Research on forest insurance policy simulation in China

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Abstract

Purpose – Forest insurance is a popular way to reduce the loss of forest disasters, so it is necessary to actively involve stakeholders. In the multi-agent simulation model, the government, insurance companies and forest farmers participate as three main stakeholders. The purpose of this paper is to mainly simulate the behavior of forest farmers under different environmental variables in order to find the important factors affecting the coverage of forest insurance, so as to improve the ability of forest farmers to resist risks in the face of disasters.
Design/methodology/approach – In the simulation process, the decision-making rule of a forest farmer's purchasing behavior is a binary selection chain, which is created at random. Forest farmer agents who adapt to the environment will remain; on the contrary, those will be eliminated. The eliminated agents will renew their behavior selection chains through learning others' successful behavior based on genetic algorithm. The multi-agent mode is set up on the Eclipse platform by using Java language.
Findings – The adjustment simulation experiments of insurance premium, insurance subsidy and forest area were carried out. According to the result, conclusions and suggestions are as follows: at present, government subsidies are necessary for the implementation of forest insurance; in the future, with the expansion of the insured forest area and the upgrading and large-scale operation of forest farms, forest farmers will be more willing to join forest insurance program, and, then, the implementation of forest insurance no longer requires government subsidies for forest insurance premiums.
Originality/value – This paper explores the impact of three important factors on the implementation of forest insurance.

Keywords Forest insurance, Multi-agent, Simulation

Paper type Research paper

1. Introduction

Natural disasters, such as fires, hurricanes, storms, floods and so on, are the major threat for forests worldwide. In the USA, Hurricane Katrina damaged 5m acres in 2005, and the 2007 wildfire in South Georgia destroyed 550,000 acres. In Europe, natural disasters damage an average of 35m m^3 of wood each year (1950–2000). Storms are responsible for 53 percent of these damages, fires for 16 percent and biotic factors for 16 percent (Schelhaas *et al.*, 2003).

In China, according to statistics released by the State Forestry Administration, 108,302 fires burst out during 13 years from 2002 to 2014, hitting an accumulative area of 1,370,358 hectares. Besides, forest areas stricken by rats and insects totally arrive at 141,919 thousand hectares during that period. These disasters, which cause great economic losses, are shown in Table I.

Forest insurance is a popular way to reduce losses of forestry disasters, and forest insurance has been implemented in many countries, such as USA (Deng *et al.*, 2013), Germany (Holecy and Hanewinkel, 2006), Spain (Barreal *et al.*, 2014), Portugal (Pinheiro and Ribeiro, 2013) and so on. In China, forest insurance has also been implemented for many years. Until 2012, forest insurance has been implemented in 17 provinces, including Fujian, Jiangxi,

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Year	Fires burst out (times)	Fire-affected areas (hectare)	Insects and rats-affected areas (thousand hectare)
2002	7,527	47,631	8,412
2003	10,463	451,020	8,887
2004	13,466	142,238	9,448
2005	11,542	73,701	9,844
2006	8,170	408,255	11,007
2007	9,260	29,286	12,097
2008	14,144	52,539	11,418
2009	8,859	46,156	11,420
2010	7,723	45,800	11,642
2011	5,550	26,950	11,681
2012	3,966	13,948	11,769
2013	3,929	13,724	12,230
2014	3,703	19,110	12,064

Table I. Forestry disasters in China from 2002 to 2014

Hunan, Liaoning, Zhejiang, Yunnan, Guangdong, Guangxi, Sichuan, Hebei, Anhui, Henan, Hubei, Hainan, Chongqing, Guizhou and Shanxi, and the insured forest field areas reach 0.859bn hectares. With the implementation of forest insurance expanding continuously, the significance of forest insurances is recognized.

However, forest insurance has trouble to spread in particular because of the existence of some brakes such as the forest insurance premium, often considered as too high compared to the profitability of the forest investment (Brunette *et al.*, 2015). To further expand insured forest areas and enhance forest farmers' abilities to guard against natural disasters, it is necessary to research on the implementation strategy of forest insurance.

2. Research review

The theory of the complex adaptive system (CAS) is proposed by John H. Holland (1995), the father of genetic algorithm. The basic idea of the CAS theory is "Adaptability causes complexities," which means that there are a large number of individualities in system, and Holland named them agents. These agents can communicate with other agents according to the designed rules. In the process of communication, these agents continue to learn, accumulate experience and optimize their behaviors; thus, the whole system will evolve finally.

