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How does the Quantity of Disclosed Information Provided by Insurers Affect Entity Behaviors in Internet Insurance Market?: A Study Based on Tripartite Evolutionary Game Analysis between Government, Insurance Companies and Consumers

Shao Jie†

A B S T R A C T

The emergence of internet insurance provides a new consumption pattern for insurance consumers in the e-commerce era. However, without insurers fulfilling duty of disclosure, consumers' interests cannot be guaranteed. This paper will analyze the costs and benefits of three parties (i.e. government, insurance companies and consumers) and their strategies regarding information disclosure of insurance products on the internet. Using an evolutionary game model under bounded rationality assumptions, the Nash Equilibrium (NE) and evolutionary stability strategy (ESS) of the system are explored. The results show that (Disclosing, not Regulating, not Complain) is the best ESS and it is consumers' buying decision not regulation that ultimately compels insurers to disclose enough information. The different current situations in China and Japan are discussed in light of the model, and some measures are suggested to promote the development of internet insurance markets in both countries.

Keywords: internet insurance; information asymmetry; information disclosure; tripartite evolutionary game analysis

Ⅰ. Introduction

Since the third revolution of science and technology, digitalization has gradually transformed many industries. However, industry commentators believe that the transformation of the insurance industry has come rather late. It was only in the 1990s that insurance products were first sold online in America (Bain and Co, 2015). Since then, the global internet insurance market has been developing by leaps and bounds. In the first quarter of 2018, InsurTech deals reached $724 million, which is a record of this industry, and a 155% increase from first quarter of 2017. Broadly speaking, internet insurance or digital insurance refers to activities that traditional insurance firms or other qualified financial institutions develop insurance products and services based on internet terminals or digital technologies (Zhong, Rutao and Xu, 2016). Internet insurance can enhance the customer experience, improve the efficiency of insurance business process, offer new products and make insurance companies more prepared for competition with other industries (Eling and Lehman, 2018). According to McKinsey (2018), 43% of commercial lines of InsurTechs are about distribution and sales. Therefore, some researchers hold that internet

† Graduate School of Commerce, Waseda University, 3-5-33 Higashifusimi, Nishitokyo-shi, Tokyo, Japan
lincshao@asagi.waseda.jp, +81-08043286114
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insurance, in a narrow sense, mainly refers to insurance products and services that are provided through an internet channel (Koduka, 2016).

Although insurance provided through an internet channel is usually simpler than that sold through traditional methods, it is still not easy for consumers to understand products or services provided by insurance firms without face-to-face communication. Concurrently, information disclosed online is much less than for traditional sales. Theoretically, internet insurance firms should disclose the following information: rights and obligations of both parties in insurance contract; premium and its cost; coverage of insurance products; financial information of the firm; prediction of future situation and social responsibility (Koduka, 2016). However, many internet insurance firms may choose not to disclose all information, because disclosure means increasing the cost and may lead to a loss of advantages over competitors. The government may regulate information disclosure to protect consumers, but strict mandated disclosure may inhibit innovation and enthusiasm of internet insurance firms, which in turn reduce consumers' welfare. Hence, this leads to a challenging decision problem for internet insurance market regarding information disclosure and its regulation.

Generally, the internet insurance market has three participants -- insurance companies, the government and consumers. Traditional game theory can solve the above three-parties decision problem based on the hypothesis that the players are strictly rational. However, in the real world, individual rationality is restricted by available information, cognitive limitations, and time available to make decisions (Jiang et al., 2018). Evolutionary game theory can solve this problem by relaxing assumptions such that each player is boundedly rational, and players can learn from opposing parties to change strategies. Therefore, this paper introduces a tripartite evolutionary game model into this information disclosure problem in the internet insurance market. Its replicated dynamic equation and players' strategies are analyzed, to characterize the factors affecting strategies and the possible stable equilibriums. The results of the model are then used to analyze the situations of the internet insurance market in Japan and China, with suggestions for some measures to promote the healthy development of these markets.

The rest of this paper is organized as follows. Section 2 contains a literature review on information disclosure of internet insurance and tripartite evolutionary game theory. In Section 3 the detailed problem, assumptions and parameter setting are described. The evolutionary model is established and solved in Section 4. Section 5 analyzes the model equilibrium and discusses the stability of every entity's strategy under different circumstances. In Section 6, conclusions and suggestions are given based on the different current situations for internet insurance in Japan and China. Section 7 provides a brief conclusion.

Ⅱ. Literature review

A. Internet insurance and information disclosure

So far, there isn't any widely accepted universal definition of internet insurance. According to China Insurance Regulatory Commission (CIRC, 2015), "Internet insurance business" means the business under which insurance institutions conclude insurance contracts and provide insurance services via self-operated network platforms, and third-party network platforms, among others, by relying on the Internet, mobile communications, and other technologies. Internet insurance is different from traditional insurance because it lacks face-to-face discussion with agents, which means the information insurers disclose online is the only source for consumers (Chen, 2017). Meanwhile, insurance buyers cannot easily tell the value of their purchases because it depends on actuarial estimates that they do not know and cannot analyze. Nor can the quality of the insurance be ascertained until a loss materializes (Shahar, 2011). Therefore, two major problems of internet insurance information disclosure are: how much information is enough for consumers and how to make sure the buyers understand the products. Shahar (2011) held that insurers must not only disclose policy terms, they must also highlight terms that are especially important or may cause unexpected agonies. Qu (2018) also pointed out that the "I have read and understood the Terms and Conditions" button is unreasonable because consumers have to click "yes" otherwise cannot move to the next step. In addition, Patten (2002) examined the use of the internet for information disclosure with a sample of property and casualty insurance firms, and concluded that financial information disclosed by the insurance firm sample is only moderate and the leaders in terms of developing web for financial gain are not balancing that leadership with respect to information disclosure. Thus, it is of great importance to study the information disclosure problem in internet insurance market.

