ICIC Express Letters
Volume **11**, Number **6**, June **2017**

ICIC International ©2017 ISSN 1881-803X
pp. 1153–1158

GAME ANALYSIS FOR LOGISTICS MODE DECISION OF B2C ENTERPRISES

Rui Ding[1], Yunfu Huo[1,2,*] and Huipo Wang[1]

[1]School of Economics and Management
[2]Research and Development Center of e-Commerce and Modern Logistic
Dalian University
No. 10, Xuefu Avenue, Jinzhou New District, Dalian 116622, P. R. China
dingrui810908@163.com; *Corresponding author: josephhuo@sina.com

Received November 2016; accepted February 2017

Abstract. *In this paper, we use Cournot-Stackerberg game model discussing the equilibrium sales, price and profits of different types of logistics distribution mode for B2C enterprise; the results show that: At a certain level of the service efforts, the purchasing cost and monitoring cost of logistics outsourcing satisfy a certain range, and there is an equilibrium outcome between B2C enterprise with self-operational logistics mode and outsourcing logistics mode. With the increase of monitoring cost of outsourcing, B2C enterprise with self-operational logistics will get more competitive advantages than outsourcing logistics. When B2C enterprise with self-operational logistics and outsourcing logistics both improve their logistics service level, B2C enterprise with self-operational logistics will lose competitive advantages.*
Keywords: B2C Enterprises, Logistics mode, Game analysis

1. Introduction.

In recent years, with the rapid development of network economy, B2C e-commerce has emerged as a burgconing economic phenomenon. According to the data of China e-Business Research Centre [1], China's e-commerce market size reached 18.3 trillion yuan in 2015, and the B2C online retail market size reached 3.8 trillion yuan, which is accounted for 20.8% of the whole e-commerce market share. In recent years, the bottlenecks of logistics and distribution greatly restrict people's enthusiasm for online shopping, and poor logistics services make the e-business enterprise brand severely damaged. At present, B2C enterprises in the market such as Jingdong, Taobao, Dangdang, Joyo Amazon, mainly use two kinds of logistics modes – self-operational logistics, outsourcing logistics or their combination. Correct logistics mode not only makes consumers satisfaction, but also makes the better development of B2C enterprises. How to determine the appropriate logistics mode has become an urgent problem for developing e-commerce.

X. Xiao et al. [2] and Y. Lv et al. [3] separately use analytical hierarchy process (AHP) and fuzzy analytical hierarchy process (FAHP) approach to select the logistics mode of B2C enterprise. S. D. Yang [4] use Hotelling model finding that when B2C enterprises are willing to pay extra for consumer safety costs, consumers are willing to choose self-built logistics distribution mode for safety, and the flexibility of outsourcing logistics is still attractive for many consumers. X. P. Guo [5] uses Hotelling model finding that self-operational logistics mode has more extra levels than outsourcing of logistics services, and when achieving a certain degree, self-operational logistics may gain greater market share and profits than outsourcing logistics. In this paper, we mainly discuss the influence of monitoring cost and logistics service level for logistics mode selection, the dynamic competition process of different types of distribution models were analyzed based on Cournot-Stackerberg game model, and the general logistics mode selection rules of e-commerce B2C enterprise were given.

The rest of the study is organized as follows. Section 2 elucidates the key technology-driven parameters and describes the basic analytical model of competition. Section 3 builds on the basic model in Section 2 to analyze the impact of differential parameters on the equilibrium outcomes in the two B2C enterprises. We perform an empirical analysis of parameters in Section 4. And we conclude the management inspiration and the prospects of the future research in Section 5.

2. **Problem Description and Model Assumptions.** (I) Its hypothesis is that in a certain market, there are quite few powerful competitive B2C enterprises, which we regard as a typical duopoly competition (such as Jingdong and Tianmao), and then the game players are: B2C enterprise with self-operational logistics mode, B2C enterprise with outsourcing logistics mode, the third party logistics (3PL) enterprise, and consumers. (II) Under the complete information environment, we suppose all the game players are rational persons, and the action order is: first, the B2C enterprises determine their logistics service level; second, the B2C enterprises determine their logistics mode: if they select outsourcing mode, 3PL enterprise determines the outsourcing price; otherwise, B2C enterprises with self-operational logistics digest their logistics cost themselves; third, the B2C enterprises decide their equilibrium sales, prices and profits; fourth, consumers decide whether to accept the price or not. (III) Suppose that the customers' demand is in a unit market, and the two B2C enterprises sell the same products; the only difference between the two enterprises is the type of logistics mode – self-operational or outsourcing; people choose which B2C enterprises is determined by price and level of logistics service satisfaction. The model is as follows.

