The Reputation Analysis Based on the Signal Game Theory Model of the Aquatic Products of Logistics Company

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Abstract. This article examines the reputation of the aquatic product logistics companies based on the signal model. We use the model to study these companies in separation equilibrium and pooling equilibrium situation and provide a static economic analysis. Suggestions are presented in the end to improve the reputation of these companies.

Keywords. Aquatic product logistics; Signal game theory; Reputation

1 Introductions

In the operation process of logistics companies, the reputation problem is one of the critical factors that have an impact on their development in China. As with examples of reputation losses in our society, the reputation loss is also prevailing in logistics companies. One of the reasons is information asymmetry between logistics companies and their suppliers. The selection behaviors among those players actually become a strategy of game theory to pursue maximized benefits respectively. For example, logistics companies, who are aware of their own reputation status, tend to get larger benefits by frauds, while suppliers, without intelligence of logistics companies' reputation, are able to get the information to judge the situation only after products are delivered to destination. Thus the signal game method is a brilliant choice and will have a far-reaching influence on the information development.

Economists have long recognized the importance of trust in economic growth, judicial efficiency, government integrity, asymmetric information, and contractual enforcement. It is necessary to solve the asymmetry issue in the labor market in order to thoroughly use the labor market's information. Analyzing effects of information asymmetry on labor market, which is the study of the reputation problems, has started from Spence since 1973[1]. ZhangWeiYing conducted a profound discussion and gave a modeling argument to reputation theory in 1997[2]. He also explained currently realistic reputation problems in China through reputation theory in 2001[3]. WengJunYi[4] is an early researcher from this angle since 1996. In 1999, WangXiaoLong[5] explored reputation problems deeply from the view of business ethics . WangXinXin[6] introduced overseas reputation situation but failed to provide breakthroughs in 1998. Yet the reputation problem in his theory was merely a byproduct instead of a well-established systematic research. Other researchers, for instance, LiuBing, LuoYiMei(2000)[7], ZhangLiZi (1994)[8] and LiuGuangMing (2001)[8], LiBinYun(2005) [9] argued to enhance the power of the law in order to make a path for developing the reputation. Liu BinLian and LuYan(2007) [10] papered the aspects of the logistics companies' reputation loss , and its cause and negative effects. Wang HaiLan and WangLi (2008) [11],WangNing and LiuXiaoJin(2008) [12],LiuHongYu(2009) [13] and TaoGang(2010) [14] surveyed the present situation of logistics companies' reputation and reasons and provided resolutions in China. Data from the report of Chinese companies` repution in 2006 shows that the economic cost in the loss of companies' reputation is as high as 600 billion[15] .

To sum up, domestic researches of logistics companies' reputation problem in China emphasize on unraveling the reasons and losses, leaving scopes for using practical model to solve the problem systematically and deeply. Nevertheless there are few articles discussing reputation problems in China from the perspective of information asymmetry.

2 Materials and Methods

The reputation problem is practical and puzzling in the transportation process for fish, where logistics companies and fish dealers can make an oral deal. However, due to the conflict of interest, fish dealers will design a considerable complicate contract to ensure their own interests, logistics companies will make a deviation to the fish dealers for their own interests. It is very difficult that for fish dealers to select a high reputation logistics companies. The paper tries to deal with the problem using the theory of complete information dynamic game model.

2.1 Assumptions

The transaction time sequence between fish dealers and logistics companies is as follows:

(1) Assume the reputation level of logistics companies' isΘ,which may be high(H) or low(L). Let P be the probability of "Θ = H" .

(2) Logistics companies realizes its reputation level and subsequently estimates a rough fresh fish rate as e (e≥0,e∈E).

(3) Fish dealers propose a pay requirement according to e based on their observation of how logistics companies operate.

(4) The fish dealer offers the logistic company a payment rate according to the last shipment.

For the logistics company, the average income is positively correlated to the proportion of fresh fish in transportation, which is a widely accepted fact that makes e a preferred variable.

2.2 Model contents

The model describes a signal game with two participants. One is fish dealers from the competitive market. The other one is a logistics company which sends the signal of the fresh fish rate level, e(e≥0,e ∈E). Assuming logistics companies are categorized into high（H） and low（L）according to their reputation level. The H company's prior probability is set for P..

