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Game Model for “shortage of logistics” in Online Shopping in Service Engineering

Haoxiong Yang^{a*}, Mengnan Zhang^a, Jing Wang^a, Xinjian Du^a^a*School of Business, Beijing Technology and Business University, Beijing, 100048***Abstract**

This paper analyzes the imbalance between e-commerce and logistics service by using factor sub-game perfect Nash equilibrium as an analytical tool from the view of system and links up the bargaining process between sellers and express enterprise involved in service engineering during online shopping with discount factor. The change of interests between sellers and express enterprise is systematically analyzed from the perspective of discount factor on the equilibrium solution through the application of model towards service engineering during holidays online shopping. Finally it is concluded that discount factor is a key factor influencing the express fee between sells and express enterprise in logistic system, and some recommendations are put forward accordingly.

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Open access under [CC BY-NC-ND license](https://creativecommons.org/licenses/by-nc-nd/4.0/).*Keywords:* holiday online shopping, service engineering, shortage of logistics, Game Theory, discount factor**1. Introduction**

With the development of commerce trading platform, more and more consumers make online shopping in service engineering as their first choice to purchase goods. Especially on holidays, online shopping sales of various products have huge increase in varying degrees, for example, during Spring Festival, online shopping sales grew over 160 percent, the daily trading volume are about 80 percent higher than usual. However, the large number of orders and sales exceed express enterprise's normal volume of operation system, meanwhile, couriers return home successively and there is no extra staff transfer course in service engineering during holidays, service that the couriers offered cannot meet the demand for logistics services during the holidays, and then temporary " shortage of logistics " phenomenon in logistic system of enterprise in service engineering arose.

In order to meet the demand for the market, ease “shortage of logistics” in service engineering that happens during the holiday, express enterprise need more funding to ensure full year operation as usual standards, this increase the operation cost of the logistic system in express enterprise involved in service engineering, they should arise the express fee transfer to logistics demander in order to reduce the cost loss. However, the purpose of seeking profit determined its nature. During the bargaining process, as the two parties involved in the logistics service engineering, express enterprise and sellers need to maximize relatively profit and to seek more reasonable delivery fee in order to release the “shortage of logistics” in service engineering that happens during holiday, thus it is a game problem that take place in the profitability and market development of express delivery companies.

Currently, there are many studies related to the bottlenecks of e-commerce logistics distribution in service engineering, Tang Shiqiang and other scholars state that the breakthrough of e-commerce logistic bottlenecks is to establish an efficient and reasonable modern logistics distribution system. Ran Baosong explores the answer of

logistics shortage during Chinese traditional Spring Festival from the perspective of online shopping platform's self-built logistics. David B. Grant and other scholars point out that the key to improve quality and efficiency of operation is dealing with the balance of cost between online shopping retailers and logistics distribution Company through their research. In short, the discussion of releasing online shopping "shortage of logistics" in service engineering mainly focus on systematic analysis of the lag situation of e-commerce logistics distribution, it seldom related to logistics bottlenecks in service engineering during holidays and lack of realistic theoretical model to further study this problem systematically. This paper bring in time variable (discount factor) based on Nash static equilibrium according to Robin stein bargaining model, gain sub-game perfect Nash equilibrium solution and proposed some applicable suggestion of this model towards service engineering during holidays from the view of system.

2. An analysis of the formation of online shopping "shortage of logistics"

The imbalance between logistics supply and demand service market lead to the appearance of temporary "shortage of logistics" phenomenon in service engineering, which affect the process of normal distribution business, but the payment balance of express fee related to the two parties involved in express delivery is the underlying causes that generate this phenomenon

When online shopping transaction happens, the buyer and express enterprise did not take place fee contact directly, but take indirect fee payment through seller, that means seller of online shopping contact express enterprise and pay express fee forward for the buyer, therefore express enterprise and seller take online shopping transaction as the two parties of logistics service. Only if the two parties reach a consensus with the price of logistics service (express fee) during bargaining, express delivery transaction can progress smoothly. However, the equilibrium is broken by the unbalance of logistics supply and demand service market during holidays. When the supply of logistics service market cannot meet the demand, express enterprise hope to gain funds through increasing express fee, in order to encourage more courier staying in their jobs and attract more workforce joining in courier service to make the supply and demand of logistics service market back to equilibrium.

