Signalling Game of Online Store Quality Based on Service Recovery

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Abstract. Changing attitudes of consumers shopping, online shopping has gradually become the mainstream. However, because of the characteristics of online shopping, there is information asymmetry in the process of trading, which makes it hard for customers to identify quality of online stores, causing a series of service failure. To solve this problem, this study regards the online store and customers as the game sides, and the level of service recovery as a signal, and establishes a signalling game model, under the three different relations of the two types of online store service failure probabilities, three Bayesian Equilibria of signal game is analyzed, and the only existence condition of the separating equilibrium is given respectively in three situation, and the countermeasures of online stores and customers in the case of information asymmetry are obtained.

1. Introduction

With the continuous maturity of network technology, customers’ consumption concepts have also changed a lot, from traditional offline shopping to online shopping [1]. This online shopping model gradually changed people’s living habits and created a new business model, which was favored by the majority of consumers. However, it cannot be ignored that, with the rapid development of the market, the service failure problem in the process of online shopping is becoming more and more prominent. According to statistics, the number of online shopping complaints in China ranks the top of the list of complaints. In the process of online shopping, customer complaints mainly focus on the product quality and description inconsistent, fake, shoddy, etc. The root cause of this situation is the asymmetric information of online shopping. Some low-quality stores disguise their stores as quality stores by means of favorable comments for cash back and brushing orders, which makes it difficult for customers to make judgments on their types, thus resulting in information asymmetry. Because of the degree of information asymmetry, it is easy to cause the problem of adverse selection. This paper attempts to study how should the stores take measures to pass the advantages and disadvantages of the store to customers, solve the "lemon market [2-3]" problem of online shopping.

This paper reviews the relevant literature from the two aspects of the occurrence mechanism of service failure of online shopping and the quality transfer mechanism of online stores through reviewing relevant literature at home and abroad. This research aims to find ways to reduce the service failure problems, and promote sustainable development of online shopping platform.

2. Related research review

2.1. Occurrence mechanism of service failure in online shopping process
With the development of service economy and network economy, many types of online service enterprises are developing rapidly, especially online shopping and tourism. The root of service failure in the online shopping process is the information asymmetry caused by the virtual characteristics of the network, which directly affects the adverse selection of the buyer and the moral hazard of the seller. Customers can judge the quality of products according to internal clues and external clues. Internal clues of products refer to their size, shape, etc. While external clues refer to price, brand name, packaging, etc. In tradition shopping, customers can according to the product's internal clues to judge its quality, but in the process of online shopping, because the information is separated from the real object and the product is separated from the consumer in space, the consumer cannot obtain the internal clues of the product as in the traditional shopping process. In general, information asymmetry in online shopping process is more serious than that in traditional shopping process, so service failure is more likely to occur.

2.2. Quality signal transmission mechanism of online store in the process of online shopping

Domestic and foreign scholars have conducted many theoretical and empirical studies on the problem of product quality information asymmetry, and found that a quality signal transmission mechanism can promote the continuous improvement of commodity quality in the food market. Compared with the traditional shopping process, the higher the uncertainty in the online shopping process, the higher the consumer's demand for signal transmission. In terms of the transmission of private product quality information, a large number of studies have been conducted in the economics literature, revealing that advertising, product price and other tools have the function of indirect hop transmission of quality information. Price and advertising strategy, as the signal transmission tool of product quality, are highly concerned and widely used as the quality and safety signal transmission tool. However, when information asymmetry appears in the market, low-quality will disguise their identity by raising the price, and the level of price no longer plays an obvious role in judging the type of store.

Chinese scholars such as Li Lei (2015) regard customer service level as the signal to transmit product quality in the article, Zhong Jingjing et al. (2017) consider the extra cost incurred by the service organization of production safety when the customer enterprise has a production safety accident, which is promised to assist the customer enterprise to carry out subsequent rectification, as a hidden transmission cost. However, there is a lack of research on online store quality.

Based on this, this paper takes the online stores and customers as the game parties, and the level of service recovery (the early commitment of online stores) as the signal, establishes the signal game model, and analyzes the conditions for the existence of the Refined bayesian equilibrium of the three signal games. The early service remedies promised by the online store to customers mainly include: guaranteed return of damaged products, 7 days' replacement without any reason, warranty, etc.