The price of enterprise 1 (with self-operational logistics) is

$$P_1 = 1 - q_1 - q_2 + S_1 \tag{1}$$

The price of enterprise 2 (with outsourcing logistics) is

$$P_2 = 1 - q_1 - q_2 + S_2 \tag{2}$$

(q_1 and q_2 are the customers' demand from B2C enterprises; S_1 and S_2 are the logistics service level of B2C enterprises). Usually the cost of the product purchasing from network contains two parts: purchasing cost and logistics cost; we suppose W is the unit purchasing cost from 3PL enterprise, and the unit distribution cost in different kinds of logistics mode is equal, it is negligible to 0, and then the logistics cost is made of service cost of self-operational logistics and monitoring cost of outsourcing logistics; suppose C_t is the unit monitoring cost of outsourcing logistics, and according to [6,7], the logistics service cost can be represented by quadratic function of logistics service level, which is denoted as $\frac{k}{2}S_i^2$, (k is the units service costs), and then:

The profits of enterprise 1 are

$$\pi_1 = (1 - q_1 - q_2 + S_1)q_1 - \frac{k}{2}S_1^2 \tag{3}$$

The profits of enterprise 2 are

$$\pi_2 = (1 - q_1 - q_2 + S_2)q_2 - Wq_2 - C_t q_2 \tag{4}$$

The profits of 3PL enterprises are

$$\gamma = Wq_2 - \frac{k}{2}S_2^2 \tag{5}$$

3. **Game Analysis.** Use backward induction to solve this problem. First, the B2C enterprises compete to maximize their own profits, and they get equilibrium sales and equilibrium prices. According to Equations (3) and (4), we get $\frac{\partial^2\pi_1}{\partial q_1^2} = -2 < 0$ and $\frac{\partial^2\pi_2}{\partial q_2^2} = -2 < 0$, so π_1 and π_2 have the maximum value. The Nash equilibrium sales exist where (6) is satisfied:

$$\begin{cases} \dfrac{\partial\pi_1}{\partial q_1} = 1 - 2q_1 - q_2 + S_1 = 0 \\ \dfrac{\partial\pi_2}{\partial q_2} = 1 - q_1 - 2q_2 + S_2 - W - C_t = 0 \end{cases} \tag{6}$$

From Equation (6), we get the equilibrium sales for the B2C enterprises as follows:

$$q_1^* = \frac{2S_1 - S_2 + C_t + W + 1}{3} \tag{7}$$

$$q_2^* = \frac{2S_2 - S_1 - 2W + 1 - 2C_t}{3} \tag{8}$$

Plug (7) and (8) into Equations (1) and (2), and we get the equilibrium prices as follows:

$$P_1^* = \frac{2S_1 - S_2 + C_t + W + 1}{3} \tag{9}$$

$$P_2^* = \frac{2S_2 - S_1 + C_t + W + 1}{3} \tag{10}$$

Plug (7) and (8) into Equations (3)-(5), and we get the equilibrium profits as follows:

$$\pi_1^* = \frac{(2S_1 - S_2 + C_t + W + 1)^2}{9} - \frac{k}{2}S_1^2 \tag{11}$$

$$\pi_2^* = \frac{(2S_2 - S_1 - 2W + 1 - 2C_t)^2}{9} \tag{12}$$

$$\gamma^* = \frac{W(2S_2 - S_1 - 2W + 1 - 2C_t)}{3} - \frac{k}{2}S_2^2 \tag{13}$$

Second, the B2C enterprise with self-operational logistics and 3PL enterprise compete to maximize their own profit, and they get the equilibrium logistics service level. According to (11) and (13), we get $\frac{\partial^2\pi_1^*}{\partial S_1^2} = \frac{8}{9} - k$ and $\frac{\partial^2\gamma^*}{\partial S_2^2} = -k$, so when $k \geq \frac{8}{9}$, π_1^* and γ^* have the maximum value. The Nash equilibrium sales exist where (14) is satisfied:

$$\begin{cases} \dfrac{\partial\pi_1^*}{\partial S_1} = \dfrac{4(2S_1 - S_2 + C_t + W + 1)}{9} - kS_1 = 0 \\ \dfrac{\partial\gamma^*}{\partial S_2} = \dfrac{2W}{3} - kS_2 = 0 \end{cases} \tag{14}$$