However, the express enterprise and the seller both have the tendency to pursue self-interest maximization, they all hope to minimize their own delivery cost after accomplish the business deal. The transaction gain that allocated between the two parties as unit "1" is the discrepancy between the highest price that seller will to pay and the lowest price that express enterprise will to accept. When the two parties reach a consensus in how to share this unit "1" during bargaining, the new equilibrium state is formed to keep the transaction progressing sequentially. Therefore, the game process of online shopping express fee during holidays is a repeated Zero-sum game process that express enterprise as logistics service supplier and seller as logistics service demander bargain to reach a consensus on logistics service price.

In summary, for the reason of fierce unbalance of logistics service engineering market during the holidays, the equilibrium state of the two parties of logistics service is broken, express delivery cannot progress smoothly, thus express enterprise and seller involved in service engineering need to take express fee game to re-establish a more reasonable equilibrium fee price that satisfied by both parties. Under this equilibrium state, the phenomenon of "shortage of logistics" in service engineering can be alleviated; the supply and demand of logistics service engineering market can reach a balance.

3. Model Formulation

3.1. The basic assumptions

1. During game process of express fee payment, assuming there are two players, one is S (express enterprise), another is B (seller). They bargain for the allocated rest and bid alternately. Firstly, player B bid P_1 for the logistics service, then player B pay P_1 , player S pay $(1 - P_1)$ in the first stage.

2. In the game model, provided player S (express enterprise) and player B (seller) share gains of unit "1". Strategy set of player B is $P_B \in [0,1]$ and that of player S is $P_S \in [0,1]$.

3. Firstly assuming player B bid P_1 for logistics services, then player S accepts or refuses the price. If player S accept it, the first round game finish and the transaction is completed on this bid. But if player S refuses the first bid, he should make a counteroffer P_2 . Player B accepts or refuses the counteroffer, and then this round finish. There is

no limit about the number of bid round, only if the player refuses the bid, game will progress sequentially, and the game will progress forever theoretically.

4. The discount factor of the two players are δ_s, δ_B respectively, and $\delta_s \in [0,1], \delta_B \in [0,1]$. Because of the cost of negotiation and the loss of interest, bargain one more round, the express fee that the two players take should multiply δ . The discount factor is determined by the “patience” of the two players toward logistics service, the less patience, the lower discount factor δ is.

5. Assuming this game has infinite number of sub-game, one of the sub-games is the game itself. Use G_1 represents this game. Assuming this game has at least a sub-game perfect Nash equilibrium. In the sub-game perfect Nash equilibrium of G_1 , Q_B and q_B represents the maximum and minimum gain of player B respectively. Another sub-game of the whole game is called game G_2 , which begin with the sub root that player S make the first counteroffer to player B. Q_S and q_S represents the maximum and minimum gain that player S can get from the sub-game perfect Nash equilibrium of G_2 respectively. The third sub-game begins with the sub root that player B makes the second bid to player S, which is called game G_3 . Game G_3 and game G_1 has the same pattern of beginning that is player B bid to player S.

6. If there is no difference that the player accept or refuse the bid, assuming accept the bid, the bargaining game has an only sub-game perfect Nash equilibrium.

3.2. Game process of express fee payment

In the first round of express fee bargaining game model, firstly, seller of online shopping bid P_1 for logistics service, seller (player B) and express enterprise (player S) pay $(P_1, 1 - P_1)$ respectively, that means the express fee that seller paid is P_1 , and the express enterprise is asked to pay $(1 - P_1)$, the express enterprise accept and refuse this bid. If express enterprise accepts the bid P_1 , the game of first round finish and the transaction is completed on this bid. If it refuses this bid, then they go into the second round.

