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Investment Timing Game of B2B E-commerce Platforms Under Network Externality

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Abstract: In the competitive investment environment of B2B E-commerce platform, the first mover has the advantage of network externality while the followers have the advantage of declining IT cost. Aimed to investigate the optimal Information Technology (IT) investment timing strategy under the interplay of network effect and declining IT cost, this paper develops an option game model under the uncertainty environment where the market demand is stochastic and the random command shock follows a geometric Brownian motion process. By solving this option game model, we offer the payoffs and threshold of platform as leader, follower or simultaneous investor. Equilibrium results show that there exist two kinds of equilibrium strategies, simultaneous equilibrium and sequential equilibrium when we take into account the interaction of network effect and IT cost decline and platforms choose which strategy depend on the relative magnitudes of network externality and IT cost decline level.

Keywords: B2B E-commerce platform, IT investment strategy, network externality, IT cost decline, investment timing

1. INTRODUCTION

Our country is basking in a great boom in B2B e-commerce industry in recent years. According to the market monitoring data reported by China Electronic Research Center [1], gross turnover of Chinese B2B e-commerce platform was 11.5 billion in the first half year of 2014 increased by 22.6% than the former year. The rapid development of B2B e-commerce provides huge market opportunity for e-intermediaries. On the other hand, competition between B2B e-intermediaries has become increasingly fierce. The number of B2B e-intermediary platform has reached 12,030 as of Jun 2014. Among these B2B platforms *Alibaba.com* account for 40.5% of the B2B market, ranked the 1st market share in 2014 followed by *Mysteel.com, global sources.com* and *Hc360.com.* The data indicates that at present stage the B2B market in our country gradually formed an oligopoly competition led by *Alibaba.com* who started early. However, in the real market some examples, such as *cn.toocle.com*, have been reported that late entrants may spar with their opponent by choosing the appropriate Information Technology (IT) investment timing. These cases show that the use of IT has become a primary factor for e-commerce platforms in the competitions for B2B market. Above all, it is vital to make a scientific IT investment decision and choose appropriate investment timing.

When making IT investment decision, enterprises will take many factors into consideration. Existing literature focus mainly on three important factors, namely, switching cost [2-3], network externality [4-8] and declining Information Technology (IT) cost [9-14]. On the one hand, network externality, as a characteristic of B2B platform; provide early entrants with a first-mover advantage that comes from the user base they captured in an early stage. Users have higher perception value of a platform under the network externality. As a result, they are more willing to attend and persist in using the platform, which generates an aggregation effect——more buyers attract more seller user and more sellers draw more buyers in return. Therefore, the two-side users are the sources of a platform’s profit and user scale is the foundation for a platform to survive and develop. Empirical studies show that network externality has a positive effect on user behavior in both B2B e-intermediary service [4] and mobile short message service [5]. Theoretic researches pay more attention on the marketing strategy of B2B platform including pricing, differentiation and other marketing strategy issues. Katsamakas and Bakos [6] studied B2B platform pricing strategy considering cross network externality between two sides users on the platform. Yoo et al. [7] further assumed that the competition between buyers would bring about a negative network effects in among supplier sides. They investigated the pricing strategy of B2B electronic intermediary platform under the interaction of these different kinds of network externality. Bhargava [8] considered the situation where there existing both negative network effect and cross network externality. He examined the differentiation strategy of information intermediary website taking into account buyers' preference heterogeneity. Learning from observation of B2B market, we find that network externality within the seller group on the platform is affected by the stage of market development. And in the initial stage of the market, the positive network effect manifest as aggregation and demonstration effect holds the advantage while in the mature period the negative effect dominates. As B2B e-commerce in our country is on a high growth path in our country, we focus only on the positive network effect in this paper. On the other hand, the latter entrants could benefit from the declining IT cost. The development and operation of B2B platform depend mainly on IT investment [9] which includes the investment on human capital, hardware assets and software assets caused by the IT research and development to upgrade platform's quality. Empirical research shows that the service quality level of B2B platform could affect the consumers' behavior and influences the consumer scale of the platform [10]. As a result, the latter entrants can utilize an advanced information technology with lower costs and higher quality to attract more consumers [11]. Studies that consider IN cost decline have concentrated on sequential duopoly enterprises' product positioning and quality strategy. Tyagi [12] proposed that the uncertainty of latter entrant's cost would influence first mover's product position. Demirhan [13] supposed IT cost is the quadratic function of quality and found the effect of IT cost decline on platform's quality was influenced by users' preference. Existing researches concerned less about the timing of IT investment. However, with the intersection of fist-mover advantage and latter-mover advantage in this market, it would be extremely important to the platform choose the proper IT investment timing strategy which deserves more attention.