A multi-agent simulation method is one of the most important methods of analyzing complex social and economic system. When there is no central authority to control entire system, all actions of agents in the system follow simple behavior and interaction rules, but agents can learn and accumulate historical experience continually. In this situation, multi-agent simulation will be a suitable method to solve these problems (Macy and Willer, 2002).

For example, the multi-agent simulation method has been recognized to be well suited to express the co-evolution of the human and landscape systems based on the interactions between human actors and their environment (Parker *et al.*, 2003; Batty, 2001; Berger, 2001). In multi-agent simulation model, each agent is a representation of one of the stakeholders in the process of land use change, and these agents can play various roles in simulation process (Ligtenberg *et al.*, 2004; Zhang *et al.*, 2015). Using the multi-agent simulation method can enhance the understanding of the land use optimization allocation process by simulating the decision-making process and human–environment interactions (An, 2012; An *et al.*, 2014; Murray-Rust *et al.*, 2014; Zhang *et al.*, 2016).

From the perspective of human–environment interactions, forest management is similar to land use optimization. Multi-agent simulation method is also a suitable approach for developing multi-stakeholder forest management strategies (Purnomo *et al.*, 2005).

Co-management of forest resources is a process of governance that enables all relevant stakeholders to participate in the decision-making processes, and multi-agent simulation is a branch of artificial intelligence that offers a promising approach to deal with multi-stakeholder management systems (Purnomo and Guizol, 2006).

In the forest insurance market, it is necessary to enable all multi-stakeholders including government, insurance company and forest farmers to participate in the implementation of forest insurance actively (Ma *et al.*, 2015). There is no central authority to control behaviors of forest farmers in the forest insurance market, and forest farmers decide to purchase forest insurance or not based on their own conditions. Forest farmers can communicate with each other and accumulate experience to optimize their behaviors continually. In view of the above features of forest insurance market, multi-agent simulation method is an effective way to solve this multi-stakeholder problem.

3. Model hypotheses

There are three kinds of agents in multi-agent simulation model of forest insurance, which are government, insurance company and forest farmers. The government is responsible for setting up the subsidy of forest insurance premium; the insurance company is responsible for making the forest insurance contract; and forest farmers decide whether to purchase forest insurance or not.

Real world is complex and dynamic. Model hypotheses can simplify the real world and reduce complexity, which are as follows:

(1) Agent boundary: forest farmer agent represents forest farmer' family, insurance company agent and government agent, respectively, represent insurance company and government.

(2) Heterogeneity of forest farmer agents: heterogeneity of agents is one of the major features of the multi-agent simulation model. In the multi-agent simulation model, different forest farmer has different properties and behavior rules, including different amount of fund, different forest field areas and different behavior.

(3) Forest planting: there are two kinds of forest planting in the simulation model. One is a timber forest, and the other is an economic forest. The main purpose of the timber forest is for wood production, and the economic forest is for forest products besides wood.

(4) Full insured: if the forest farmer decides to purchase forest insurance, all of the forest field area owned by the forest farmer will be insured.

(5) Full damaged: if the forest farmer suffers from natural disasters, all of the forest field area owned by the forest farmer will be damaged.

(6) Same probability of disaster damage: when natural disasters occur, every forest farmers in the model can be affected. The probability of economic losses of forest farmers caused by natural disasters is the same.

4. Behavior rules of agents

4.1 Behavior rules of the government agent

Behavior rules of the government agent are to encourage the insurance company agent and forest farmer agents to participate in forest insurance program actively. The government agent will offer appropriate subsidy for forest insurance premium to forest farmer agents.

4.2 Behavior rules of the insurance company agent

Insurance company is the provider of forest insurance. In the simulation model, forest insurance is provided by the insurance company agent.

Behavior rules of the insurance company agent are as follows: the insurance company agent provided forest farmer agents with forest insurance contract, including insurance premium, insurance compensation and deductible area. When the forest field of the forest farmer agent is damaged by natural disasters,the insurance company agent will compensate the forest farmer agent according to the insurance contract.

4.3 Behavior rules of forest farmer agents

Forest farmers are main participants in the forest insurance market. In the simulation model, behavior rules of forest farmer agents are as follows.