3. Description of signal game model

This paper constructs a three-stage dynamic game model between the asymmetric information store and the customers. C2 is used in this model to express that the online store is punished by the supervision department when the service fails (because this article is mainly to discuss service recovery play a role in the process of signal transmission, so in the event of a service failure, two types of online stores have punished both consistent). There are two costs for the store to deliver signals. One is the basic cost (publicity, training, advertising, etc.) C1 for the shop to deliver signals, and the other is the extra cost Cθ(R) that the store promises to reimburse customers in case of service failure. See table 1 for specific symbols and instructions. This paper makes the following assumptions about the signal game:
Table 1. symbols and descriptions

| The game party | Behavior collection | symbol | Syntactic meaning |
|----------------|---------------------|--------|-------------------|
| Deliver quality service | P_H | The selling price of a product or service when an online store chooses to deliver a quality service recovery signal |
| recovery signals | P_L | The selling price of a product or service when an online store chooses to deliver a low-quality service recovery signal |
| online store | C_H | The cost of products or services of quality online store |
| | C_L | The cost of products or services of low-quality online store products or services |
| a_H | The probability of quality online store service failure |
| Deliver poor service recovery signals | a_L | The probability of low-quality online store service failure |
| Select online stores | R_H | The basic cost that online store delivers a signal |
| | R_L | The invisible cost when online store delivers signal |
| customer | V_H | Revenue when customers choose quality stores |
| No-Select online stores | V_L | Revenue when customers choose low-quality stores |
| P | Customers lose when services fail |

Hypothesis 1: \( \theta = (\theta_1, \theta_2) \) represents the type space of the online store, \( \theta_1 \) means providing quality online store, and \( \theta_2 \) means providing low-quality online store.

Hypothesis 2: the probability of the quality online store is \( P(\theta=\theta_1)=q \), and the probability of the low-quality online store is \( P(\theta=\theta_2)=1-q \).

Hypothesis 3: the action set of the store is \( S(S_1, S_2) \), \( S_1 \) indicating that the store delivers the signal of quality service recovery and \( S_2 \) indicating that the store delivers the signal of poor service recovery.

Hypothesis 4: \( A = \{A_1, A_2\} \) represents the decision-making space of the customer, \( A_1 \) represents the customer's choice of online store, and \( A_2 \) represents that the customer does not choose the online store.

Hypothesis 5: the quality service recovery expected by customers is \( R_H \), and the minimum it is \( R_L \). When \( R \geq R_H \), the customer thinks that the online store is a quality online store, and chooses to buy its products or services at the price of \( P_H \). When \( R_L < R < R_H \), the customer thinks that the store is an inferior store, and chooses to purchase its products or services at the price of \( P_L \); When the service recovery issued by the online store is less than \( R_L \), customers choose not to buy. On the basis of this assumption, when the store chooses to deliver quality service recovery, as long as \( R \geq R_H \) can be satisfied, but when make this choice, the online store to pay a higher cost, the rational online store will choose \( R = R_H \). Similarly when the online store chooses to deliver inferior signal, \( R = R_L \).

Hypothesis 6: the two types of online stores have the same degree of service failure.

Game process: using Harsanyi Transformation \([21]\), introducing virtual participant--Nature. Nature acts first, determines online store type, then online store signals the level of service recovery, customer according to the signal from the online store, using Bayes' rule, get the posterior probability \( \bar{p} = p(\theta|S) \) of the online real type by the prior probability \( p(\theta) \), and then make decisions whether to choose. Using \( U_i(\theta_i, S_i, A_i)(i=1, 2) \) to represent the revenue function of both sides of the game, 1 represents the store, 2 represents the customer. The benefits of online stores and customers are shown in figure 1.

Figure 1. The dynamic game between the online store and the customer

4. Equilibrium analysis of signal game

All possible Refined bayesian equilibrium of signal transmission games can be divided into three categories: separating equilibrium, mixed equilibrium, and quasi-separating equilibrium \([22-25]\). Since the probability of failure of the two online store services is unknown, and \( a_1 < a_2 \) is only known, there are three situations on the probability relationship between the two types of stores' service failure as follows:

\[
\begin{align*}
\frac{a_2 - a_1}{a_2 - a_1} &< \frac{C^L(1) - C^H(1)}{PH - PL}, & \frac{a_2 - a_1}{a_2 - a_1} &> \frac{C^L(1) - C^H(1)}{PH - PL}, & \frac{a_2 - a_1}{a_2 - a_1} &> \frac{C^L(1) - C^H(1)}{PH - PL},
\end{align*}
\]
4.1. When \( \frac{a_2-a_1}{a_2-a_1} < \frac{c^H(R_L)-c^H(R_L)}{p_H-p_L} \), three equilibrium states are discussed as follow:

(1) The first kind of separating equilibrium: quality store chooses to deliver quality service recovery signal \( S_1 \), poor quality store chooses to relay defective service recovery signal \( S_2 \):

\[
\begin{align*}
&\bar{p}(0|S_1)=1, \bar{p}(0|S_2)=0, \bar{p}(0|S_2)=1, \bar{p}(0|S_1)=0
\end{align*}
\]

Proposition 1: when \( c^H(R_H) < \frac{p_H-P_L}{a_1} + c^H(R_L) \) and \( c^H(R_H) > \frac{p_H-P_L}{a_2} + c^H(R_L) \), high quality store selects \( R = R_H \), low quality store selects \( R = R_L \), the first kind of separating equilibrium appears.