B. Evolutionary game model

Evolutionary game models were originally developed by biologists and mathematicians to address substantive questions in evolutionary biology (Smith and Price, 1973; Taylor and Jonker, 1978). Friedman (1991) first introduced the evolutionary game into economics. At present, it has been widely used in industrial organization, law, economic development, international trade and policy analysis. Güth (2007) analyzed buyer insurance and seller reputation in online markets applying an evolutionary framework. Ma (2015) explored complex and dynamic game relationship among participants in the forest insurance market based on a tripartite evolutionary game model. Gao (2017) applied evolutionary game theory to discuss and analyze selection behavior of trans-regional hospitals and patients in a telemedicine system. Yang (2019) constructed an evolutionary game model under incomplete information to research the role whistleblowing is playing in the air pollution control campaign in China. Compared to traditional game theory, evolutionary game theory pays more attention to the long-term interaction processes through which each party can learn to acquire knowledge from the other parties to change their strategies (Jiang, 2018). It is also very useful for investigating the foundations of game-theoretic solution concepts, especially Nash Equilibrium (NE) and selection among multiple NE (Friedman, 1998). Recently, evolutionary games have been widely used to analyze internet financial industry development and its regulation boundary (Su, 2015; Zhao, 2015; Zhang, 2016; Zhou, 2016). This article will also apply an evolutionary game model to analyze the information disclosure problem in internet insurance markets.

Ⅲ. Problem statement and assumptions

There are three direct stakeholders in the internet insurance market, and each of them has two kinds of strategies when it comes to information disclosure.

Internet insurance firms have two kinds of strategies about information disclosure. One is disclosing enough effective information for consumers to buy suitable insurance ("disclosing" strategy in brief). This may cause some direct cost like labor cost and indirect cost like giving important information away to competitors. Together, let the total cost be C_1 when insurers choose "disclosing" strategy. The other strategy is not to disclose enough information for consumers to buy suitable insurance ("not disclosing" strategy in brief). This may reduce the cost (let it be C_2, and $C_1 > C_2$), but it may jeopardize consumers' trust and reduce the sales volume. Let the revenue loss from not disclosing be S. For convenience sake, let the extra cost of disclosing extra information be C_i ($C_i = C_1 - C_2$). Let η, where $0 \leq \eta \leq 1$, represent the probability of internet insurers disclosing enough information.

The government acts as the supervisor of the internet insurance market, and accordingly has two strategies: "regulating" and "not regulating" information disclosure of insurers. When government regulates the information disclosure of internet insurance firms, there is some direct cost like labor cost, and if the mandated disclosure requirement is too much, it may jeopardize competition in this market (indirect cost). Together, let the total cost be C_g. Also, government can impose a penalty on insurers if they fail to fulfill government requirements (let this be F_c). When insurers disclose enough information, the market is perfect with welfare V_g. Meanwhile, if insurers don't disclose enough information, the government may suffer from a market efficiency loss L_1, and a loss of reputation and trust from consumers (L_2) when government choose "not regulating" strategy. Let μ, where $0 \leq \mu \leq 1$, represent the probability of government choosing "regulating" strategy.

Let V_m represent the consumers' welfare when insurance companies disclose enough information, and V_m' be the consumers' welfare when insurance companies do not disclose enough information. Consumers might buy the unsuitable insurance because of lack of information, therefore V_m' is smaller than V_m ($V_m > V_m'$). Consumers can express their dissatisfaction by complaining about insurers. This may cause consumers cost of complaining (C_m), but may also bring them compensation (F_m) if the insurers don't disclose enough information. Let σ, where $0 \leq \sigma \leq 1$, represent the probability of consumers choosing "not Complain" strategy.

Based on the statements above, the game strategies of three parties and corresponding parameters are shown in Table 1.

For the sake of convenience, some other assumptions are made as below.

(1) Each player is boundedly rational in deciding whether to change their strategies, and they are all self-interested when entering the system.
(2) Each player can adjust their behavior to achieve long-term equilibrium.
(3) Government has the motivation to regulate the market when insurance companies don't disclose enough information ($F_c - C_g > 0$).
(4) Consumers can get compensation from insurance companies only if government regulates the market.

The payoff matrix of the game is shown in Table 2.