Based on the analysis of previous research, we consider both the first mover's advantage of network effect and the follower's advantage of declining IT cost in the IT investment timing strategy of B2B e-commerce platforms. To analyze how these factors influence IT investment strategy, we develop an option game model of duopoly B2B platforms in the environment with market demand uncertainty based on classical standard option game model [15-17]. 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. THE MODLE

We consider two identical, risk neutral and value maximizing B2B platforms that can make investment expenditure to improve the quality of their service through innovative products and value-added services. We assume that investment is bound to be successful, whereas the market demand is stochastic. Risk-free interest rate in the market is set to be r. The inverse demand function of platform i (i=1, 2) can be expressed as follows:

$$P_i(t) = Y(t)D(N_i, N_j)$$

In this equation, $P_i(\mathrm{t})$ represents the price of the upgraded platform i; $D(\mathrm{N_i, N_j})$ denotes the market demand parameter of platform i that depend on both platform's investment state. $\mathrm{Y(t)}$ is the random command shock in the B2B e-commerce market that follows a geometric Brownian motion process:

$$dY(t) = \alpha Y(t)dt + \sigma Y(t)dz$$

Where $\alpha \in (0, r)$ is the drift parameter of $Y(t)$'s growth expectation, σ is the volatility parameter, and dz is an increment of a Wiener process under risk neutral measurement. Thus dz is distributed according to a normal distribution with mean zero and variance dt.

We make the following assumption on D's with four possible cases: $D(0,0)$ indicates neither platforms have invested; $D(1,1)$ denotes both platforms have invested; $D(1,0)$ represents platform i have invested while platform j haven't; $D(0,1)$ represents platform j have invested while platform i haven't. As is stated, the two B2B platforms have been active in the market and one of them success in IT investment would cut down the other one's user amount. First, a platform makes the highest amount of users with a given IT investment if the other firm gives up the option to upgrade (monopoly). It also holds that, given its own IT investment decision, user amount will be lowest when the other platform is a strong competitor. Second, given the technology of the competitor, the platform's user base is higher when grasping the investment option. Finally, since both platforms have been active in the market before, the user amount on either platform is non-negative. In this way the following inequalities are obtained: $D(1,0) > D(1,1) > D(0,0) > D(0,1) > 0$

Considering B2B e-commerce platform's characteristic of network externality, the first movers may enjoy the advantage that comes from the user base they captured in an early stage. That is, for the same IT investment innovation project, the leading platform would earn more users than the follower due to the aggregation effect under network effect. This implies that, the inequality, $D(1,0) - D(0,0) > D(1,1) - D(0,1)$, makes sense.

As to the IT investment expenditure, we assume two kinds of IT investment cost named fixed cost and variable cost in platforms' IT innovation, expressed as I_i and C_i respectively. The fixed cost refers to the expenditure that is used to improve platform's quality level while the variable cost refers to the extra maintenance fee due to the higher platform quality. Given that platform 1's fixed cost and variable cost are set to be I and C, then the two platforms' investment costs are:

$$\begin{cases} I_1 = I, I_2 = kI \\ C_1 = C, C_2 = \mu C \end{cases}$$

The constant terms μ and k indicate the declining IT cost, that is, the following platform involves in a lower IT investment cost than the leader.

