of the later-entrant's cost structure would affect the first mover's product position. With the perspective of declining information technology cost, Demirhan et al. [9] investigated the impact of a declining IT cost and the switching cost on the IT investment strategies of firms, they found that the later entrant could improve its service quality with lower IT cost and surpass the former entrant. Xie and Li [10] studied the IT investment strategies of e-commerce website with sequential entry, the results indicated that the later entrant could attract more consumers by a higher platform quality when making IT investment with much lower IT cost. All these researches mentioned above only considered the fixed costs of IT investment, ignoring the effects of variable costs. This part of costs refers to the marginal costs caused by the operation and website maintenance because of the higher platform quality.

As for the impact of consumer behavior on the IT investment, previous research mainly focused on the switching cost, Shi et al. [11] analyzed the pricing competition with the effects of switching cost, the research results showed that the lower switching cost could provide more advantage of investment cost to latter entrant. While the related literatures indicate that the consumer preference of platform also influences consumers' switching intention. Singh et al. [12] studied on the impact of using price on platform's market competitiveness. Except for the using price, quality of the platform is also an important factor of consumers' selection and using. Lin et al. [13] examined the impact of both price and quality on consumer's switching intention, this empirical research indicated that a higher using price lead to a higher switching intention while a higher quality lead to a lower switching cost. All these researches confirm that consumer's sensitivity of platform's price and quality could influence the selection decision, which is related to the platform's IT investment strategy. In our model, we consider the sensitivity of price and quality.

Based on the analysis of previous research, we consider both the first entrant's advantage of switching cost and the latter entrant's advantage of declining IT cost in the IT investment decision making. Variable investment cost and consumer's sensitivity of price and quality are also in our study consideration. To analyze how these factors influence the platforms' IT investment decisions, we develop a game theoretic model of a duopoly with sequential entry. After solving and analyzing the equilibrium of this game theoretic model, we can investigate the interplay of all these related factors on IT investment strategies of B2B e-commerce platforms.

2. MODEL SETUP

In this section, we describe the basic game theoretic model of our research. We consider two B2B e-commerce platforms with sequential entry, labeled as platform 1 and 2. Following the sequential entry game, Platform 1 is the former entrant (or the pioneer) and platform 2 is the latter entrant. These two platforms improve their platform qualities to certain levels by information technology investments. There is only a single product or service in this market. Consumers prefer higher to lower platform quality, although their valuations of quality may be different [14]. All consumers are heterogeneous in preferences on content dimension.

The detail assumptions of the model, along with their justifications, are as follows:

Assumption 1. Former entrant platform 1 makes its IT investment first, which results in its quality level k_1, and offers its service at price p_0. Latter entrant platform 2, after observing k_1, makes its IT investment latterly, which results in its quality level k_2. After observing each other's platform quality level, platform 1 and 2 set their service prices p_1 and p_2 simultaneously.

Assumption 2. After the two platforms finish their IT investments, the loss of consumer's utility due to the using price is φp_i, i = 1, 2. φ, user's price-sensitive coefficient, refers to the utility loss incurred per unit price [15]. The utility a consumer gains from quality is given by $r + \theta k_i + \varepsilon$, i=1, 2. r is the utility when platform has the base-level quality without any investment. θ, user's quality-sensitive coefficient, refers to the margin utility for each additional unit of per product quality. ε is a random variable with zero mean and support [- $\underline{\varepsilon}$, $\overline{\varepsilon}$]. Here we assume that the quality is more important for consumer than price ($\theta > \varphi$). Consumers that switch from platform 1 to platform 2 incur a utility loss of switching cost s.

Assumption 3. We assume that the consumers' preferences of platform quality are distributed uniformly on the line [0, 1], where platform 1 is located at point zero and platform 2 is located at point one [16]. Consumers incur a utility loss of t per unit distance between the real platform quality and their preferences. A consumer located at s incurs a utility loss of ts for using platform 1 and a utility loss of $t(1-s)$ for using platform 2.

Assumption 4. According to the basic game model, the investment cost structures of two platforms are given by $C_1 = k_1^2/2 + q_1 k_1$, $C_2 = \delta k_2^2/2 + \delta q_2 k_2$, where the fixed costs are $k_1^2/2$ and $\delta k_2^2/2$ and the variable costs are $q_1 k_1$ and $\delta q_2 k_2$ [17], q_1 and q_2 refer to market demands for platforms, δ models the declining cost of IT investment.