Assume fish dealers pay ω to logistics companies. $c(\theta,e)$ is the cost of providing a fresh fish rate of e and $y(\theta,e)$ is the amount of fresh fish. When a logistics company is selected by a fish dealer, the logistics company's income is $\omega - c(\theta,e)$ and the fish dealer's income is $y(\theta,e)-\omega$. One basic assumption is that if a low reputation logistics company wants to get the same fresh fish rate, it has to cost more compared with a high reputation company. "e"s are $\frac{\partial c(L,e)}{\partial e} > \frac{\partial c(H,e)}{\partial e}$

When it is incomplete information, if the fish dealers observe the signals for e and then get a posteriori probability of H company for $\widetilde{P}(H \mid e)$.Assuming the risk for fish dealers is neutral, then we can get a expectation output of the logistics company as follows:

$$\widetilde{P}(H \mid e) y(H,e) + (1 - \widetilde{P}(H \mid e)) y(L,e)\,. \tag{1}$$

Due to competition, fish dealers would take the [4] step.

$$W(e) = \widetilde{P}(H \mid e) y(H,e) + [1 - \widetilde{P}(H \mid e) y(L,e)]\,. \tag{2}$$

As a signal game, this model is discussed in two scenarios, namely separation equilibrium and pooling balanced equilibrium in certain conditions.

In separation equilibrium, low reputation companies can't imitate high reputation ones because the cost of high survival rate is not enough to compensate their own costs. Therefore we get:

$$W^*(L) - c(L, e^*(L)) > W^*(H) - c(L, e^*(H))\,. \tag{3}$$

See fig. 1

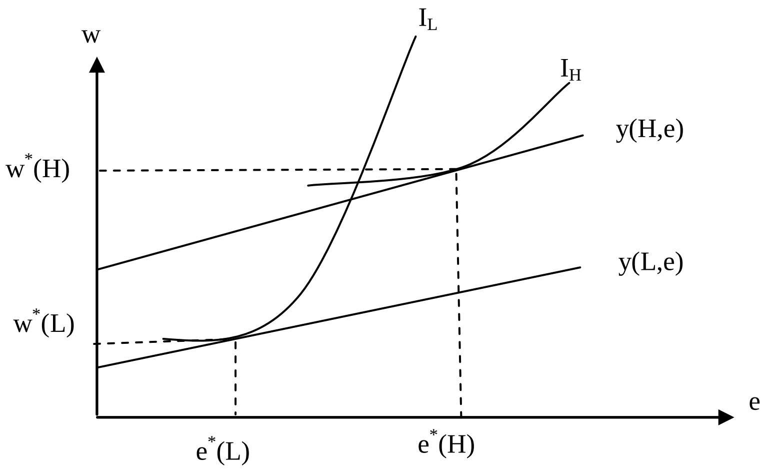

Fig. 1. Separation equilibrium condition

But in pooling equilibrium, low reputation companies can imitate high survival rate and therefore get larger benefits to compensate their own costs.

$$W^*(L) - C[L, e^*(L)] < W^*(H) - C[L, e^*(H)]\,. \tag{4}$$

See fig. 2

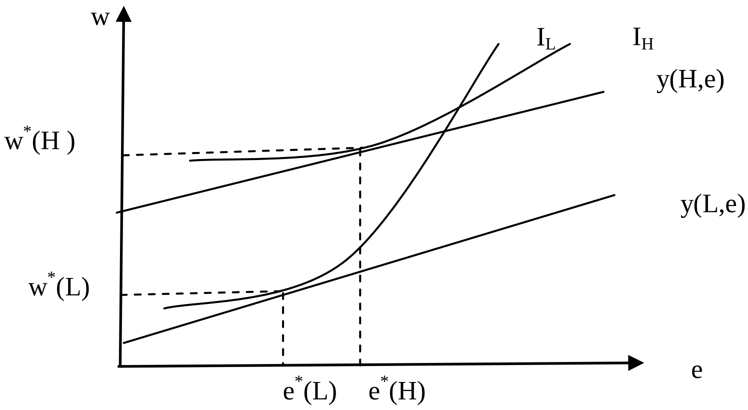

Fig. 2. Pooling equilibrium condition

2.2.1 Pooling equilibrium

The assumption in pooling equilibrium is that both two types of logistics companies choose the same reputation level e_p, then fish dealers observe the e_p and get $\tilde{P}(H \mid e_P) = P$ (P is the prior probability of the H companies). According to the assumption, fish dealers' optimal wage rate is:

$$W_P = Py(H, e_P) + (1-P)y(L, e_P). \tag{5}$$

In the disequilibrium path, here we get:

$$\tilde{P}(H \mid e) = \begin{cases} P & e = e_p \\ 0 & e \neq e_P \end{cases}. \tag{6}$$