3. THE PAYOFFS

As our purpose is to establish the analysis on duopoly platforms' investment strategy, we first have to determine the payoffs in cases the platform roles are fixed beforehand. For definiteness and without loss of generality, our analysis focuses only on platform i, who has 3 possible investment behaviors: invests first and gets the leader role; invests latter to be the follower and choose to invest simultaneously with the other platform. Backward induction method will be applied to solve the dynamic game and payoffs are obtained in three cases.

3.1 Follower's payoff and investment threshold

IT investment option value function of platform i, as the follower, satisfy the partial differential equation:

$$\frac{1}{2}\sigma^2 Y^2 \frac{\partial^2 V}{\partial Y^2} + \alpha Y \frac{\partial V}{\partial Y} - rV + YD(0,1) = 0$$

The homogeneous solution of the above ordinary differential equation can be expressed in the form of $V(\mathrm{Y}) = B_1 Y^{\beta_1} + B_2 Y^{\beta_2}$ where β_1, β_2 can be solved from the equation: $\frac{1}{2}\sigma^2\beta^2 + (\alpha - \frac{1}{2}\sigma^2)\beta - r = 0$

$$\beta_1 = \frac{-(\alpha - 0.5\sigma^2) + \sqrt{(\alpha - 0.5\sigma^2)^2 + 2r\sigma^2}}{\sigma^2} > 1$$

$$\beta_2 = \frac{-(\alpha - 0.5\sigma^2) - \sqrt{(\alpha - 0.5\sigma^2)^2 + 2r\sigma^2}}{\sigma^2} < 0$$

When $\mathrm{Y} \to 0^+$, there are $Y^{\beta_1} \to 0$, $Y^{\beta_2} \to +\infty$. In this case, $V_i^F(\mathrm{Y}) \to +\infty$. However, when the demand is approaching to zero, the value of investment option can never be infinitely great. To avoid this paradox, constant coefficient B_2 must equal 0. Therefore, the IT investment option value is obtained as follows:

$$V_i^F(\mathrm{Y}) = \begin{cases} B_1 Y^{\beta_1} + \frac{YD(0,1)}{r-\alpha} & \mathrm{Y} < \mathrm{Y}_i^F \\ \frac{YD(1,1)}{r-\alpha} - (\mathrm{I}_i + \frac{C_i}{r}) & \mathrm{Y} \geq \mathrm{Y}_i^F \end{cases}$$

Then we can solve the followers of the optimal investment threshold Y_i^F by using dynamic programming method. Value function at the point of Y_i^F should satisfy value-matching condition and smooth pasting condition:

$$\begin{cases} B_1 Y^{\beta 1} + \dfrac{YD(0,1)}{r-\alpha} = \dfrac{YD(1,1)}{r-\alpha} - (\mathrm{I_i} + \dfrac{c_i}{r}) & \text{.....(1)} \\ V_i^{F'}(\mathrm{Y}_i^F) = \dfrac{\mathrm{YD}(1,1)}{r-\alpha} & \text{................................(2)} \end{cases}$$

Combine equation (1) and (2) we will get:

$$\begin{cases} Y_i^F = \dfrac{\beta_1}{\beta_1 - 1} \cdot \dfrac{r-\alpha}{D(1,1) - \mathrm{D}(0,1)} \cdot (\mathrm{I}_i + \dfrac{c_i}{r}) \\ B_1 = \dfrac{(\mathrm{Y}_i^F)^{1-\beta_1}}{\beta_1} \cdot \dfrac{[\mathrm{D}(1,1) - \mathrm{D}(0,1)]}{r-\alpha} \end{cases}$$