Ⅳ. Evolutionary game model and solution

Based on the payoff matrix above, the expected payoff of the parties can be expressed as below:

Table 1. Variables setting and meaning

Variables	Meaning of the variables
V_g	Public welfare of government when insurers disclose enough information
C_g	Cost of government regulating the disclosure of internet insurance products
L_1	Market efficiency loss of government when insurers don't disclose enough information
L_2	Reputation and trust loss when government choose not-regulating and insurers choose not-disclosing enough information
V_c	Revenue of internet insurers
C_i	Cost of internet insurers when they disclose extra information
S	Revenue loss of reduced sale volume when internet insurance firms don't disclose enough information
F_c	Penalty on internet insurers if the government thinks they don't disclose enough information
F_m	Compensation to the consumers by the internet insurers if they are sued by consumers because of not disclosing enough information
V_m	Welfare of consumers when insurers disclose enough information
V_m'	Welfare of consumers when insurers do not disclose enough information
C_m	Cost of complaining when the consumers are not satisfied with products
μ	Probability of government regulating the disclosure of internet insurance products
η	Probability of internet insurers disclosing enough information
σ	Probability of consumers being satisfied and don't complain internet insurance firms

Table 2. Payoff matrix of three parties

		Government			
		Regulating		Not regulating	
		Insurance company		Insurance company	
		Disclosing	Not disclosing	Disclosing	Not disclosing
Consumer	not Complain	$\begin{pmatrix} V_g - C_g \\ V_c - C_i \\ V_m \end{pmatrix}$	$\begin{pmatrix} V_g - C_g - L_1 + F_c \\ V_c - F_c - S \\ V_m' \end{pmatrix}$	$\begin{pmatrix} V_g \\ V_c - C_i \\ V_m \end{pmatrix}$	$\begin{pmatrix} V_g - L_1 \\ V_c - S \\ V_m' \end{pmatrix}$
	Complaining	$\begin{pmatrix} V_g - C_g \\ V_c - C_i \\ V_m - C_m \end{pmatrix}$	$\begin{pmatrix} V_g - C_g - L_1 + F_c \\ V_c - F_c - F_m - S \\ V_m' + F_m - C_m \end{pmatrix}$	$\begin{pmatrix} V_g \\ V_c - C_i \\ V_m - C_m \end{pmatrix}$	$\begin{pmatrix} V_g - L_1 - L_2 \\ V_c - S \\ V_m' - C_m \end{pmatrix}$

Note: each combination is shown as $(\text{government, insurers, consumers})^T$

A. Internet insurance firms

The payoff equation of internet insurance firms choosing "disclosing" strategy is:

$$U_{\eta} = V_c - C_i \tag{1}$$

The equation of internet insurance firms choosing "not disclosing" strategy is:

$$\begin{aligned} U_{1-\eta} &= \mu\sigma(V_c - S - F_c) + \mu(1-\sigma)(V_c - S - F_c - F_m) \\ &\quad + (1-\mu)\sigma(V_c - S) + (1-\mu)(1-\sigma)(V_c - S) \\ &= V_c - S - \mu(F_c + F_m - \sigma F_m) \end{aligned} \tag{2}$$

The equation of average expected payoff of internet insurance firms is:

$$U_{\eta,1-\eta} = \eta U_{\eta} + (1-\eta)U_{1-\eta} \tag{3}$$

Following the method used by Taylor and Jonker (1978), replicator dynamics equation is used to represent the learning and evolution mechanism, that is, the change rate of η is:

$$\begin{aligned} F(\eta) &= \frac{d\eta}{dt} = \eta(U_{\eta} - U_{\eta,1-\eta}) \\ &= \eta(1-\eta)[S - C_i + \mu F_c + \mu(1-\sigma)F_m] \end{aligned} \tag{4}$$

B. Government

The equations of government choosing "regulating" and "not regulating" strategies are:

$$\begin{aligned} U_{\mu} &= \eta(V_g - C_g) + (1-\eta)(V_g - L_1 + F_c - C_g) \\ &= V_g - C_g + (1-\eta)(F_c - L_1) \end{aligned} \tag{5}$$

$$\begin{aligned} U_{1-\mu} &= \eta V_g + (1-\eta)[\sigma(V_g - L_1) \\ &\quad + (1-\sigma)(V_g - L_1 - L_2)] \\ &= V_g - (1-\eta)(L_1 + L_2 - \sigma L_2) \end{aligned} \tag{6}$$

The equation of average expected payoff and corresponding replicator dynamics equation are:

$$U_{\mu,1-\mu} = \mu U_{\mu} + (1-\mu)U_{1-\mu} \tag{7}$$

$$\begin{aligned} F(\mu) &= \frac{d\mu}{dt} = \mu(U_{\mu} - U_{\mu,1-\mu}) \\ &= \mu(1-\mu)[(1-\eta)(L_2 - \sigma L_2 + F_c) - C_g] \end{aligned} \tag{8}$$

C. Consumers

The equations of consumers choosing "not complain" and "complaining" strategies, respectively, are:

$$U_{\sigma} = \eta V_m + (1-\eta)V_m' \tag{9}$$

$$\begin{aligned} U_{1-\sigma} &= \mu\eta(V_m - C_m) + \mu(1-\eta)(V_m' + F_m - C_m) \\ &\quad + (1-\mu)\eta(V_m - C_m) \\ &\quad + (1-\mu)(1-\eta)(V_m' - C_m) \\ &= \eta V_m + (1-\eta)V_m' + \mu(1-\eta)F_m - C_m \end{aligned} \tag{10}$$

Average expected payoff and replicator dynamics equations are:

$$U_{\sigma,1-\sigma} = \sigma U_{\sigma} + (1-\sigma)U_{1-\sigma} \tag{11}$$

$$\begin{aligned} F(\sigma) &= \frac{d\sigma}{dt} = \sigma(U_{\sigma} - U_{\sigma,1-\sigma}) \\ &= \sigma(1-\sigma)[C_m - \mu(1-\eta)F_m] \end{aligned} \tag{12}$$