4.3.1 Behavior selection chain. In the simulation model, the decision-making rule of purchasing forest insurance is a binary behavior selection chain. Every behavior selection chain is created randomly by seven binary digits: the first digit (initial section), second to fourth digits (Section 1) and fifth to seventh digits (Section 2).

As shown in Figure 1, the initial section is only a turning part. The first and the second section are mix sections (including one behavior part, one satisfactory turning part and one unsatisfactory turning part). If the forest farmer agent is satisfied with current behavior, the satisfactory turning part will be triggered; otherwise the unsatisfactory turning part will be triggered. Behavior selection chain of every agent is created at random, which can produce 128 different behavior selection chains.

In the simulation model, if the forest farmer agent purchases forest insurance, insurance premium, which is the price of forest insurance, should be paid. When the forest field of the forest farmer is damaged by natural disasters, insurance compensation will be provided by the insurance company. If the forest farmer agent does not purchase forest insurance, when natural disasters occur, the forest farmer will bear the economic losses by himself.

Satisfaction degree of current behavior depends on satisfaction function, which can be described as $F(x) = f(x_1) - f(x_2)$. In the satisfaction function, $f(x_1)$ refers to the amount of fund of forest farmer agent at current behavior (purchase or no purchase), and $f(x_2)$ refers to the amount of fund at opposite behavior (no purchase or purchase). If $F(x) > 0$, it shows that the forest farmer agent will be satisfied with current behavior; otherwise the forest farmer agent will be unsatisfied.

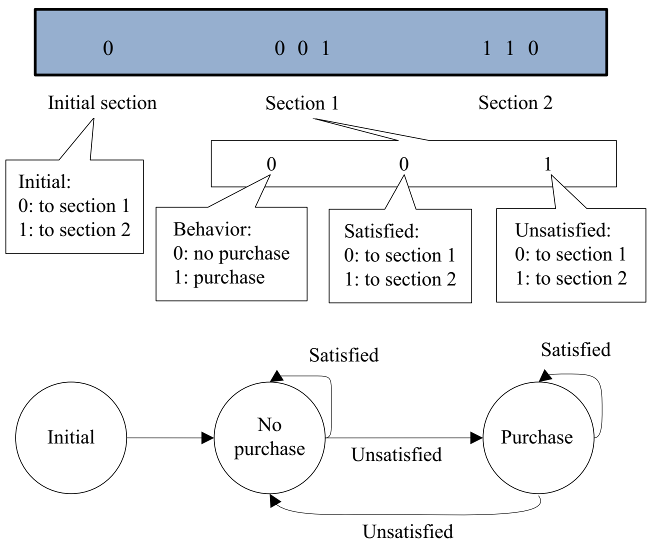


Figure 1.
Behavior selection chain of forest farmers

According to the behavior selection chain in Figure 1, the first behavior of the forest farmer agent is "no purchase." Then the satisfaction degree of "no purchase" will be calculated by the satisfaction function $F(x) = f(x_1) - f(x_2)$. If $F(x) > 0$, the forest farmer agent will be satisfied with "no purchase," then the satisfactory turning part will be triggered, and the next behavior will be "no purchase." On the contrary, if $F(x) < 0$, the forest farmer agent will be unsatisfied, and the next behavior will be "purchase." The rest can be done in the same manner. Assuming that the forest farmer agent is not eliminated in the whole simulation cycle, it will follow this rule all along to decide to purchase forest insurance or not.

4.3.2 Forest profit calculation. In the simulation model, the forest profit of forest farmer agent comes from forest products, including the timber and economic forests. The profit of forest farmer agent can be calculated in the following formulas:

$$Tprofit = TEFprofit + TTFprofit, \tag{1}$$

$$TEFprofit = EFprofit \times S_{ef}, \tag{2}$$

$$TTFprofit = TFprofit \times S_{tf}. \tag{3}$$

where *Tprofit* refers to the total profit of the forest farmer agent. *TEFprofit* refers to the profit gained from the economic forest, and *TTFprofit* gained from the timber forest. *EFprofit* refers to the profit per mu of the economic forest, and *TFprofit* refers to profit per mu of the timber forest (1 hectare = 15 mu). S_{ef} and S_{tf} refer to the area of the economic and timber forests, respectively.