Substitute B_1 into $V_i^F(\mathrm{Y})$, follower's investment value can be expressed:

$$V_i^F(\mathrm{Y}) = \begin{cases} \dfrac{YD(0,1)}{r-\alpha} + \left\{ \dfrac{Y_i^F[\mathrm{D}(1,1) - \mathrm{D}(0,1)]}{r-\alpha} - Ii - \dfrac{Ci}{r} \right\} \cdot (\dfrac{Y}{Y_i^F})^{\beta_1} & \text{... (3)} \\ \dfrac{YD(1,1)}{r-\alpha} - I_i - \dfrac{C_i}{r} & \text{....................... (4)} \end{cases}$$

Expression (3) denotes the present value of platform *i*' s profit when it hasn't invested any more, of which the first item is platform *i*' s profit if it never invest on the new technology and the second item is the option value of this IT investment. Expression (4) denotes the payoff of platform *i* after its investment.

The optimal investment timing is at the moment when the random demand shock equals the investment threshold:

$$T_i^F = \inf\left\{ t : Y \geq Y_i^F \right\}$$

3.2 Leader's payoff and investment threshold

Assuming that the leader, platform *i,* invests only once and in this monopoly situation the option value of leader satisfy the following partial differential equation:

$$\frac{1}{2}\sigma^2 Y^2 \frac{\partial^2 V}{\partial Y^2} + \alpha Y \frac{\partial V}{\partial Y} - rV + YD(1,0) = 0$$

Solve the differential equation we can obtain the option value:

$$V(\mathrm{Y}) = \mathrm{B_2 Y}^{\beta_1} + \frac{YD(1,0)}{r-\alpha}$$

At the point of the follower's investment threshold $Y = Y_j^F$, leader's investment option value equals to the value when the two platforms invest simultaneously. At this point, the following equation can be established:

$$B_2(\mathrm{Y}_j^F)^{\beta_1} + \frac{Y_j^F D(1,0)}{r-\alpha} = \frac{Y_j^F D(1,1)}{r-\alpha}$$

Solve the equation:

$$\Rightarrow B_2 = \frac{Y_j^F[\mathrm{D}(1,1) - \mathrm{D}(1,0)]}{(\mathrm{Y}_j^F)^{\beta_1}(\mathrm{r} - \alpha)}$$

As we have stated, $D(1,1) < D(1,0)$, so B_2 is negative which means that in the duopoly economic environment the entry of follower would decrease leader's investment value.

At the point of $Y < Y_j^F$ when the follow make no investment the leader's investment value can be expressed as the option value minus the investment cost:

$$V_i^L(\mathrm{Y}) = \frac{YD(1,0)}{r-\alpha} + (\frac{Y}{Y_j^F})^{\beta_1} \frac{Y_j^F[\mathrm{D}(1,1) - \mathrm{D}(1,0)]}{r-\alpha} - I_i - \frac{C_i}{r}$$

At the point of $Y \geq Y_j^F$ when both platforms have made invested, the value of both platforms is equal to the simultaneous investment value:

$$V_i^L(\mathrm{Y}) = \frac{YD(1,1)}{r-\alpha} - I_i - \frac{C_i}{r}$$

To sum up, the payoff of leading platform i can be concluded as follows:

$$V_i^F(\mathrm{Y})=\begin{cases}\dfrac{YD(1,0)}{r-\alpha}+\dfrac{Y_j^F[\mathrm{D}(1,1)-\mathrm{D}(1,0)]}{r-\alpha}\cdot(\dfrac{Y}{Y_j^F})^{\beta_1}-I_i-\dfrac{C_i}{r} & Y<Y_j^F \quad ...(5)\\ \dfrac{YD(1,1)}{r-\alpha}-I_i-\dfrac{C_i}{r} & Y\geq Y_j^F \quad ....(6)\end{cases}$$