Ultimately, the population dynamic of the evolutionary game can be represented as:

$$\begin{cases} F(\eta) = \eta(1-\eta)(S - C_i + \mu F_c + \mu F_m - \mu\sigma F_m) \\ F(\mu) = \mu(1-\mu)\{(1-\eta)[(1-\sigma)L_2 + F_c] - C_g\} \\ F(\sigma) = \sigma(1-\sigma)[C_m - \mu(1-\eta)F_m] \end{cases} \tag{13}$$

Now, by setting equations in (13) equal to zero, we solve for 11 equilibrium solutions in the system as follows $X_1 \sim X_{11}$:

$$X_1(0,0,0),\ X_2(1,0,0),\ X_3(0,1,0),\ X_4(0,0,1),\ X_5(0,1,1),$$
$$X_6(1,0,1),\ X_7(1,1,0),\ X_8(1,1,1),$$
$$X_9\left(1 - \frac{C_m}{F_m}, 1, \frac{S - C_i + F_c + F_m}{F_m}\right),\ X_{10}\left(1 - \frac{C_g}{F_c}, \frac{C_i - S}{F_c}, 1\right),$$
$$X_{11}\left(1 - \frac{C_g}{L_2 + F_c}, \frac{C_i - S}{F_c + F_m}, 0\right)$$

V. Equilibrium analysis and discussion

A. Stability analysis

The stability of equilibrium points can be derived by analyzing the local stability of the Jacobian matrix

(Friedman 1991). The Jacobian matrix can be presented as following J:

$$J = \begin{bmatrix} a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{bmatrix} = \begin{bmatrix} \frac{\partial F(\eta)}{\partial \eta} & \frac{\partial F(\eta)}{\partial \mu} & \frac{\partial F(\eta)}{\partial \sigma} \\ \frac{\partial F(\mu)}{\partial \eta} & \frac{\partial F(\mu)}{\partial \mu} & \frac{\partial F(\mu)}{\partial \sigma} \\ \frac{\partial F(\sigma)}{\partial \eta} & \frac{\partial F(\sigma)}{\partial \mu} & \frac{\partial F(\sigma)}{\partial \sigma} \end{bmatrix} \quad (14)$$

Where,

$$a_1 = \frac{\partial F(\eta)}{\partial \eta} = (1-2\eta)(S-C_i+\mu F_c+\mu F_m-\mu\sigma F_m)$$

$$a_2 = \frac{\partial F(\eta)}{\partial \mu} = \eta(1-\eta)(F_c+F_m-\sigma F_m)$$

$$a_3 = \frac{\partial F(\eta)}{\partial \sigma} = -\mu\eta(1-\eta)F_m$$

$$b_1 = \frac{\partial F(\mu)}{\partial \eta} = \mu(1-\mu)(\sigma L_2-F_c-L_2)$$

$$b_2 = \frac{\partial F(\mu)}{\partial \mu} = (1-2\mu)\{(1-\eta)[(1-\sigma)L_2+F_c]-C_g\}$$

$$b_3 = \frac{\partial F(\mu)}{\partial \sigma} = -\mu(1-\mu)(1-\eta)L_2$$

$$c_1 = \frac{\partial F(\sigma)}{\partial \eta} = \sigma(1-\sigma)\mu\eta F_m$$

$$c_2 = \frac{\partial F(\sigma)}{\partial \mu} = \sigma(1-\sigma)(\eta-1)F_m$$

$$c_3 = \frac{\partial F(\sigma)}{\partial \sigma} = (1-2\sigma)[C_m-\mu(1-\eta)F_m]$$

According to Lyapunov's indirect method, when all eigenvalues (λ) of the Jacobian matrix are real and have the same sign, the equilibrium point is called Node. The node is stable (unstable) when the eigenvalues are negative (positive). Otherwise, when all eigenvalues are real and at least one of them is positive and at least one is negative, the equilibrium point is called Saddle. Saddles are always unstable (Izhikevich, 2019).

For equilibrium point $X_1(0,0,0)$,

$$J_1 = \begin{bmatrix} S-C_i & 0 & 0 \\ 0 & L_2+F_c-C_g & 0 \\ 0 & 0 & C_m \end{bmatrix}$$

$$\lambda_1 = S-C_i$$

$$\lambda_2 = L_2+F_c-C_g$$

$$\lambda_3 = C_m$$

According to the parameter setting and model assumptions, $\lambda_2 > 0$ and $\lambda_3 > 0$. Therefore, X_1 is unstable.

Similarly, the stability of remaining 10 equilibrium points are analyzed using the same method. The stabilities of eight pure strategy equilibriums are shown in Table 3.

As for the mixed strategy equilibriums ($X_9 \sim X_{11}$), their existence ($\eta, \mu, \sigma \in [0,1]$) relies on the model variables.

For X_9: $L_m+C_m < F_m$ and $F_c < C_i-S < F_c+F_m$;

for X_{10}: $C_i > S$, $C_i-S < F_c$;

for X_{11}: $C_i > S$, $C_i-S < F_c+F_m$.

Then, their stabilities are discussed as below.

As shown in Table 4, each of these three equilibriums has one real eigenvalue and a pair of complex-conjugate eigenvalues with zero real part. That means these mixed strategy equilibriums are not stable.