From Equation (14), we get the equilibrium logistics service level for the B2C enterprises as follows:

$$S_1^* = \frac{4[3k(C_t + W + 1) - 2W]}{3k(9k - 8)} \tag{15}$$

$$S_2^* = \frac{2W}{3k} \tag{16}$$

Plug (15) and (16) into Equations (7)-(13), and we get the equilibrium sales, equilibrium prices, and equilibrium profits as follows:

$$q_1^* = \frac{3k(C_t + W + 1) - 2W}{9k - 8} \tag{17}$$

$$q_2^* = \frac{9k^2(1 - 2W - 2C_t) + 12k(2W + C_t - 1) - 8W}{3k(9k - 8)} \tag{18}$$

$$P_1^* = \frac{3k(C_t + W + 1) - 2W}{9k - 8} \tag{19}$$

$$P_2^* = \frac{9k^2(C_t + W + 1) - 12k(C_t + 1) - 8W}{3k(9k - 8)} \tag{20}$$

$$\pi_1^* = \frac{[3k(C_t + W + 1) - 2W]^2}{9k(9k - 8)} \tag{21}$$

$$\pi_2^* = \frac{\left[9k^2(1 - 2W - 2C_t) + 12k(2W + C_t - 1) - 8W\right]^2}{9k^2(9k - 8)^2} \tag{22}$$

$$\gamma^* = \frac{W\left[27k^2(1 + 2W + 2C_t) + 4k(16W - 9 + 9C_t) - 8W\right]}{9k(9k - 8)} \tag{23}$$

($W \geq 0$, $C_t \geq 0$, and $k \geq 8/9$). For $q_2^* \geq 0$, $9k^2(1-2W-2C_t)+12k(C_t+2W-1)-8W \geq 0$, and this is a one-variable quadratic inequality about k; with the help of Vieta theorem, if $W + C_t > \frac{1}{2}$, when the roots of the equation are less than zero, it is obviously false; and when the roots of the equation are greater than zero, $f\left(\frac{8}{9}\right) = -\frac{8}{9}W - \frac{32}{9}C_t - \frac{32}{9} < 0$ is also false, so we get $W + C_t < \frac{1}{2}$. With the help of Vieta theorem, k is greater than or equal to the positive roots of the equation, so $k \geq \frac{-12(2W+C_t-1)+\sqrt{144(2W+C_t-1)+218W(1-2W-2C_t)}}{18(1-2W-2C_t)}$; we simplify it as $k \geq \frac{2}{3} \times \frac{-(2W+C_t-1)+\sqrt{(C_t-1)^2-2W}}{(1-2W-2C_t)}$; suppose $\iota = 1 - 2W - 2C_t$, then $\iota \leq 1$ and $\frac{1}{\sqrt{\iota}} \geq 1$, so $k \geq \frac{2}{3} \times \frac{\iota+C_t+\sqrt{C_t^2+\iota}}{\iota} \geq \frac{2}{3} \times \frac{\iota+\sqrt{\iota}}{\iota} = \frac{2}{3} + \left(1 + \frac{1}{\sqrt{\iota}}\right) \geq \frac{4}{3}$.

Proposition 3.1. *With the increase of the unit monitoring cost of outsourcing logistics, the game equilibrium price for B2C enterprise with self-operational logistics and outsourcing logistics will both increase, the game equilibrium sales and profits for B2C enterprise with self-operational logistics will increase, and will decrease for B2C enterprise with outsourcing logistics.*

Proof: For $k \geq \frac{8}{9}$, $\frac{\partial q_1^*}{\partial C_t} = \frac{3k}{9k-8} > 0$, $\frac{\partial P_1^*}{\partial C_t} = \frac{3k}{9k-8} > 0$. For $S_1^* = \frac{4[3k(C_t+W+1)-2W]}{3k(9k-8)} \geq 0$, $\frac{\partial \pi_1^*}{\partial C_t} = \frac{2[3k(C_t+W+1)-2W]}{3(9k-8)} \geq 0$; it shows that with the increase of the unit monitoring cost of outsourcing, the game equilibrium sales, price, and profits for self-operational logistics will increase; for $k \geq \frac{4}{3}$, $\frac{\partial q_2^*}{\partial C_t} = \frac{2(2-3k)}{9k-8} < 0$, and $\frac{\partial P_2^*}{\partial C_t} = \frac{3k-4}{9k-8} > 0$. For $q_2^* = \frac{9k^2(1-2W-2C_t)+12k(2W+C_t-1)-8W}{3k(9k-8)} \leq 0$, $\frac{\partial \pi_2^*}{\partial C_t} = \frac{4(2-3k)\left[9k^2(1-2C_t-2W)+12k(2W+C_t-1)-8W\right]}{3k(9k-8)^2} \leq 0$; it shows that with the increase of the unit monitoring cost of outsourcing, the game equilibrium price for outsourcing logistics will increase, and the game equilibrium sales and profits for outsourcing logistics will decrease.