Depending on the assumptions above, after platforms finish their IT investments, the utilities of consumer located at x using platform 1 and platform 2 are:

$$U_1 = r + \theta k_1 + \varepsilon - \varphi p_1 - tx$$
$$U_1 = r + \theta k_2 + \varepsilon - \varphi p_2 - t(1-x) - s$$

Set $U_1 = U_2$, then the consumers, who are indifferent between using platform 1 and switching to platform 2, are located at:

$$\hat{x} = \frac{\theta(k_1 - k_2) - \varphi(p_1 - p_2) + t + s}{2t}$$

Then the market demands for platform 1 and platform 2 can be obtained as:

$$q_1 = \hat{x} = \frac{\theta(k_1 - k_2) - \varphi(p_1 - p_2) + t + s}{2t}$$
$$q_2 = 1 - \hat{x} = \frac{-\theta(k_1 - k_2) + \varphi(p_1 - p_2) + t - s}{2t}$$

Considering the cost structures and the market demands of both platforms, we can compute the profits of platform 1 and platform 2:

$$\pi_1 = p_1 q_1 - C_1 = (p_1 - k_1)\left[\frac{\theta(k_1 - k_2) - \varphi(p_1 - p_2) + t + s}{2t}\right] - \frac{k_1^2}{2} \quad (1)$$

$$\pi_2 = p_2 q_2 - C_2 = (p_2 - \delta k_2)\left[\frac{-\theta(k_1 - k_2) + \varphi(p_1 - p_2) + t - s}{2t}\right] - \frac{\delta k_2^2}{2} \quad (2)$$

3. EQUILIBRIUM

3.1 Price equilibrium

In this game theoretic model, platform 1 and 2 confirm their platform qualities in the first stage and set the prices simultaneously in the second stage. We use the backward induction to compute the subgame-perfect Nash equilibrium in this sequential game model.

In the stage of the pricing subgame, we can get the equilibrium prices by solving the first-order conditions of profit equations. Set $\partial\pi_1/\partial p_1=0$ and $\partial\pi_2/\partial p_2=0$, we obtain the following equilibrium prices:

$$p_1^*=\frac{(2\varphi+\theta)k_1+(\varphi\delta-\theta)k_2+3t+s}{3\varphi} \tag{3}$$

$$p_2^*=\frac{(\varphi-\theta)k_1+(2\varphi\delta+\theta)k_2+3t-s}{3\varphi} \tag{4}$$

We can also compute the equilibrium demands for platform 1 and 2:

$$q_1^*=\frac{(\theta-\varphi)k_1+(\varphi\delta-\theta)k_2+3t+s}{6t} \tag{5}$$

$$q_2^*=\frac{(\varphi-\theta)k_1+(\theta-\varphi\delta)k_2+3t-s}{6t} \tag{6}$$

3.2 Quality equilibrium

In the first stage before pricing subgame, platform 2 makes IT investment and set its quality after observing the quality of platform 1. Combining equation (3), (4), (5), (6) and (2), then the profit of platform 2 can be written as:

$$\pi_2=\frac{\left[(\varphi-\theta)k_1+(\theta-\varphi\delta)k_2+3t-s\right]^2}{18\varphi t}-\frac{\delta k_2^2}{2} \tag{7}$$

Solving the first-order condition of (7), we can get reaction function of platform 2's quality:

$$k_2(k_1)=\arg\max\pi_2=\frac{(\theta-\varphi\delta)\left[(\varphi-\theta)k_1+3t-s\right]}{9\varphi\delta t-(\theta-\varphi\delta)^2} \tag{8}$$

In this dynamic game of complete information, platform 1 sets its quality level by anticipating platform 2's optimal quality given by equation (8). Substituting (8) to profit function (1), we can get the new profit function of platform 1:

$$\pi_1=\frac{t\left[3\varphi\delta(\theta-\varphi)k_1-2(\theta-\varphi\delta)^2+3\varphi\delta(3t+s)\right]^2}{2\varphi\left[9\varphi\delta t-(\theta-\varphi\delta)^2\right]^2}-\frac{k_1^2}{2} \tag{9}$$

Then we can compute the equilibrium quality of platform 1 by solving the first-order condition of (9):

$$k_1^*=\frac{3\delta t(\theta-\varphi)\left[3\varphi\delta(3t+s)-2(\theta-\varphi\delta)^2\right]}{\left[9\varphi\delta t-(\theta-\varphi\delta)^2\right]^2-9\varphi\delta^2t(\theta-\varphi)^2} \tag{10}$$