Thus, there are only three possible stable strategy combinations. These are X_3 (not Disclosing, Regulating, Complain), X_5 (not Disclosing, Regulating, not Complain) and X_6 (Disclosing, not Regulating, not Complain),

B. Entity behavior discussion

In this section, we will analyze how the model variables affect the equilibrium strategies of the three parties in this model.

The internet insurance firms can choose to disclose enough information or not. There are five variables that

Table 3. Result of analyses of stabilities of pure strategy equilibriums

Balancing point	λ_1	λ_2	λ_3	Stability
X_1	$S-C_i$	$L_2+F_c-C_g>0$	$C_m>0$	If $S<C_i$, saddle; otherwise unstable node
X_2	C_i-S	$-C_g<0$	$C_m>0$	Saddle
X_3	$S-C_i+F_c+F_m$	$C_g-L_2-F_c$	C_m-F_m	If $C_g-L_2<F_c$, $C_m<F_m$, $F_c+F_m<C_i-S$, stable; otherwise unstable
X_4	$S-C_i$	$F_c-C_g>0$	$-C_m<0$	Saddle
X_5	$S-C_i+F_c$	$C_g-F_c<0$	F_m-C_m	If $F_m<C_m$, $F_c<C_i-S$, stable; otherwise unstable
X_6	C_i-S	$-C_g<0$	$-C_m<0$	If $C_i<S$, stable; otherwise saddle
X_7	$C_i-S-F_c-F_m$	$C_g>0$	$C_m>0$	If $F_c+F_m<C_i-S$, unstable node; otherwise saddle
X_8	C_i-S-F_c	$C_g>0$	$-C_m<0$	Saddle

may affect their behavior: the fines paid to the government or consumers (F_c, F_m), consumers' complaining cost (C_m), revenue loss caused by sales volume decreasing (S), and the cost of disclosing extra information (C_i). Of which, C_i is the only variable that can be controlled by insurers. As shown in Table 5, if $C_i > F_c + F_m + S$, insurers always tend to choose not to disclose enough information in spite of the size of F_m. While if $F_c + S < C_i < F_c + F_m + S$, insurers choose not to disclose enough information when $F_m < C_m$. If $F_m < C_m$ or $S < C_i < F_c + S$, there is no stable point in this system, every equilibrium is a saddle point, the system will become chaotic and insurers disclose or not disclose with a random possibility. However, if $C_i < S$, insurers choose to disclose enough information.

The government can control three variables to affect the other parties' behavior: the fines paid by insurers (F_c, F_m) and the cost of consumer complaining (C_m). As stated above, if F_c and F_m are too small compared to C_i, insurers will choose not to disclose enough information in the long run. But when $F_c + S < C_i < F_c + F_m + S$, if government makes $F_m > C_m$, although the system would be chaotic, there is a possibility that the insurers will choose to disclose enough information. Besides, C_m and F_m can

Table 4. Eigenvalues of Jacobian matrix of mixed strategy equilibriums

	$\|\lambda E - A\|$	λ
X_9	$\begin{bmatrix} \lambda & a_2 & a_3 \\ 0 & \lambda - b_2 & 0 \\ c_1 & c_2 & \lambda \end{bmatrix}$	$\lambda_1 = b_2 = C_g - \frac{C_m}{F_m}(\frac{C_i - S - F_c}{F_m} L_2 + F_c)$ $\lambda_2 = \pm\sqrt{a_3 c_1} = \frac{F_m - C_m}{F_m}\sqrt{\frac{(S - C_i + F_c + F_m)(C_i - S - F_c)}{F_m}}$ $\lambda_3 = -\sqrt{a_3 c_1} = \frac{F_m - C_m}{F_m}\sqrt{\frac{(S - C_i + F_c + F_m)(C_i - S - F_c)}{F_m}}$
X_{10}	$\begin{bmatrix} \lambda & a_2 & a_3 \\ b_1 & \lambda & b_3 \\ 0 & 0 & \lambda - c_3 \end{bmatrix}$	$\lambda_1 = \sqrt{a_2 b_1} = \frac{\sqrt{(F_c - C_g)C_g(C_i - S)(C_i - S - F_c)}}{F_c}$ $\lambda_2 = \sqrt{a_2 b_1} = -\frac{\sqrt{(F_c - C_g)C_g(C_i - S)(C_i - S - F_c)}}{F_c}$ $\lambda_3 = c_3 = \frac{(C_i - S)}{F_c} * \frac{C_g}{F_c} * F_m - C_m$
X_{11}	$\begin{bmatrix} \lambda & a_2 & a_3 \\ b_1 & \lambda & b_3 \\ 0 & 0 & \lambda - c_3 \end{bmatrix}$	$\lambda_1 = \sqrt{a_2 b_1} = \sqrt{\frac{(L_2 + F_c - C_g)(C_i - S)(C_i - S - F_c - F_m)C_g}{(L_2 + F_c)(F_m + F_c)}}$ $\lambda_2 = -\sqrt{a_2 b_1} = -\sqrt{\frac{(L_2 + F_c - C_g)(C_i - S)(C_i - S - F_c - F_m)C_g}{(L_2 + F_c)(F_m + F_c)}}$ $\lambda_3 = c_3 = C_m - \frac{C_i - S}{F_c + F_m} * \frac{C_g}{L_2 + F_c} * F_m$