Proposition 3.1 shows that with the increase of monitoring cost of outsourcing, B2C enterprise with self-operational logistics has more competitive advantages than outsourcing logistics. At present, 3PL enterprises in China are still in preliminary stage, market system and related laws are not perfect, and this leads to poor service quality, information disclosure, information asymmetry and other dishonest behaviors; it brings us very great difficulty in logistics monitoring. So to control the transaction cost that will determine the final market power, we should establish stable relations of cooperation to make trading conditions improve.

Proposition 3.2. *With the increase of the unit logistics service level, the game equilibrium sales, price and profits for B2C enterprise with self-operational logistics will decrease, and will increase for B2C enterprise with outsourcing logistics.*

Proof: For $W \geq 0$ and $C_t \geq 0$, $\frac{\partial q_1^*}{\partial k} = \frac{-6(4C_t+W+4)}{(9k-8)^2} < 0$, $\frac{\partial P_1^*}{\partial k} = \frac{-6(4C_t+W+4)}{(9k-8)^2} < 0$; for $q_1^* = \frac{3k(C_t+W+1)-2W}{9k-8} \geq 0$, $\frac{\partial \pi_1^*}{\partial k} = \frac{-4[3k(C_t+W+1)-2W][9k(6C_t+5W+6)+4W]}{[9k(9k-8)]^2} \leq 0$; it shows that with the increase of the unit logistics service cost, the game equilibrium sales, price and profits for B2C enterprise with self-operational logistics will decrease; for $k \geq \frac{4}{3}$, $W \geq 0$, $C_t \geq 0$, and $W + C_t < \frac{1}{2}$, $1 - 2C_t - 2W > 0$ and $2 - C_t - W > 0$, and then $\frac{\partial q_2^*}{\partial k} = \frac{147(1-2W-2C_t)k^3+72k^2(2-W-C_t)+144kW-64W}{3k^2(9k-8)^2} > \frac{(144k-64)W}{3k^2(9k-8)^2} \geq 0$; for $k \geq \frac{4}{3}$ and $W+C_t < \frac{1}{2}$, $9k-4 > 0$ and $C_t+1-2W > 0$, and then $\frac{\partial P_2^*}{\partial k} = \frac{36k^2(C_t+1-2W)+16W(9k-4)}{3k^2(9k-8)^2} > 0$, $\frac{\partial \pi_2^*}{\partial k} = 2q_2^* \times \frac{147(1-2W-2C_t)k^3+72k^2(2-W-C_t)+144kW-64W}{3k^2(9k-8)^2} > 0$; it shows that with the increase of the unit logistics service costs, the game equilibrium sales, price and profits for B2C enterprise with outsourcing logistics will increase.

Proposition 3.2 shows that when B2C enterprises with self-operational logistics and with outsourcing logistics both improve their service level at the same time, the advantage of B2C enterprise with outsourcing logistics is more than B2C enterprise with self-operational logistics. The main reason that consumers tend to self-operational logistics is that the service level of self-operational logistics is usually higher than 3PL logistics; when B2C enterprises with self-operational logistics and with outsourcing logistics both improve their service level, the advantage of B2C enterprise with self-operational logistics is reduced, and the possibility of B2C enterprise choosing logistics outsourcing will increase greatly.

4. **Numerical Example.** To examine if the analytic results hold, we perform an empirical analysis of parameters at a B2C enterprise with self-operational logistics and a B2C enterprise with outsourcing logistics. Using the settings $W = 0.25$ and $k = 4$, then $0 < C_t < 0.25$. Figure 1 presents the tendency of equilibrium price increasing with C_t $(0 < C_t < 0.25)$. It shows that with the increase of monitoring cost, two enterprises both improve their sale price, and the growth of B2C enterprise with self-operational logistics is slightly faster than outsourcing logistics.