In the second round, express enterprise makes a counteroffer P_2 and asks seller paying P_2 , if the seller accept the counteroffer P_2 , the express fee that seller pays is $\delta_s \cdot P_2$ and express enterprise pays is $\delta_s \cdot (1 - P_2)$. If seller refuse this bid, the game progress sequentially and they go into the third round.

The third round and the round after reason by analogy, assuming two players make a deal in period t , the seller and express enterprise pay $(\delta_B^t \cdot P_t, \delta_S^t \cdot (1 - P_t))$ respectively.

3.3. Equilibrium solution of express fee game

According to the assumption, G_1 represent for the sub-game that seller of online shopping bid to express enterprise, G_2 represent the opposite process, and these sub-games have at least a sub-game perfect Nash equilibrium. In the sub-game perfect Nash equilibrium of G_1 , Q_B and q_B represents the maximum and minimum gain of seller respectively, Q_S and q_S represents the maximum and minimum gain that express enterprise can get from the sub-game perfect Nash equilibrium of G_2 respectively.

In the first round of G_1 , the seller, in order to get the opportunity to make its bid accepted (that is, to make its sub-game perfect), express enterprise must receive at least $\delta_s \cdot q_s$. This is for the reason that once the game goes into the sub-game G_2 , express enterprise must gain q_s and the next round of this game must be discounted by δ_s . If the express enterprise gain at least $\delta_s \cdot q_s$, and the total number of allocation is unit “1”, then the maximum that the seller gain is $1 - (\delta_s \cdot q_s)$. That means,

$$Q_B \leq 1 - (\delta_s \cdot q_s) \tag{1}$$

And so on, the boundaries of q_B can be obtained. If the bid that seller offers to express enterprise is greater than or equal to $\delta_s \cdot Q_S$, express enterprise accept it. Therefore, in the sub-game G_1 , there is no meaning if the bid of sell exceed $\delta_s \cdot Q_S$. This means seller can gain at least $1 - (\delta_s \cdot Q_S)$ immediately, namely,

$$q_B \geq 1 - (\delta_s \cdot Q_S) \tag{2}$$

In the sub-game G_2 , if seller refuse the counteroffer that express enterprise offered, the game goes into sub-game G_3 , seller make its second bid. It's easy to prove that reversed the previous logic location of seller and express enterprise can get restrict as follows,

$$Q_S \leq 1 - (\delta_B \bullet q_B) \tag{3}$$

$$q_S \geq 1 - (\delta_B \bullet Q_B) \tag{4}$$

Simultaneous inequalities (1) (2) (3) (4) can get result,

$$Q_B = q_B = \frac{1 - \delta_S}{1 - (\delta_S \bullet \delta_B)} , \quad Q_S = q_S = 1 - \frac{1 - \delta_S}{1 - (\delta_S \bullet \delta_B)} = \frac{\delta_S \bullet (1 - \delta_B)}{1 - (\delta_S \bullet \delta_B)}$$

In summary, this bargaining game has an only sub-game perfect Nash equilibrium, the sub-game perfect solution is $(\frac{1 - \delta_S}{1 - (\delta_S \bullet \delta_B)}, \frac{\delta_S \bullet (1 - \delta_B)}{1 - (\delta_S \bullet \delta_B)})$. When $\delta_B = \delta_S, \delta \in (0,1)$, the sub-game perfect solution is $(\frac{1}{1 + \delta}, \frac{\delta}{1 + \delta})$.

3.4. Interpretation of equilibrium solution

In the game model, discount factor δ_S represents the supply degree of logistics service that express enterprise offers, δ_B represents the demand degree of logistics service that seller offers.