Table 5. Stabilities of equilibriums with C_i of different size

Balancing point	Numeric size of C_i			
	$(-\infty, S)$	$[S, F_c + S)$	$[F_c + S, F_c + F_m + S)$	$[F_c + F_m + S, +\infty)$
X_1	Unstable	Saddle	Saddle	Saddle
X_2	Saddle	Saddle	Saddle	Saddle
X_3	Saddle	Saddle	Saddle	$C_m < F_m$, stable; $C_m > F_m$, saddle
X_4	Saddle	Saddle	Saddle	Saddle
X_5	Saddle	Saddle	$C_m > F_m$, stable; $C_m < F_m$, saddle	$C_m > F_m$, stable; $C_m < F_m$, saddle
X_6	Stable	Saddle	Saddle	Saddle
X_7	Saddle	Saddle	Saddle	Unstable
X_8	Saddle	Saddle	Saddle	Saddle
X_9	Not exist	Saddle	Saddle	Not exist
X_{10}	Not exist	Saddle	Not exist	Not exist
X_{11}	Not exist	Saddle	Saddle	Not exist

also affect consumers' behavior: if $C_m > F_m$, there is no benefit of complaining, so the consumers will choose "not complain" strategy.

On the other hand, there are also three variables that may affect government's decision: penalty on internet insurers (F_c), cost of government regulating the market (C_g) and reputation and trust loss from consumers (L_2). The government only has the motivation to regulate the market when the penalty government charges from internet insurers is more than its regulating cost ($C_g < F_c$). C_g might be too big to bear when there is a serious information asymmetry problem between supervision department and insurers. L_2 functions similarly to F_c, it guarantees that the government has the motivation to regulate the market.

Consumers' strategy is affected by C_m and F_m. If $C_m > F_m$, there is no benefit of complaining, so the consumers would prefer "not complain" strategy. On the other hand, consumers can affect other parties' behavior by changing their confidence level in government (L_2) and the sensitivity of insurance demand to information (S). That means if insurers don't disclose enough information, the revenue loss caused by sales volume decreasing might be unbearably big. It will push insurers to disclose enough information (like Scenario 4) when S is too large for insurers. L_2 functions similarly to S: when the penalty charged by government F_c is not enough to motivate the government to regulate the market, L_2 can work as a supplement and push the government to regulate (like Scenario 1).

C. ESS discussion

The evolutionary stability can be analyzed to conclude an evolutionarily stable strategy (ESS) justification under different circumstances, as detailed below. In each scenario, no party would have the motivation to change current behavior and the system will stay stable.

Scenario 1: $C_m < F_m$, $F_c + F_m + S < C_i$

In this case, based on Table 3 and Table 4, $X_3(0,1,0)$ is the only asymptotic stable point. The phase diagram is shown as Figure 1. This means, internet insurance firms would choose not to disclose enough information to consumers, while even though the government chooses to regulate information disclosure of insurers, consumers are still not satisfied and choose to complain about it. This situation occurs because even if the penalty government charges internet insurers is more than its regulating cost ($C_g < F_c$), and the compensation consumers get from insurers is more than their complaining cost ($C_m < F_m$), the summation of total fines paid by the insurers and revenue loss is less than the cost of disclosing sufficient information ($F_c + F_m + S < C_i$). That is to say, this situation is caused by insufficiency of regulation, or low information sensitivity of consumers, or information disclosure cost being too high.

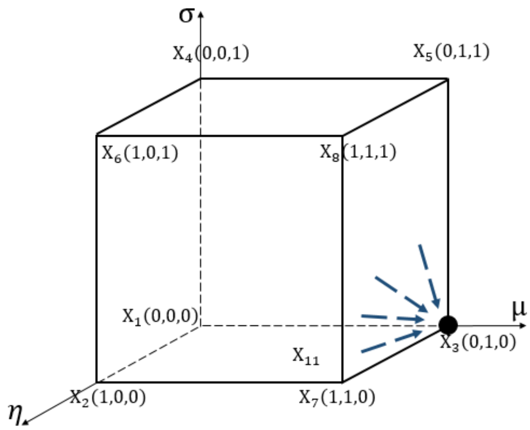

Figure 1. Phase diagram of scenario 1

Scenario 2: $F_m < C_m, F_c < C_i - S < F_c + F_m$

Scenario 3: $F_m < C_m, F_c + F_m < C_i - S$

In both scenario 2 and scenario 3, $X_5(0,1,1)$ is the only asymptotic stable point. The phase diagram is shown as Figure 2. That means, the system will be stable with (not Disclosing, Regulating, not Complain) strategy under these circumstances. The insurers choose not to disclose enough information because the cost of disclosing is larger than the summation of penalties paid to government and revenue loss from consumers ($C_i > F_c + S$). The government has the motivation to regulate the market because the penalty government charges from internet insurers is more than its regulating cost ($C_g < F_c$). However, consumers would choose "not complain" strategy because the compensation they can get is less than their complaining cost ($F_m < C_m$). That is to say, even though the government is regulating the market, the supervision is not enough