With the equilibrium quality of platform 1 and the reaction function (8), equilibrium quality of platform 2 is found to be

$$k_2^*=\frac{(\theta-\varphi\delta)\left\{\left[9\varphi\delta t-(\theta-\varphi\delta)^2\right](3t-s)-6\delta t(\theta-\varphi)^2\right\}}{\left[9\varphi\delta t-(\theta-\varphi\delta)^2\right]^2-9\varphi\delta^2t(\theta-\varphi)^2} \tag{11}$$

After solving the equilibrium prices and equilibrium qualities of platform 1 and 2, the equilibrium profits of these two platforms can be computed as:

$$\pi_1^*=\frac{t\left[3\varphi\delta(3t+s)-2(\theta-\varphi\delta)^2\right]^2}{2\varphi\left\{\left[9\varphi\delta t-(\theta-\varphi\delta)^2\right]^2-9\varphi\delta^2t(\theta-\varphi)^2\right\}} \tag{12}$$

$$\pi_2^*=\frac{\delta(9\varphi\delta t-(\theta-\varphi\delta)^2)\left\{\left[9\varphi\delta t-(\theta-\varphi\delta)^2\right](3t-s)-6\delta t(\theta-\varphi)^2\right\}^2}{2\left\{\left[9\varphi\delta t-(\theta-\varphi\delta)^2\right]^2-9\varphi\delta^2t(\theta-\varphi)^2\right\}^2} \tag{13}$$

4. EQUILIBRIUM ANALYSIS

4.1 The impact of the switching cost on the IT investment.

In this section, we determine the impact of s on platforms' quality levels and profits. For a given decline in the IT investment cost, we can get the impact of a switching cost on platforms' quality levels and profits as follows:

Proposition 1. For a given δ, $\partial k_1^* / \partial s > 0$, $\partial \pi_1^* / \partial s > 0$ and $\partial k_2^* / \partial s < 0$, $\partial \pi_2^* / \partial s < 0$. With an increase in switching cost, the quality and profit of platform 1 increase while the quality and profit of platform 2 decrease.

The Proposition 1 shows how the switching cost influences the quality levels and profits of B2B platforms. We can conclude that a higher switching cost always has a positive effect on platform 1 and a negative effect on platform 2. Because when the switching cost is higher enough, it is very difficult for the consumers that use platform 1 before to switch to the new entrant platform 2.

4.2 The impact of the declining IT cost on the IT investment.

In this section, we determine the impact of δ on platforms' quality levels and profits. Generally speaking, the declining IT cost helps the latter entrant platform 2 to improve its quality level. But existence of switching cost will weaken latter entrant's advantage of declining IT cost. By computing the first-order condition of k_1^* and k_2^* on δ, we find that platforms' optimal strategies depend on not only the decline in IT cost but also the level of switching cost. So we cut the valuation of s into three intervals $[0, s_1)$, $[s_1, s_2)$, $[s_2, +\infty)$, and analyze the impact of decline in IT cost. We summaries the results as follows:

Proposition 2. There exist two critical values of switching cost s:

$$s_1 = \frac{4\delta^3\theta\varphi^3 - \delta^4\varphi^4 - 6\delta^2\theta^2\varphi^2 + 4\delta\theta^3\varphi - \theta^4 + 9t\delta\theta^2\varphi - 9t\delta^2\theta^2\varphi + 9t\delta^3\varphi^3 - 9t\delta^2\varphi^3}{3\varphi\delta\left[9\varphi\delta t - (\theta - \varphi\delta)^2\right]}$$

$$s_2 = \frac{3\varphi t\left[9\theta t + (\theta-\varphi\delta)^2\right]\left[9\varphi\delta t - (\theta-\varphi\delta)^2\right]^2}{\varphi\left[9\theta t + (\theta-\varphi\delta)^2\right]\left[9\varphi\delta t - (\theta-\varphi\delta)^2\right]^2 - 9\varphi\delta t(\theta-\varphi)^2\left[9\varphi\delta\theta t - (2\theta+\varphi\delta)(\theta-\varphi\delta)^2\right]}$$
$$+\frac{3t(\theta-\varphi)^2\left[18\varphi^2\delta^3\theta t(\theta-\varphi)^2 - 243\varphi^2\delta^2\theta t^2 - 27\varphi^2\delta^2 t(\theta-\varphi\delta)^2 + 18\varphi\delta\theta t(\theta-\varphi\delta)^2 + 2(\theta-\varphi\delta)^4(\theta+2\varphi\delta)\right]}{\varphi\left[9\theta t + (\theta-\varphi\delta)^2\right]\left[9\varphi\delta t - (\theta-\varphi\delta)^2\right]^2 - 9\varphi\delta t(\theta-\varphi)^2\left[9\varphi\delta\theta t - (2\theta+\varphi\delta)(\theta-\varphi\delta)^2\right]}$$