According to (2), the optimal choice for fish dealers is:

$$W(e) = \begin{cases} w_P & ,e = e_P \\ y(L,e) & ,\ e \neq e_P \end{cases}. \tag{7}$$

Given fish dealer's given reaction, logistics companies that have a reputation of θ will be forced to choose a e by the following condition:

$$\max_e [w(e) - c(\theta, e)]. \tag{8}$$

The equation（8）is really simple, logistics companies with reputation of θ choose a e_p or make $y(L,e) - c(\theta, e)$ get the optimal fresh fish rate and rightly equal to the low reputation logistics companies' $e^*(L)$. In fig. 3, the former choice is optimal for both types of companies that the low reputation companies' indifference curves through the point $[e^*(L), w^*(L)]$ are below the point (e_p, w_p)' s indifference curves and the high ones' indifference curves through the point (e_p, w_p) are above the payment function of $w = y(L,e)$. The outcome is that, according to the given indifference curves in fig. 3, the amount of products and the value in graph, the companies' strategy of

$[e(L)=e_p, e(H)=e_p]$,the inference $\tilde{P}(H \mid e)$ in（6）and the dealers' strategy of $w(e)$ in（7）combined to the perfect bayesian pooling equilibrium of the game.

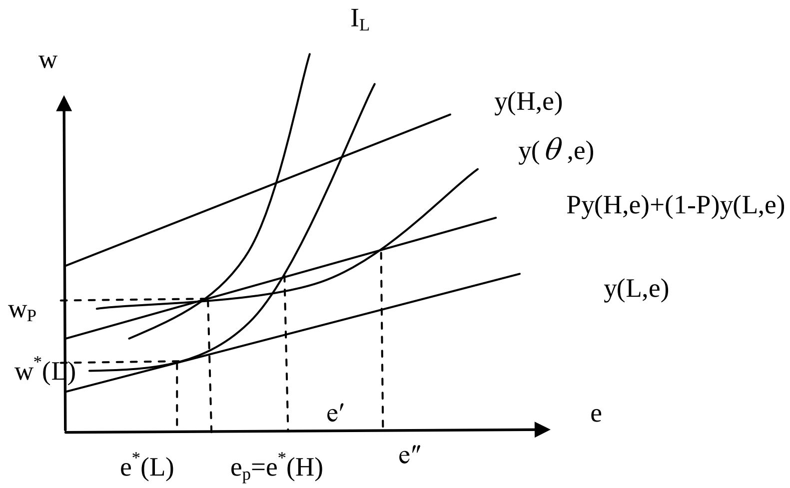

Fig. 3. pooling equilibrium

Even for the indifference curves and the amount of products in fig. 3, there are also many other perfect poolings, some of which are chosen the different fresh fish rate and of other which are in the different disequilibrium signals.

Obviously, in fig. 3, as long as the fresh fish rate is between e^* and $e^{'}$, it is easy to constitute more infinite pooling equilibriums.

It can be inferred that we can also get other pooling equilibriums by solely changing the path of information disequilibrium.

Exchange the (6) to :

$$\tilde{P}(H|e)=\begin{cases} 0 & e \le e'' \quad but \quad e \ne e_p \\ P & e = e_p \\ P & e > e'' \end{cases} \qquad \textbf{(9)}$$

The e_P is a random signal located in between $e^*(H)$ and e'. The fish dealers' strategy is :

$$W(e)=\begin{cases} y(L,e) & e \le e'' \quad but \quad e \ne e_p \\ w_p & e = e_p \\ w_p & e > e'' \end{cases} \qquad \textbf{(10)}$$

For the H logistics companies, if they choose e_P, the benefits locate in the I_H through the (w_P, e_P). When they choose $e \le e''$ but $e \ne e_P$, they locate in the indifference curve of $y(L,e)$. When they do $e > e''$, they make below the I_H. So e_P is the optimal choice. For the L logistics companies, if they choose e_P, the benefits locate in the I_L. when they choose $e \le e''$ but $e \ne e_P$, they locate in the indifference curve of $y(L,e)$. When they do $e > e''$, they make below the I_L. So e_P is also the optimal choice.