In addition, the economic forest and timber forest have their own fixed growth period. When the growth period is not reached, the forest farmer agent will gain no profit. When the growth period is reached, the economic forest will generate fixed profit annually, and the timber forest will generate one-time profit.

5. Interaction rules between forest farmer agents

In the forest insurance market, forest farmers decide to purchase forest insurance or not according to their own situation. Behaviors of forest farmers will be influenced by other forest farmers to a certain degree, especially by "successful" forest farmers who are so-called "models." Thus, interaction rules between forest farmer agents are needed in the simulation model, so that forest farmer agents can exchange information with each other to improve their behaviors.

In the simulation model, the relationship between forest farmer agents can be described, as shown in Figure 2. Each node on network represents a forest farmer agent. The line

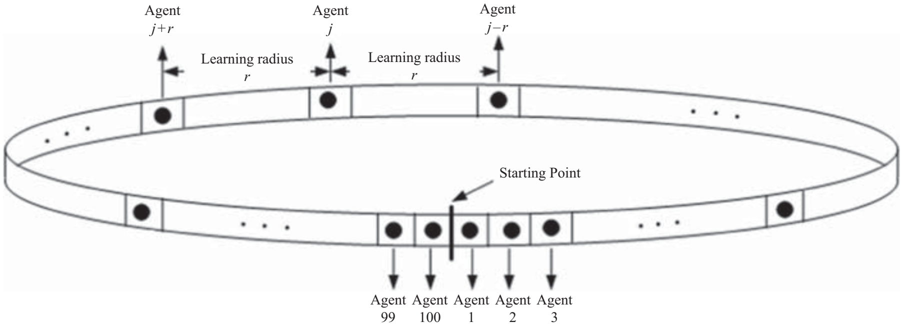


Figure 2.
Social relation network of forest farmers

connecting nodes represents the interactive relationship between forest farmer agents, and the forest farmer agent can only communicate with neighboring agents.

In Figure 2, there are 100 forest farmer agents in the simulation model. $Agent_j$'s behavior can be affected by neighboring forest farmer agents within learning radius. Supposing the learning radius is r, the learning "model" of $Agent_j$ will be selected from $Agent_{j-r}$ to $Agent_{j+r}$, and $Agent_j$'s behavior will not be influenced by forest farmer agents beyond learning radius.

Interaction rules are mainly used to improve the adaptability of forest farmer agents. In the simulation model, agents who adapt to the environment will remain, while those who are not adaptive will be eliminated gradually. That will lead to simulation model evolution continually.

As forest farmer agents in the simulation model make decisions based on the behavior selection chain, they optimize their behaviors through learning others' successful behavior selection chain. The learning process is as follows.

5.1 Selection operation

Natural selection leads to the survival of the fittest, which constantly optimizes the whole species. The idea of natural selection can be applied in the simulation model. Through natural selection, more adaptive forest farmer agents will remain and less adaptive agents will be eliminated.

In the simulation model, forest farmer agents will be eliminated in the following conditions: fund of the forest farmer agent is less than zero; and the forest farmer agent decides to purchase insurance, but fund is not enough to pay for insurance premium.

The eliminated forest farmer agent will select a "model" agent to learn within learning radius. In the selection operation, the roulette selection method is used, and the selection process can be shown as follows:

(1) Assuming that the average fund of $Agent_i$ is f_i, the probability of $Agent_i$ being selected as "model" among n agents is:

$$p_i = \frac{f_i}{\sum_{i=1}^{n} f_i}.$$

(2) The average fund of the forest farmer agent can be calculated as follows:

$$f = \frac{Prefund + Tprofit - Insurance + Subsidy + Compensation - Cost}{S},$$

where *Prefund* represents the fund of the forest farmer agent in previous cycle; *Tprofit* represents the total profit mentioned in Section 4.3; *Premium*, S*ubsidy* and *Compensation* represent premium, subsidy and compensation, respectively, of the forest field insured; S represents the forest field area; and *Cost* refers to the re-planting cost of forest field, which is shown as:

$$Cost = Cost_{ef} \times S_{ef} + Cost_{tf} \times S_{tf},$$

where $Cost_{ef}$ and $Cost_{tf}$ present the re-planting cost per mu of the economic forest and timber forest, and S_{ef} and S_{tf} present the area of the economic and timber forest fields.

(3) Each forest farmer agent is arranged in the order of the selected probability from small to large, and then the probability is accumulated and the interval (0, 1) is divided into several sub-intervals.