1. If δ_B fixed, $\delta_S \rightarrow 1$, the sub-game perfect equilibrium solution is (0,1), seller almost pay all of the express fee. The greater δ_S is, bargaining one more round, the lower loss of express enterprise takes, therefore it seems has more patience. Similarly, if δ_S fixed, $\delta_B \rightarrow 1$, it means that seller has more patience, express enterprise will take the whole fee. When the discount factor of seller is fixed, express enterprise is more patient and the express fee it pays is less. Conversely, when the discount factor of express enterprise is fixed, seller is more patient and the express fee it pays is less. As shown in figure 1.

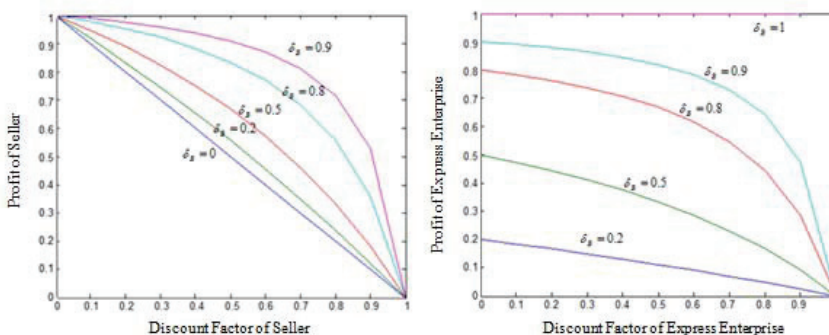


Figure 1: The influence of discount factor towards profit of the two parties

2. If $\delta_S = 0$, for seller, if only $0 < \delta_B < 1$, they will not take any express fee, because $\delta_S = 0$ means that express enterprise has no patience, it will accept any bid without bargaining. On the contrary, for the express enterprise, the situation is not necessarily so, if $0 < \delta_S < 1$, and $\delta_B = 0$, the profit that seller gain is $1 - \delta_S$, express enterprise gains δ_S . Therefore, seller bid first, even only gain $1 - \delta_S$, is much better than the situation of express enterprise.

3. If $\delta_{express} = \delta_{seller} = \delta < 1$, sub-game perfect solution is $(\frac{1}{1 + \delta} > \frac{1}{2}, \frac{\delta}{1 + \delta} < \frac{1}{2})$, namely express enterprise always pays more fees than seller. As shown in figure 2.

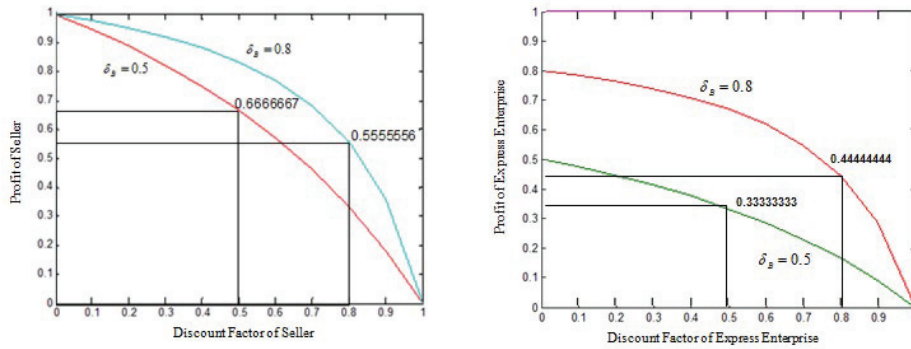


Figure 2: The profit comparison of the two parties when $\delta_{express} = \delta_{seller}$

4. If both seller and express enterprise have patience, $\delta \rightarrow 1$, so who bid first has little relations toward express fee payment, so the two parties will pay the express fee equally.