For former entrant platform 1, if $s < s_1$, then $\partial k_1^* / \partial \delta > 0$; if $s > s_1$, then $\partial k_1^* / \partial \delta < 0$. For latter entrant platform 2, if $s < s_2$, then $\partial k_2^* / \partial \delta < 0$; if $s > s_2$, then $\partial k_2^* / \partial \delta > 0$.

Proposition 2 shows the impact of declining IT cost on the platforms' quality levels. It seems that the decline in IT cost help the latter entrant only when the switching cost is at a lower level. When the switching cost is higher enough, latter entrant's advantage of declining IT cost is weaker than the former entrant's advantage of switching cost. Because when the switching cost is lower enough, the consumers' switching intentions are much more easily influenced by the quality levels of platforms. So the latter entrant could have chance to attract more consumers by improving its quality level with lower IT cost. But when the switching cost is at a higher level, it is extremely difficult for the latter entrant to attract platform 1's consumer. So platform 2 should not pay more cost to improve its quality level.

Proposition 3. For former entrant platform 1, $\partial \pi_1^* / \partial \delta > 0$, the platform 1's profit always decreases with a decline in IT cost. For latter entrant platform 2, it has a critical value of switching cost s:

$$s_3 = 3t - \frac{18\delta t(\theta-\varphi)^2\left\{\left[9\varphi\delta t - (\theta-\varphi\delta)^2\right]^2 + 3\varphi\delta^2 t(\theta-\varphi)^2\right\}}{27\varphi\delta^2 t(\theta-\varphi)^2\left[9\varphi\delta t - (\theta-\varphi\delta)^2\right] + \left[9\varphi\delta t - (\theta-\varphi\delta)^2\right]^3}$$

If $s < s_3$, then $\partial\pi_2^*/\partial\delta < 0$, platform 2's profit increases with a decline in IT cost. If $s > s_3$, then $\partial\pi_2^*/\partial\delta > 0$, platform 2's profit decreases with a decline in IT cost.

Proposition 3 shows the impact of declining IT cost on the platforms' profits. With the decline of IT cost, the profits of platform 1 will always decrease no matter at what level the switching cost is. The reason is that, if platform 1 makes its IT investment defensively, the consumer will switch to platform 2 that has a much higher quality level. But if platform 1 makes its IT investment offensively, it has to pay a large amount of cost because of the higher IT cost. So the profit of platform 1 decrease because of the disadvantage of IT cost.

As for the latter entrant platform 2, when the switching cost is at a lower level, platform 2 can easily attract more consumers by improving its quality level with declining IT cost. Larger user scale will finally make the profit increase. But when the switching cost is at a higher level, the platform 2 would make its investment defensively while the platform 1 would make investment offensively according to proposition 2. So platform 2's user scale decreases. Decrease of user scale will make the profit decrease.

5. NUMERIC STUDY

In this section, we analyze the impacts of price-sensitive coefficient φ and quality-sensitive coefficient θ on platforms' investment strategies. We present a numerical analysis to draw managerial insights from the proposed model. In order to analyze the impact of φ on the platforms' quality levels and profits, we set $t=1$, $\theta=1$, $\delta=1$, $s=0$, $\varphi\in[0.5, 0.9]$. Figure 1 depicts how the platforms' quality levels and profits change with the increase of price-sensitive coefficient φ.

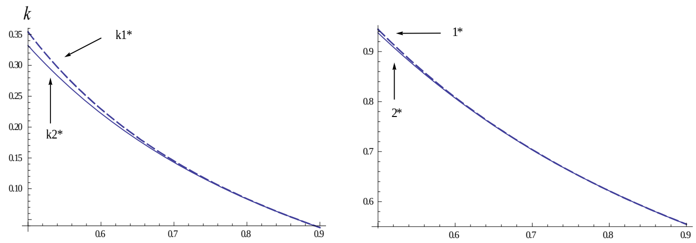

Figure 1. The impacts of φ on platforms' quality levels and profits

According to the lines in figure 1, we can conclude the impact of price-sensitive coefficient as follows:

Proposition 4. All the platforms' qualities levels and profits will decrease with the increase of consumers' price-sensitive coefficient φ.