(4) A 0–1 random number is generated, which falls into one of the sub-intervals mentioned above, and the corresponding forest farmer agent of the sub-interval is selected as the learning model.

5.2 Crossover operation

After selection operation, the eliminated forest farmer agent will learn from the "model" agent to create a new behavior selection chain through crossover operation. Behavior selection chains of both the eliminated forest farmer agent and "model" forest farmer agent will be parents, and create a new selection chain for the eliminated forest farmer agent through a one-point crossover. Detailed steps of the one-point crossover are shown as Figure 3.

In Figure 3, "1 011 111" is the behavior selection chain of the eliminated forest farmer agent, and "0 001 110" is the behavior selection chain of the "model" forest farmer agent selected in Section 5.1. The crossover point is random from 1 to 7. Supposing the random crossover point is 5, then "0 001," which is behavior selection chain of the "model" agent from 1 to 4, and "111," which is behavior selection chain of the eliminated agent from 5 to 7, will create "0 001 111," which is the new behavior selection chain for the eliminated agent.

5.3 Mutation operation

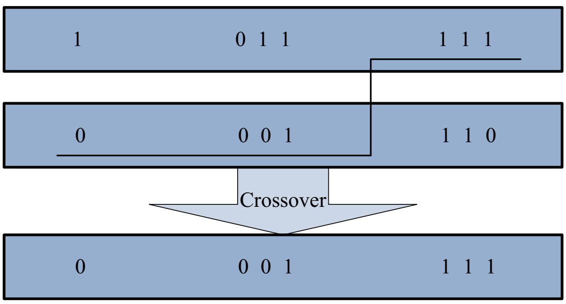
In biology, gene mutation is a popular phenomenon during gene transmission from parental generation to offspring. In the simulation model, through mutation operation, the newly-created behavior selection chain will obtain different characteristics of parental generation.

In mutation operation, each digit of behavior selection chain can mutate randomly. For instance, for a digit at position i ($i = 1, 2, \ldots, 7$), a random number r_i between 0 and 1 will be created. If $r_i < p$ (p is mutation probability of genetic algorithm), then mutation operation will occur on digit at position i. That is to say, if the digit at position i is 0, it will become 1; on the contrary, if the digit is 1, it will become 0.

In Figure 4, r_1, r_2, r_3, r_4, r_5, r_6 and r_7 are created randomly, supposing $r_4 < p$ and $r_6 < p$, and then digits at position 4 and position 6 on the behavior selection chain will mutate. "0 001 111" will change into "0 000 101," which will be the final behavior selection chain of the eliminated forest farmer agent.

6. Simulation experiment and results analysis

Based on the concept model above, the multi-agent simulation model is set up on the Eclipse platform by using Java language. The simulation procedure on the Eclipse platform is shown as Figure 5.



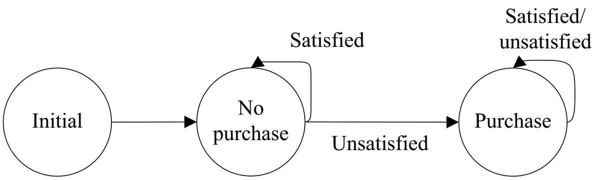


Figure 3.
Process of one-point crossover operation

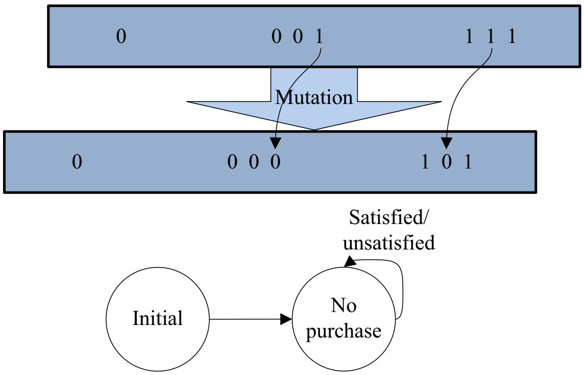


Figure 4. Process of mutation operation

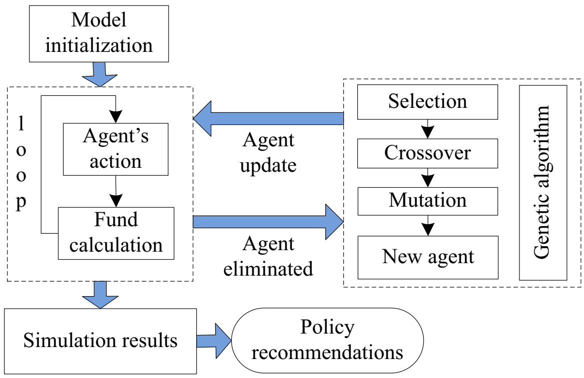


Figure 5. Flowchart of simulation on the Eclipse platform

At the beginning of the simulation procedure, model parameters will be initialized as Table II.