Faced with threat of rival's preemptive investment behavior, platform wouldn't wait for monopoly investment critical value point. If the payoffs of being the leader are greater than that of to be the follower, platform *i* is motivated to become the leader especially when it knows that the competitor face the same situation. In that case, platform i's strategy is to invest and to become the leader at the point when platform j's payoffs of to be the leader are equal to that of to be the follower. Due to the symmetry of this problem, there exists $V_i^L(\mathrm{Y})=\mathrm{V}_i^F(\mathrm{Y})$ and $V_j^L(\mathrm{Y})=\mathrm{V}_j^F(\mathrm{Y})$ for all the stochastic demand *Y*. Therefore, we can set the leader's investment threshold Y_i^L as $0<Y_i^L<Y_j^F$ and the value of leader and follower are equivalent:

$$Y_i^L=\left\{0<Y_i^L<Y_j^F \mid V_L(\mathrm{Y})=\mathrm{V}_F(\mathrm{Y})\right\}$$

3.3 Payoff of simultaneous investment

In the circumstance of simultaneous investment, platform *i*' s payoffs are as follows:

$$V_i^s(\mathrm{Y})=\frac{YD(1,1)}{r-\alpha}-I_i-\frac{C_i}{r}$$

If the stochastic demand is high enough that $Y\geq Y_j^F$, simultaneous investment is optimal for both platforms. Otherwise in the case of $Y<Y_j^F$ it would be wrong.

Figure 1 presents the magnitude relation of duopoly platforms' investment payoffs and thresholds. Where $V_L(Y)$, $V_F(Y)$ and $V_S(Y)$ are platforms' investment payoff curves as the leader, follower and simultaneous investor, respectively. While Y_L, Y_M and Y_F denote the investment threshold of platform to be the leader, monopoly and follower, respectively. When there is only one platform in the market, it will invest at the point of Y_M. The timing would be brought forward ($Y_L< Y_M$) once being aware of the competitor's threat. When the demand arrives at Y_L, $V_L(Y) =V_F(Y)$, both platforms have incentive to preempt investment and strive for the leadership. The successful one would be the leader while the other platform would watch its time and enter at the point $Y=Y_F$. On the situation that the market demand is high enough, the two platforms would invest at the same time $Y=Y_F$ and they would gain the same investment payoffs.

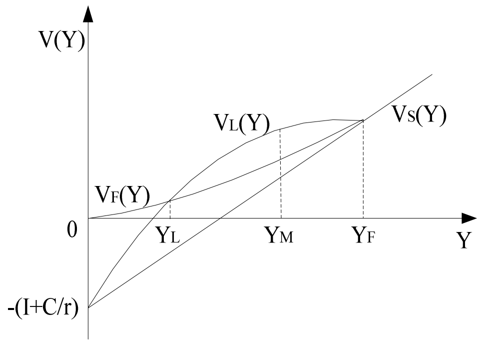

Figure 1. Values and investment thresholds of duopoly platforms

4. EQUILIBRIUM ANALYSIS

4.1 Effect of investment cost

In this section, we determine the impact of I_i and C_i on platforms' investment timing and strategies. For a given value of other parameters, we can get the impact of the investment cost on platforms' investment threshold as follows:

$$\frac{\partial Y_i^F}{\partial I_i}=\frac{\beta_1}{\beta_1-1}\cdot\frac{r-\alpha}{D(1,1)-\mathrm{D}(0,1)}>0$$

$$\frac{\partial Y_i^F}{\partial C_i}=\frac{\beta_1}{\beta_1-1}\cdot\frac{1}{D(1,1)-\mathrm{D}(0,1)}>0$$

The above inequalities show a positive correlation between follower's investment critical value and costs. In the real market of B2B e-commerce industry, follower platforms process a cost advantage due to the declining IT cost as a result of which their investment threshold will decrease. Therefore, platform still have opportunity to invest for the second time even if they fail in first preemption.

4.2 Equilibrium strategies

With the interaction of network externality and IT cost decline, platforms have two kinds of investment strategy equilibrium: simultaneous equilibrium and sequential equilibrium. As we have discussed that the fix investment cost and the variable cost have the same influence on platform's investment critical value. So for convenience, we assume an equivalent declining level of fixed cost and variable cost, that is $k=\mu$, and set $W_i = I_i + \frac{C_i}{r}, i = 1, 2.$ Without loss of generality, we hold the assumption that platform 1 is the leading investor while platform *2* is the follower. We will investigate the how IT cost decline and network externality interplay on the equilibrium strategy.