2.2.2 Separation equilibrium

Additionally, we investigate the separation equilibrium situation, see figure 1. Obviously, the most natural of separation of logistics company strategy equilibrium is for $[e(L)=e^*(L), e(H)=e^*(H)]$. After the signal, fish dealers get a posteriori probability for:

$$\tilde{P}(H \mid e^*(L))=0 \text{ and } \tilde{P}(H \mid e^*(H))=1. \quad \textbf{(11)}$$

According to （2） we get a result as follows :

$$W(e^*(L))=W^*(L) \text{ and } W(e^*(H))=W^*(H). \quad \textbf{(12)}$$

Under the disequilibrium condition, the provisions are as follows:

$$\tilde{P}(H \mid e)=\begin{cases} 0 & e<e^*(H) \\ 1 & e \ge e^*(H) \end{cases}. \quad \textbf{(13)}$$

The optimal choice for fish dealers are:

$$W(e)=\begin{cases} y(L,e) & e<e^*(H) \\ y(H,e) & e \ge e^*(H) \end{cases}. \quad \textbf{(14)}$$

For the H logistics companies, if they choose $e^*(H)$, the benefits locate in an indifference curve I_H and if they choose $e>e^*(H)$, it locates below it , so e is inferior to $e^*(H)$.When it comes to $e<e^*(H)$, they gets $y(L,e)$ .At this time , it locates below the I_H , and according to the fig.1 it is in the lower indifference curve . We have got the benefits for $y(H,e)$ when it is in the $e>e^*(H)$ and the income is inferior to $e^*(H)$. So the $e^*(H)$ is the optimal choice.

For the L logistics companies, if they choose $e<e^*(H)$, they get $y(L,e)$ that is necessarily less than the benefits when they choose $e^*(L)$.Because $e^*(L)$ is the biggest fresh fish rate under the function of $w=y(L,e)$. When they do $e \ge e^*(H)$, they make $y(H,e)$ and their net income is paid for $y(H,e)-c(L,e)$. According to fig. 1, this negative net profit is obviously less than zero net profit when they choose $e^*(L)$. So $e^*(L)$ is the optimal choice.

If we assume geometric relations in figure 2 instead of in figure. 1, we study the separation equilibrium. At this point, due to the tendency of being imitated, high reputation logistics companies need to take actions to resist it and require higher costs to obtain a higher fresh rate, thus making it difficult for imitation to continue. At last it appears a separation equilibrium. Fish dealers, who observe the costs of the high fresh fish rate, also consider these companies as high reputation ones and then offer them a higher wage rate as a reward.

Thus, we know that the high reputation logistics companies need to choose $e_s>e^*(H)$ to constitute separation equilibrium. See fig.4.