In Table II, parameters of insurance, such as insurance premium, insurance compensation, deductible area and subsidy, are all from forest insurance program of Fujian Province in 2014. Parameters of forest, such as the range of forest field area, re-planting cost, forest growth period, forest sales profit and so on, are mainly from the survey of forest farmers in Sanming city, Fujian province. Other parameters are set based on convention: for instance, forest sales profit is higher than re-planting cost; forest growth period of the timber forest is longer than that of the economic forest; and, in addition, mutation probability of the genetic algorithm is 0.001, which is generally between 0.0001 and 0.1.

6.1 Insurance premium adjustment analysis

Insurance premium is an important factor for the implementation of forest insurance. Model parameters in this group of experiments are shown in Table II, and insurance premium is adjusted, and then results of simulation experiments are shown in Table III.

In Figure 6, when the insurance company lowers the insurance premium rate from 0.0055 to 0, the insurance coverage rate will increase from 54 to 100 percent. In the simulation model, the lower the forest insurance premium rate is, the more forest farmer agents will purchase forest insurance.

Table II. Parameters of simulation model

Type	Parameter name	Explanation	Value
Environment parameters	Cycle (year)	Cycles of simulation	500
	Forest farmers	Forest farmers in the simulation model	100
	Network degree	Scope of model agent selection	6
	Probability of natural disasters	Natural disasters occurrence probability in each cycle	0.5
	Probability of damage	Damage probability of forest field, when natural disasters occur	0.5
	Mutation probability of genetic algorithm	Mutation probability, when new behavior selection chain is created	0.001
Parameters of insurance	Insurance premium (yuan)	The payment per mu for forest insurance	1.5
	Insurance compensation (yuan)	The highest compensation per mu from insurance company	600
	Premium rate	Insurance premium divided by insurance compensation	0.0025
	Deductible area (mu)	Areas not covered by insurance compensation	10
	Subsidy (yuan)	The subsidy per mu for forest farmer to purchase forest insurance	1.125
	Subsidy rate	Subsidy divided by insurance premium	0.75
Parameters of forest	Largest forest area (mu)	Maximum forest area owned by farmers	140
	Smallest forest area (mu)	Minimum forest area owned by farmers	10
	Re-planting cost of timber forest (yuan)	The re-planting cost of timber forest, when forest field is empty or damaged	600
	Growth period of timber forest (year)	Cycles for timber forest to grow up	10
	Sales profit of timber forest (yuan)	Profit of selling wood after timber forest growing up	1,200
	Re-planting cost of economic forest (yuan)	The re-planting cost of economic forest, when forest filed is empty or damaged	800
	Growth period of economic forest (year)	Cycles for economic forest to grow up	3
	Sales profit of economic forest (yuan)	Profit of selling forest products after economic forest growing up	1,600
Output parameter	Insurance coverage rate	Forest farmers purchasing insurance divided by all of forest farmers	–

Note: 1 hectare = 15 mu

Table III. Experiment data record based on insurance premium adjustment

	Experiment 1	Experiment 2	Experiment 3	Experiment 4	Experiment 5
Insurance premium rate	5.5	4.5	3.5	2.5	0
Insurance coverage rate	54	63	70	75	100
Coverage rate increment	–	9	7	5	25

Notes: Insurance premium rate equals insurance premium divided by insurance compensation. Insurance coverage rate equals forest farmers purchasing insurance divided by all forest farmers

From the standpoint of sensitivity analysis, when the insurance premium rate falls from 5.5 to 2.5 percent, the insurance coverage rate increment will reduce from 9 to 5 percent. When the premium rate falls from 2.5 to 0 percent, the insurance coverage rate will increase by 25 percent from 75 to 100 percent.