Huisman et al [15] have proved that the leader has one and only IT investment threshold $T_1^L = \inf\left\{t : Y \geq Y_1^L\right\}$, where $Y_1^L = \frac{U_1}{D(1,0) - D(0,0)}, U_1 = \frac{\beta_1}{\beta_1 - 1} \cdot (r - \alpha) \cdot (I_i + \frac{C_i}{r}).$ In order to get the equilibrium results, we first have to determine the relative magnitude of the two platforms' investment threshold. In the competitive B2B market, a platform gains more users as monopoly than being the duopoly (*D(1,1) < D(1,0)*). There exists a $W_1^* = \frac{1}{k} W_1 \frac{D(1,1)}{D(1,0)}$ making $Y_{L_1} = Y_{F2}$ established.

Case 1: If $W_1 \in (0, W_1^*)$, then $Y_{L_1} < Y_{F_2}$.

On condition that IT cost decline level (*1/k*) is greater than network externality (*D(1,0)/D(1,1)*), platform *1*'s investment threshold is lower than platform *2*'s and platform 1 will invest before T_{F2}. As $V_1^L(Y_{L1}) < V_1^F(Y_{F2})$ platform 1 is incline to be the follower. But platform 1 believes that platform 2 will not invest before T_{F2} for which it may choose delay strategy and invest at its optimal investment point T_{L1} for Y_{L1} is the optimal investment threshold under monopoly environment. And platform 2 will invest at T_{F2} accordingly. Thus we get sequential investment equilibrium as is shown in figure 2.

Case 2: If $W_1 \in (W_1^*, W_2)$, then $Y_{L_1} \geq Y_{F_2}$.

On condition that network externality (*D(1,0)/D(1,1)*) is greater than IT cost decline level (*1/k*), the leader, platform 1's investment critical value is greater than that of the follower, platform 2. On such occasion, platform 2 would choose to invest immediately once platform 1 make its investment and the two platforms will end up invest at the same time T_{F2}. Thus we get a simultaneous equilibrium as is shown in figure 3.

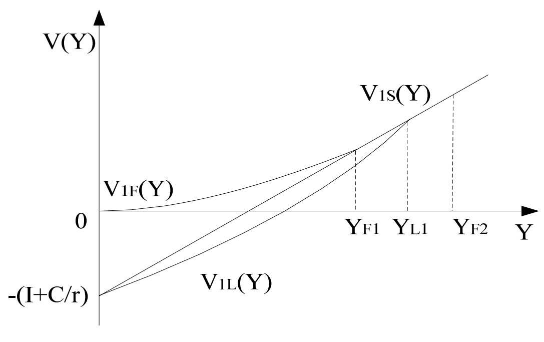

Figure 2. Values of platform 1 in case 1

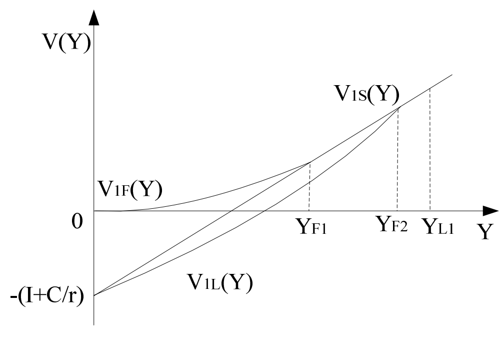

Figure 3. Values of platform 1 in case 2

5. NUMERIC ANALYSIS

In this section numeric analysis was performed by which we further verify the impact of network effect and the declining IT cost on platforms' investment strategy. We make the assumption on a virtual B2B market where there exist two B2B e-commerce platforms both of which possess an IT innovation investment opportunity to upgrade their platforms. The two platforms' market demand follow geometric Brownian motion process and we set α=1.5%, σ=10%, r=5%, I=60million, C=2million. Supposed that after upgrading they would possess an absolutely new market, that is $D(0,1)=D(0,0)=0$. For convenience of calculation we set $D(1,0)=1$. In the following we will assign a few of numerical simulation to k (<1) and $D(1,1)/D(1,0)$ (<1) with the purpose of obtain the investment threshold and equilibrium results shown in table 1:

Table 1. The effect of network externality and declining IT cost on equilibrium

IT cost decline coefficient k	Network externality coefficient $D(1,1)/D(1,0)$	(Platform 1's investment threshold, Platform 2's investment threshold)	Equilibrium results
1	1	(6.16 , 6.16)	Simultaneous equilibrium
	0.9	(6.16 , 6.84)	Sequential equilibrium
	0.6	(6.16 , 10.27)	Sequential equilibrium
	0.3	(6.16 , 20.53)	Sequential equilibrium
0.9	1	(5.54 , 5.54)	Simultaneous equilibrium
	0.9	(6.16 , 6.16)	Simultaneous equilibrium
	0.6	(6.16 , 9.24)	Sequential equilibrium
	0.3	(6.16 , 18.48)	Sequential equilibrium
0.6	1	(3.70 , 3.70)	Simultaneous equilibrium
	0.9	(4.11 , 4.11)	Simultaneous equilibrium
	0.6	(6.16 , 6.16)	Simultaneous equilibrium
	0.3	(6.16 , 12.32)	Sequential equilibrium
0.3	1	(1.85 , 1.85)	Simultaneous equilibrium
	0.9	(2.05 , 2.05)	Simultaneous equilibrium
	0.6	(3.08 , 3.08)	Simultaneous equilibrium
	0.3	(6.16 , 6.16)	Simultaneous equilibrium

Table 1 shows that:

(1) There can be two kinds of equilibrium strategies, namely simultaneous equilibrium and sequential equilibrium when we take into account the interaction of network effect and IT cost decline.

(2) Consistent with equilibrium analysis conclusion in previous section, equilibrium results depend on the relative magnitude of the two variable factors. When the network effect level is larger ($D(1,1)/D(1,0)$ being a smaller value), threshold of leader is lower than that of the follower and a sequential equilibrium works out; when the IT cost decline level is larger (k being a smaller value), threshold of follower is lower or equal that of the leader and a simultaneous equilibrium comes about.

(3) When there is a fixed IT cost decline level, follower's investment threshold is positively related to network effect. With the decrease of the value of $D(1,1)/D(1,0)$, follower's investment threshold becomes larger.

(4) Without consideration of network effect, follower's investment critical value has negative relation to IT cost decline level. The threshold decreases as k' s value decreasing.

6. THE CONCLUSION

In this paper, we focus on B2B e-commerce platforms' IT investment timing strategy of which the core business is to provide trade service for small and medium Enterprises on internet market. Considering two important characteristics of B2B platform, network externality and IT cost decline, we build up a duopoly B2B platform IT innovation investment decision-making model based on the foundation framework of Huisman-Kort model. By solving this option game model, we offer the payoffs and threshold of investment based on which equilibrium and numeric analysis were discussed on B2B platforms' investment strategies. Result shows that there exist two kinds of equilibrium investment strategy, simultaneous equilibrium and sequential equilibrium, with the interplay of the level of IT cost decline and network effect.

Our work can offer guidance on IT innovation investment timing strategy for B2B e-intermediaries. However, due to various restricts, there are still several some aspects need to be further perfected. Firstly, the number of agent in the model can expand to multi-oligopolies to further discuss firms' strategic interaction among the whole industry which is more consistent with reality that more than one platform would like to be the follower after observing the leader have succeed in IT innovation. Secondly, the study should be performed under an incomplete information setting as no firm can obtain perfect information of rivals in the competitive investment environment. In our further research, we will concentrate on the above factors so as to accord better with the realistic market.

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