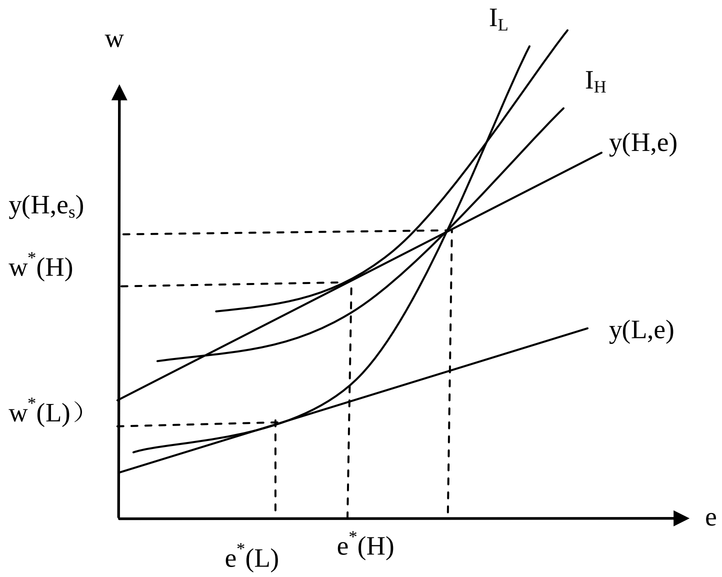

Fig. 4. Sending signals costs in separation equilibrium

Between $e^*(H)$ and e_s, if the imitation activities can confuse fish dealers in identifying reputation level, then low reputation logistics company has motivations to do so. When the high reputation logistics company sends a signal e_s, the low one replicates the choice . If it gets no difference with the imitation e_s to expose its own type of $e^*(L)$, it will choose $e^*(L)$.Then with logistics company's strategy the signals of the information set is given below and to prove that they make up a separate equilibrium.

Logistics company's strategy is

$$e(\theta) = \begin{cases} e^*(L) & \theta = L \\ e_s & \theta = H \end{cases} . \tag{15}$$

When fish dealers observe signals, there is a posteriori probability for

$$\tilde{P}(H \mid e) = \begin{cases} 0 & e < e_s \\ 1 & e \geq e_s \end{cases} . \tag{16}$$

The optimal choice of fish dealers is

$$W(e) = \begin{cases} y(L,e) & e < e_s \\ y(H,e) & e \geq e_s \end{cases} . \tag{17}$$

For the low reputation logistics company, selecting $e^*(L)$ and e_s gets a net earning of zero, but others gets a negative net earning , fore assumption results the optimal $e^*(L)$. For the high reputation logistics company, at that time, if they choose $e \geq e_s$, the benefits locate below an indifference curve I_H and if they choose $e < e_s$, it also locates below it, so e_s is the optimal choice.

The game also includes other separation equilibriums. In some separation equilibriums, high reputation logistics companies choose different fresh rates and low ones keep fixed $e^*(L)$. In other separation equilibriums, high reputation logistics companies stay put in e_s while the low ones keep $e^*(L)$, although signals in the disequilibrium path are different. As to the former one, setting $\hat{e}$ is higher than the fresh rate of e_s but high enough rather to be considered themselves as the low reputation logistics companies than to make the high ones want to choose $\hat{e}$, namely $\hat{e}$ in fig. 4. If we exchange the "e_s"s to "$\hat{e}$"s in $\tilde{P}(H \mid e)$ and $W(e)$ in fig. 4, the formed dealers' signals and strategies combined with logistics company strategies produce a separate equilibrium. As for the latter one, the fresh fish rate is between $e^*(H)$ and e_s, and strictly positive and small enough in order to get a strategy of $W(e)$ which is strictly below the indifference curve that the low reputation logistics companies go right through $[e^*(L), w^*(L)]$.

3 Conclusions and Discussion

Based on current achievements in economics and realistic information asymmetry problems, the article discusses the reputation theory between the fish dealers and the logistics companies in aquatic logistics supply chain, and analyzes the reputation relations between them using Spence's models from the perspective of game theory.

Several measures can be taken to establish more stable relations with fish dealers and enhance the development of modern logistics industry, for instance:

(1) Offer a price high enough to high reputation logistics companies in order to make them feel worthwhile to keep their reputation, and to ensure that long-term revenues are not less than short-term income .

(2) For low reputation logistics companies, effective regulations and punishment mechanism should be founded. Once frauds are found in such companies, fish dealers can fire them and discard them afterwards

(3) Use the "collectivism" punishment mechanism. If a logistics company's reputation is low, all dealers in one transaction region will participate in this mechanism and ensure that any company in blacklist will never be hired again.

(4) For the companies in the pooling equilibrium situation, namely low reputation ones that imitate high ones, government should on one hand establish stricter laws for prevention and punishment, and on the other hand launch favorable policies to promote the logistics industry. Try to turn the pooling equilibrium into the separation equilibrium, thus eliminating low reputation companies or helping them convert to high reputation companies.

Applications of strict measures to control dynamic information and to monitor the logistics companies' reputation can to some extent lead logistics industry to a better stage. However in face of many different equilibriums, it is crucial to understand why certain equilibrium is eventually chosen and its subsequent development. This article does not explore how to gradually squeeze out low reputation companies from the industry, or change into the high reputation companies, which, hopefully, I will be able to supplement in later researches.

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