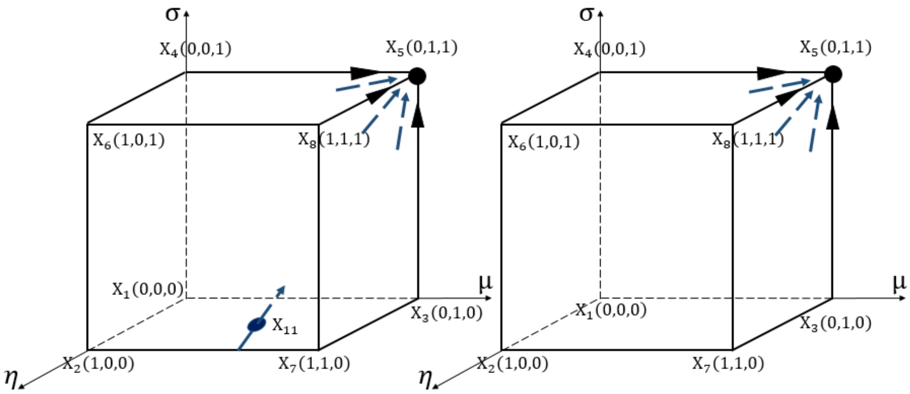

Figure 2. Phase diagram of scenario 2 (left) and scenario 3 (right)

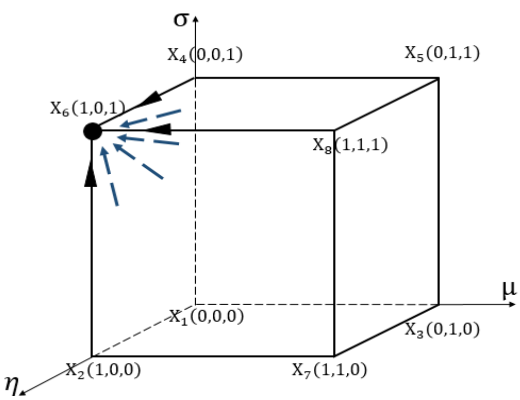

Figure 3. Phase diagram of scenario 4

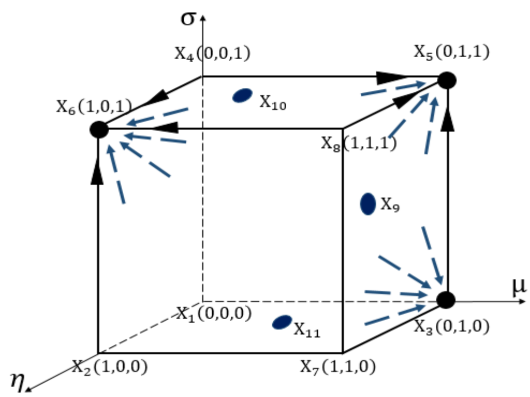

Figure 4. Phase diagram of all stable points

to push insurers to disclose enough information. Meanwhile, the supervision from consumers is not enough either (S is not big enough), and it might also be the case that the consumers are easily satisfied. Therefore, it is not a good stable state because insurers tend to not disclose enough information and consumers' rights are not well protected.

Scenario 4: $C_i < S$

$X_6(1,0,1)$ is the only asymptotic stable point in this scenario. The system would be stable with (Disclosing, not Regulating, not Complain) strategy. The phase diagram is shown as Figure 3. In this case, the insurers would choose to disclose enough information to consumers, because the revenue loss caused by sales volume declines is larger than the cost of disclosing ($C_i < S$). And if the insurers choose not to disclose enough information, they might also have to pay a government penalty. Considering insurers are voluntarily disclosing enough information, the government doesn't have the motivation to regulate, thus the government would choose "not regulating" strategy. On the other hand, once the insurers choose to disclose enough information, the consumers would tend to be satisfied. This is a relatively good stable state because the market is regulating itself, and the government doesn't need to spend extra money on supervising information disclosure.

D. Summary

(1) There are only three possible stable strategy combination from long-term perspective (as shown in Figure 4). That is, X_6 (Disclosing, not Regulating, not Complain), X_3 (not Disclosing, Regulating,

Complaining) and X_5 (not Disclosing, Regulating, not Complain). That means, under these three circumstances, nobody would have motivation to change their strategies, new comers of this market would also follow these strategies.

(2) When insurers do not disclose enough information, the government always tends to choose to regulate the market. However, when the government regulates insurers' disclosure, no matter how strictly the government regulates, there would always be occasions that insurers choosing "not disclosing" strategy.

(3) The quantity of information insurers disclose mainly depends on the cost (or profit) of disclosing. The penalty from the government would motivate insurers to disclose more information, but it is consumers' buying decision (S) that ultimately compel insurers to disclose enough information to consumers.

Ⅵ. Application to China and Japan

The results of the theoretical analysis may be adapted to explain different situations in different countries. Here we consider China and Japan. For instance, China has become one of the most advanced internet insurance markets because of its developed mobile payment systems, and it is still developing very rapidly. According to INZURER(2018)'s report, 10 of the top 100 InsurTech firms in 2018 are located in China, while that number of Japan is zero. However, as shown in Table 6, in the year of 2017, consumer complaints are much less in Japan than in China, which may indicate that consumers in Japan are more easily satisfied than in China. Governments in both Japan and China tend to regulate the market due to their East Asia culture background. But in China, because of the rather short history of the insurance industry and the rapid growth of internet insurance, regulation is less sufficient than Japan, and the internet insurers are inclined to not disclose enough information. However, Japan's insurance industry has a very long history, and FSA (Financial Services Agency) of Japan is one of the strictest supervisors in the world. According to the data provided by the Life Insurance Association of Japan and the General Insurance Association of Japan[1], complaints about information disclosure are less than 13% of total complaints number. Thus, we can conclude that the internet insurers in Japan are inclined to disclose enough information. Therefore, the current situation in China is more similar to X_3 (not Disclosing, not Regulating, Complaining) and situation in Japan is more similar to X_8 (Disclosing, Regulating, not Complain).