Proof: According to hypothesis 5, as long as the service recovery level \( R \geq R_L \) observed by the customer, the customer will adopt the strategy of choosing this online store (A₁).

\[
\text{Proposition 2: when } c^H(R_H) > \frac{p_H-P_L}{a_1} + c^H(R_L) \text{ and } c^H(R_H) < \frac{p_H-P_L}{a_2} + c^H(R_L), \text{ high quality store selects } R = R_L, \text{ low quality store selects } R = R_n, \text{ the second kind of separating equilibrium appears.}
\]

Proof: According to hypothesis 5, as long as the service recovery level \( R \geq R_L \) observed by the customer, the customer will adopt the strategy of choosing this online store (A₁).

\[
\text{Proposition 3: when } c^H(R_H) > \frac{p_H-P_L}{a_1} + c^H(R_L) \text{ and } c^H(R_H) < \frac{p_H-P_L}{a_2} + c^H(R_L), \text{ high quality store selects } R = R_L, \text{ low quality store selects } R = R_n, \text{ the second kind of separating equilibrium appears.}
\]
(2) Pooling equilibrium

Both quality and low-quality online stores choose to transmit the same signal \( R = RH \) or \( R = RL \). At this time the customer cannot judge its type according to the signal that online store delivers. Again there are two types of pooling equalization depending on the type of signal.

1) The first type pooling equilibrium: both types of store choose to deliver the signal of quality service recovery, the first type of pooling equilibrium appears.

\[
\frac{p(\theta_1)}{p(\theta_2)} = \frac{p(\theta_1)q(\theta_2)}{p(\theta_2)q(\theta_1)} = \frac{q_1}{q_2} = \frac{q}{1-q}
\]

Proposition 3: when \( C^H(RH) = \frac{PH - PL}{a_1} + C^H(RL) \) and \( C^L(RH) = \frac{PH - PL}{a_2} + C^L(RL) \), both types of online stores choose the signal of quality service recovery \( (R = RH) \), the first type of pooling equilibrium appears.

Proof: Similarly, according to hypothesis 5, as long as the service recovery level \( R \geq RL \) observed by the customer, the customer will adopt the strategy of choosing this online store \((A_1)\).

\[
\gamma(S_1, A_1, R) > \gamma(S_2, A_1, R); \gamma(S_1, A_1, R > \gamma(S_1, A_2, R)
\]

When \( C^H(RH) = \frac{PH - PL}{a_1} + C^H(RL) \) and \( C^L(RH) = \frac{PH - PL}{a_2} + C^L(RL) \), both types of stores choose to deliver the signal of quality service recovery. Customers can't judge the type of products according to the signals sent by online stores. So the first kind of pooling equilibrium is an invalid equilibrium.

In a similar way the second kind of pooling equilibrium is also an invalid equilibrium.

(3) Semi-separating equilibrium

This paper refers to the practice of Chinese scholars tang run et al. [26] and liu yongsheng et al. [27]. As a quality store \( \theta_1 \), it will declare its own type by transmitting the signal of quality service recovery \( S_1 \) with probability 1. As a low-quality store \( \theta_2 \), it will transmit the signal of quality service recovery \( S_1 \) with probability \( \alpha \), and transmit poor service recovery \( S_2 \) with probability \( 1-\alpha \). That is:

\[
\frac{p(S_1|\theta_1)}{p(S_2|\theta_1)} = \frac{p(S_1|\theta_2)}{p(S_2|\theta_2)} = \frac{q_1}{q_2} = \frac{q}{1-q}
\]

According to the strategy of the online store, the posterior probability of customers is:

\[
\frac{p(\theta_1|S_1)}{p(\theta_2|S_1)} = \frac{p(\theta_1)p(S_1|\theta_1)}{p(\theta_2)p(S_1|\theta_2)} = \frac{q_1}{q_2} = \frac{q}{1-q}
\]

\[
\frac{p(\theta_1|S_2)}{p(\theta_2|S_2)} = \frac{p(\theta_1)p(S_2|\theta_1)}{p(\theta_2)p(S_2|\theta_2)} = \frac{(1-q_1)(1-\alpha)}{q_1 + (1-q_1)\alpha} = 1
\]

Proposition 5: when \( C^H(RH) = \frac{PH - PL}{a_1} + C^H(RL) \) and \( C^L(RH) = \frac{PH - PL}{a_2} + C^L(RL) \), quality online stores choose to deliver the signal of quality service recovery, while low-quality online stores will randomly choose the type of signal \( (R = RL) \).