In general, the player who bid first has little first mover advantage, but when the bargaining round is unlimited, who bid first has little influence toward game solution. When the number of possible round is infinite, the equilibrium profit of two players is determinate, which is only depends on the discount factor of them. Generally, the player who is more patient, namely whose discount factor is greater can get more than half of the profit. With the effect of discount factor, the value of the same share that player gets on this and next round is different. After discount, the share of next round only equals to the share of this round multiply δ , which is less than the share of this round. Thus, player should accept the reasonable bid that the counterpart offered as soon as possible, otherwise, even if the player get the same or even more share in the bargaining of next round may be less than the share of this round.

4. Application recommendations of game model during holiday

Through the game model of express fee bargaining, seller and express enterprise in service engineering re-establish an equilibrium express fee that both parties satisfied. During the process of express fee bargaining, in order to reach a deal, two parties should rely on each other, but for the reason of diversity and randomness of choices that seller choose express enterprise, when the degree of increase in price are too high and the cooperation adversely, seller will turn to other express enterprise seeking cooperation. Thus, express enterprise often has no bid advantages during bargaining process. Under this curriculum, express enterprise should take full use of the profit it gains to improve the service level during holiday. Thus, in the bargaining process, the express delivery companies often do not have bid advantage. In this case, the express delivery companies should take full advantage of the gains to improve the level of service during the holidays.

Firstly, in order to alleviate the problem of low on-the-job rate, express enterprise can take sequential rest, motivate employees stay in their job by afford high wage or employ some local temporary worker to distribute goods during holidays. The demand of courier service during holidays is much more than usual, in order to meet the market demand which has sudden increase, express enterprise need sufficient workforce to afford courier service. The method of sequential rest can let the courier service employee work more intense during holidays and arrange them rest in usual, this can enhance on-the-job rate of employees effectively. If express enterprise need workforce immediately, they can retain current employees by raising wage or employ some local temporary worker to distribute goods. In this way, the pressure of lacking workforce that express enterprise facing can be released and the inadequate supply of logistic services market can be make up.

Besides, in order to improve the efficiency of logistics distribution, express enterprise can use the profit buying advanced equipments. Such as, changing distribution tools from artificial or semi-automatic bicycle to the faster cars, buying sorting machine replace artificial sorting goods and so on. Thus means using limited human resources meet more logistics demand, raise efficiency of work and alleviate conditions of resource shortage of express enterprise

In addition, express enterprises can take cooperation during the holidays for resource sharing and realize win-win in the industry. Express enterprises which have the ability to get the order can apportion their orders to other small enterprises, and express enterprises which have the ability of distribution can use its resources help other

enterprise share the pressure of order. In this way, they can realize win-win cooperation through the internal specialization and cooperation.

In addition, the express delivery companies can take a cooperative approach between the sharing of resources during the holidays, to achieve a win-win industry. Have the ability to get orders of express delivery companies can not meet its share of orders to other companies, and have the ability to make a delivery courier companies can use their resources to help pressure other companies share the order by the division of labor within the industry to achieve win-win situation.

Through the above ways, the equilibrium solution of express fee in service engineering during holidays can form benign circulation in the operation process, which makes a balance between logistics supply and demand service engineering market. To some extent, the solution will ease "shortage of logistics" in service engineering that happens during the holiday, reach a real full year service and smooth the logistics flow.

5. Conclusion and future work

This paper analyzes the phenomenon of the imbalance between the development of the electronic commerce and logistics service engineering from system perspective, and then it links up the bargaining process of the seller and express enterprise involved in logistic service engineering system with discount factor. The change of interests between sellers and express enterprise is systematically analyzed from the view of discount factor on the equilibrium solution through the application of model towards service engineering during holidays, and some recommendations are put forward accordingly to improve the efficiency in logistic service engineering system. Discount factor is the key factor which can influence the express fee payment, and the greater the discount factor is, the party is correspondingly at an advantage, which will afford less express fee.

This paper considers the time cost advantage between the two parties of the game-the influence towards express fee of discount factors, but in the real game process, there are many factors that can influence finally fee payment, and uncertainty factors will make the results of the model more complex, which may lead to more balanced category and more complex results, and this is the next step for the research to solve.

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