An implication of proposition 4 is the B2B platform that wants to enlarge its user scale of seller. The sellers are more sensitive of price because sellers must pay some fees before using the B2B platform. In this situation, the competitive strategies should be concentrated on the prices. So the pricing competition will make profits of both platforms decrease.

In order to analyze the impact of θ on the platforms' quality levels and profits, we set $t=1$, $\varphi=0.5$, $\delta=1$, $s=0$, $\theta\in[0.6, 1.0]$. Figure 2 and figure 3 depict how the platforms' quality levels and profits change with the increase of quality-sensitive coefficient θ.

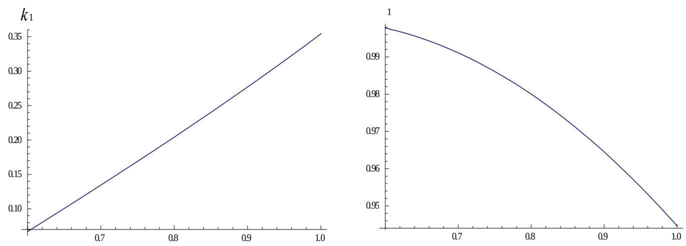

Figure 2. The impacts of θ on platform 1's quality level and profit

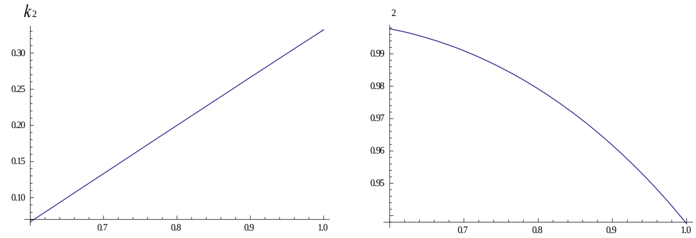

Figure 3. The impacts of θ on platform 2's quality level and profit

According to the lines in figure 2 and figure 3, we can conclude the impact of quality-sensitive coefficient as follows:

Proposition 5. With the increase of consumer's quality-sensitive coefficient θ, quality levels of both platforms increase while the profits decrease.

A practical implication of proposition 5 is the B2B platform that wants to enlarge its user scale of buyer. The buyers are more sensitive of platforms' qualities because they do not have to pay any money for the service. So quality is much more important for these buyers who use the platform for free. In this situation, B2B platforms must make IT investment to improve their quality levels, the quality competitions will finally result in the decrease of profits.

6. CONCLUSIONS

In this paper, we focus on the competition environment of B2B e-commerce market, in which the former entrant (or the pioneer) has the advantage of switching cost while the latter entrant has the advantage of declining IT cost. Considering the influences of consumers' sensitivities of price and quality, we develop a game theoretic model to analyze the optimal IT investment strategies for B2B platforms with sequential entry. Solving and analyzing the equilibrium prices and qualities of this game model, we summaries the optimal IT investment strategies under the effects of switching cost, declining IT cost, consumers, price sensitivities and quality sensitivities.

The results of our study indicate that the first-mover's advantage of switching cost could be eliminated by the impact of declining IT cost. With the increase of switching cost, the former entrant should make its IT investment offensively while the latter entrant should make its IT investment defensively. The decline in IT cost could help the latter entrant improve its quality level and make more profit only when the switching cost is at a lower level.

Our research also shows the impact of consumer's sensitivity on the platforms' IT investment strategies. With the increase of consumer's price-sensitive coefficient, former entrant and later entrant should both decrease investment in platform quality. With the increase of user quality-sensitive coefficient, former entrant and later entrant should both increase investment in platform quality.

There are several limitations in the research model. One critical assumption of our model is that consumers switching from platform 1 to platform 2 incur a utility loss of switching cost s. We didn't consider the factors that result in the switching cost. In the future research, we could focus on the specific factors that determine the switching cost of consumers switching from one platform to another.

ACKNOWLEDGEMENT

This research was supported by the National Natural Science Foundation of China under Grant 71271115, the Graduate Practice Innovation Projects of Jiangsu Province (No.SJLX_195) and the Graduate Practice Innovation Projects of Nanjing University of Science and Technology (2014).

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