Proof: According to hypothesis 5, as long as the service recovery level \( R \geq RL \) observed by the customer, the customer will adopt the strategy of choosing this online store \((A_1)\).

\[
\gamma(S_1, A_1, R) > \gamma(S_2, A_1, R) \quad \gamma(S_1, A_1, R) = \gamma(S_1, A_2, R)
\]

In a similar way, when \( C^H(RH) = \frac{PH - PL}{a_1} + C^H(RL) \) and \( C^L(RH) = \frac{PH - PL}{a_2} + C^L(RL) \), the quality stores will choose to deliver the signal of quality service recovery, and the low-quality stores will randomly choose to deliver the signal. When given the store's level of service recovery and customer choice. According to the sequential rationality strategy: when the stors delivers the signal of quality service recovery, the customer will identify it as a quality store with a probability \( \frac{q}{q + (1-q)\alpha} \) and choose this store; and identify it as a low-quality store with a probability \( 1- \frac{q}{q + (1-q)\alpha} \) and choose not to select this store or wait for its price to drop to \( PL \).
4.2. When \( \frac{a_2 - a_1}{a_1 a_2} = \frac{C^L(R_L) - C^H(R_L)}{P_H - P_L} \) and \( \frac{a_2 - a_1}{a_1 a_2} = \frac{C^L(R_L) - C^H(R_L)}{P_H - P_L} \), three equilibrium states were discussed.

Similarly if \( C^H(R_H) < \frac{P_H - P_L}{a_1} + C^H(R_L) \) and \( C^L(R_H) > \frac{P_H - P_L}{a_2} + C^L(R_L) \), there exists a unique separating equilibrium, the quality stores choose to deliver the quality service recovery, while the low-quality stores choose to deliver the low-quality service recovery. Two types of pooling equilibrium are invalid balance. If \( C^H(R_H) < \frac{P_H - P_L}{a_1} + C^H(R_L) \) and \( C^L(R_H) = \frac{P_H - P_L}{a_2} + C^L(R_L) \), the quality stores choice to deliver the quality service recovery, poor-quality stores randomly choice to deliver the service recovery signal.

5. Conclusion
First: no matter what the relationship between the two types of online store service failure probability is, as long as \( C^H(R_H) < \frac{P_H - P_L}{a_1} + C^H(R_L) \) and \( C^L(R_H) > \frac{P_H - P_L}{a_2} + C^L(R_L) \) are satisfied, the system will have an unique separating equilibrium. The quality store chooses to deliver the signal of quality service recovery, while the low-quality store chooses to deliver the signal of low-quality service recovery, so the type of store can be effectively separated. At the same time, mixed equilibrium and quasi-separating equilibrium can be avoided. Through the equilibrium conditions, we find that this equilibrium focuses on the customer’s expectation of quality service remedy and poor service remedy, as well as the probability of service failure in the online store, and the price difference set by the online store. Only when these variables meet the equilibrium conditions the purpose of effective separation be achieved.

Second: the analysis found that, no matter what kind of situation the relationship between the two classes online stores’ service failure probability is, there is no \( R_H \) could satisfy both \( C^H(R_H) > \frac{P_H - P_L}{a_1} + C^H(R_L) \) both \( C^L(R_H) < \frac{P_H - P_L}{a_2} + C^L(R_L) \). Therefore, this conclusion supposed by this paper proves that in reality, quality store do not sell their quality products or services at a low price, nor do they damage their reputation by passing on inferior service recovery level. This conjecture is similar to the point of view of Chinese scholar Li Lei (2015) [18] in the signal game model of product quality problems of manufacturing enterprises: because in reality, enterprises have information advantages, and if it is indeed a quality product, enterprises are unlikely to sell it at a low price.

Above all, quality store can prove to the customer their quality in the way that promising customers expected service recovery. The premise is that the quality store must understand the customer expectations of quality service recovery, poor service recovery, their own probability of service failure and price difference of their product or service. It will make inferior online store exit the market gradually, thereby reducing the service failure rate that the customer suffers in shopping process from \( qa_2 + (1 - q)a_1 \) gradually to \( a_1 \). In this way, it can not only ensure the interests of quality stores not violated, but also reduce customers’ complaints, to achieve a win-win situation.

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