Table 6. Situation of consumer complaints in China and Japan in 2017[2]

	China	Japan
complaints number per billion-dollar premium	175.6	18.8
complaints number per thousand-policy	4.7	2.2
complaints number per thousand- figure	0.9	0.8

Based on the evolutionary game model, the current situation in China is unstable in the long run, as shown in Figure 4. That means that any disturbance would change the situation in an unpredictable direction. The reason for this situation is mainly because of insufficient regulation under overgrowth of the internet insurance market. The regulator in China cannot change policies quickly enough in such rapidly changing industry, and is also unwilling to regulate too harshly in order to protect the vitality of this industry. Besides, consumers in China do not trust insurance agents as much as themselves[3], and they are more high-tech savvy, price sensitive and brand independent. Both insurers and consumers are more willing to take risks.

Although internet insurance in China is taking off very fast, with insurers not disclosing and consumers being unsatisfied, it is not a good occasion for future development of the internet insurance market. Therefore, changes to move to a stable equilibrium might be needed. This paper proposes the following suggestions.

(a) Lowering the cost of disclosing information would make insurers more willing to disclose enough information to consumers. Insurers could lower the cost by simplifying and modularizing services and

[1] Data of life insurance are from https://www.seiho.or.jp/contact/report/; data of non-life insurance are from http://www.sonpo.or.jp/news/statistics/adr/

[2] Data of China are from website of CIRC, data of Japan are from FSA and Life Insurance Association of Japan, where complaints number per thousand-policy and per thousand-figure are derived from life insurance data. Premiums derive from Swiss Re (2018) Sigma No 3/2018.

[3] According to China Internet Insurance Development Report 2017, 28.9% of the interviewees believe that buying insurance without agents is actually the merit of internet insurance.

products. The authority could also lower that cost by better communicating with insurers and making a better industry standard.

(b) The government can enhance the regulation of information by raising the standard of “enough” information and increasing the penalty for insurers who violate it.

(c) Enhancing consumers’ education so that consumers make their buying decisions not based on price only, but also their needs. Consumers need to be able to interpret information provided by insurers and learn to only buy if enough information is disclosed.

Based on the evolutionary game model, the current situation in Japan is also unstable, as shown in Figure 4. Any disturbance would change the situation in an unpredictable direction. The market might stop developing and shrink until it disappears. There are two main possible reasons for this situation. One is that the regulation may be too strict. The standard of “enough” disclosure is too high, and the fines are unbearable. The other reason might be that S is too high. In Japan, insurance agents have a long history and high acceptance. According to Lifenet’s investigation (Lifenet, 2011), 52.3% of the interviewees believe that buying insurance without talking with agents is the biggest demerit of internet insurance. Consumers care more about the companies’ brand than about cheap prices. They are also risk averters, with 51.7% of the interviewees worried about their personal information security online and 51.5% worried that their insurance knowledge is not enough to make decisions by themselves. Therefore, proper guidance of this market is necessary. For the healthier development of the internet insurance market in Japan, this paper proposes the following suggestions.

(a) The government should appropriately loosen regulation, and since innovation can effectively lower disclosing cost and help with consumer education, authority should also encourage innovation of internet insurance. For example, lowering standards for traditional insurance companies entering the internet insurance market, or giving internet companies more access to insurance market.

(b) The regulation of information disclosure should not only focus on the quantity, but also the quality. The information provided for internet insurance and traditional insurance should be comparable. The insurance companies should also try to simplify and modularize their products, make them easy to understand. That will also lower the cost of disclosing information and make internet insurance business more appealing.

(c) Enhance consumers’ education to give consumers more confidence in making their own decisions. Their rational decisions would benefit the development of this market.

Ⅶ. Conclusion

This paper focuses on information asymmetry problems in the internet insurance market. Compared to traditional insurance, insurance provided through internet channel is usually simpler and modularized. That means, different from traditional insurance, it is the insurers instead of consumers who have the information advantage. Without agents fulfilling information duty, consumer protection could be more difficult than traditional insurance. Most papers are studying this problem from legal or normative perspectives; there is little research using economic analysis, especially behavior strategy studies based on game theory. This paper employs three-party evolutionary game theory to study how the quantity of disclosed information provided by insurers affects the behaviors of the government and consumers, and how insurers react to their strategies.

On the basis of the research above, there are only three possible stable long-term equilibriums, which are (Disclosing, not Regulating, not Complain), (not Disclosing, Regulating, Complaining) and (not Disclosing, Regulating, not Complain). Amongst the three, (Disclosing, not Regulating, not Complain) would be the best for healthy development of internet insurance industry. Comparison of China and Japan suggests that China’s situation is similar to (not Disclosing, not Regulating, Complaining) and Japan’s situation is similar to (Disclosing, Regulating, not Complain). Neither of these are stable equilibriums. Suggestions for changes in China and Japan to move to a healthy stable equilibrium are provided based on analysis of the model variables that are shown to affect strategies.

However, this paper still has two limitations. Firstly, this paper puts more consideration on the information advantage of insurers, the information advantage of consumers or moral hazard is not involved. Another limitation is that this study only considers the effect of quantity of information. The quality of information is not involved. Future extensions of this research could be developed in several directions. Firstly, the effect of quality of information might be incorporated into this model. Furthermore, some empirical analysis could be done on the basis of this model.

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