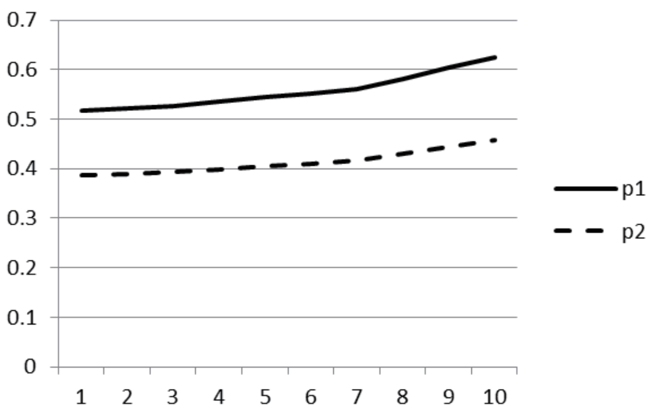

FIGURE 1. Sensitivity analysis of the unit monitoring cost for equilibrium price

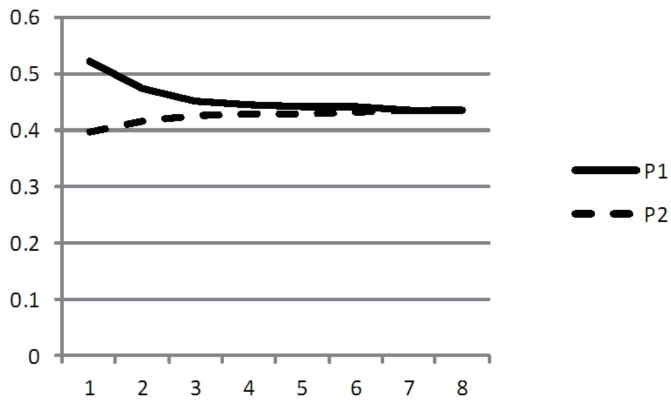

FIGURE 2. Sensitivity analysis of the unit service level for equilibrium price

Using the settings $W = 0.1$, $C_t = 0.2$, Figure 2 presents the tendency of equilibrium price increasing with k ($k \geq \frac{4}{3}$). It shows that with the increase of service level, the equilibrium price for B2C enterprises with self-operational logistics and outsourcing logistics tends to be uniform. In real life, when B2C enterprises with outsourcing logistics choose 3PL enterprise with good service, they usually pay a higher purchasing cost, so they will increase the sale price.

5. **Conclusions.** In this paper, we studied the selection of logistics distribution mode for B2C e-commerce enterprises based on the Cournot-Stackerberg game theory; we found that the monitoring cost of logistics outsourcing and the efforts of logistics service level both affect the selection of logistics mode, and reducing monitoring cost and improving service level are good for outsourcing logistics. There are several limitations in this paper, as for the future research direction: firstly, we regard the unit logistics distribution cost is equal, which can be widespread differently in different kinds of logistics mode; secondly, this study considers the same unit logistics service level, but in fact B2C enterprise with self-operational logistics and 3PL enterprise usually have different service efforts; thirdly, we only consider the influence of monitoring cost and logistics service level of the B2C enterprise, and with the development of the real life, we should incorporate new factors into the model.

Acknowledgment. This work is partially supported by the National Natural Science Foundation of China No. 71372120, Dalian City Association of Social Science No. 2015dl-skzd129, and Dalian Jinzhou New District Science and Technology Project No. KXYJ-RKX-2015-001.

REFERENCES

[1] *China's E-commerce Market Data Monitoring Report for 2015*, http://www.100ec.cn/zt/2015ndbg (May 17, 2016).

[2] X. Xiao, Y. Liu, Z. Zhang and X. Guan, The analysis to the logistics mode decision of B2C, *Proc. of the 2nd International Conference on Logistics, Informatics and Service Science*, pp.1129-1134, 2013.

[3] Y. Lv, H. S. Sun and X. F. Wang, Research on choice of logistics mode of B2C enterprises with FAHP, *Applied Mechanics & Materials*, pp.672-674, 2014.

[4] S. D. Yang, Game analysis for logistics distribution mode choice of B2C e-commerce enterprise, *Northern Economy and Trade*, no.9, pp.34-35, 2013.

[5] X. P. Guo, Game analysis for selecting logistics distribution mode – Self-built or outsourcing, *Market Modernization*, no.21, pp.66-67, 2015.

[6] J. Tirole, *The Theory of Industrial Organization*, MITPress, Boston, MA, 1988.

[7] M. H. XU, G. Yu and H. Q. Zhang, Game analysis in a supply chain with service provision, *Journal of Management Science in China*, vol.9, no.2, pp.18-27, 2006.