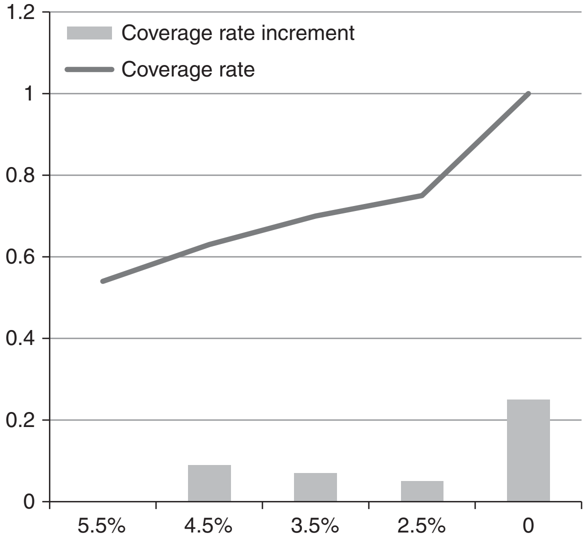


Figure 6.
Experiment results based on insurance premium adjustment

6.2 Insurance subsidy adjustment analysis

Subsidy of insurance premium from government will affect behaviors of forest farmers. In this group of experiments, insurance subsidy is adjusted and all other parameters are shown as Table II. Results of simulation experiments based on subsidy adjustment are shown in Table IV.

In Figure 7, when the government increases the insurance subsidy rate from 20 to 100 percent, the insurance coverage rate will change from 34 to 100 percent. Thus, the higher insurance subsidy from government is, the lower payment of forest insurance by forest farmer agents will be, and the more forest farmer agents will purchase forest insurance.

Otherwise, when the insurance subsidy rate increases from 20 to 80 percent, the insurance coverage rate increment will fall from 19 to 10 percent. When the insurance subsidy rate increases from 80 to 100 percent, the coverage rate will increase by 23 percent from 77 to 100 percent.

6.3 Forest field area adjustment analysis

Forest field area is a potential influence factor of forest farmers' behaviors. Model parameters in this group of experiments are shown in Table II, and the parameter of the "forest field area" is adjusted. Two groups of experiments are performed in this part: the insurance subsidy rate is 75 percent, and the insurance subsidy rate is 25 percent. Two groups of experiment results are shown in Figure 8.

	Experiment 6 (%)	Experiment 7 (%)	Experiment 8 (%)	Experiment 9 (%)	Experiment 10 (%)
Insurance subsidy rate	0.2	0.4	0.6	0.8	1.0
Insurance coverage rate (%)	34	53	67	77	100
Coverage rate increment (%)	–	19	14	10	23

Notes: Insurance subsidy rate equals insurance subsidy divided by insurance premium. Insurance coverage rate equals forest farmers purchasing insurance divided by all forest farmers

Table IV.
Experiment data record based on insurance subsidy adjustment

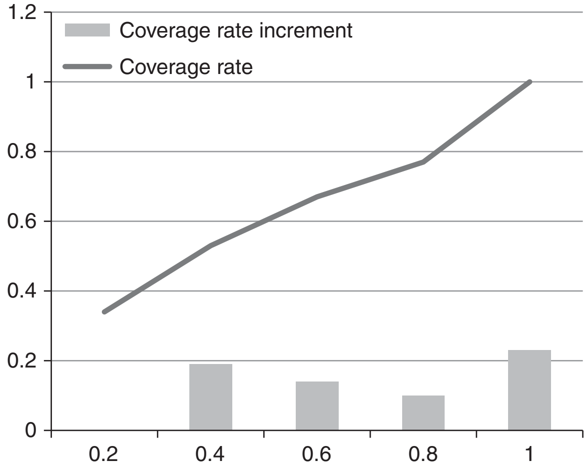


Figure 7.
Experiment results based on insurance subsidy adjustment

In Figure 8, when the insurance subsidy rate is 0.75, experiment11 and experiment12 are performed. With an increasing forest field area, the insurance coverage rate increases from 73 to 93 percent. In a similar way, when the insurance subsidy rate is 0.25, experiment13 and experiment14 are performed. The insurance coverage rate increases from 42 to 89 percent based on forest field area adjustment. Thus, the larger forest field area of the forest farmer agent is, the more actively the forest farmer agent will purchase forest insurance.

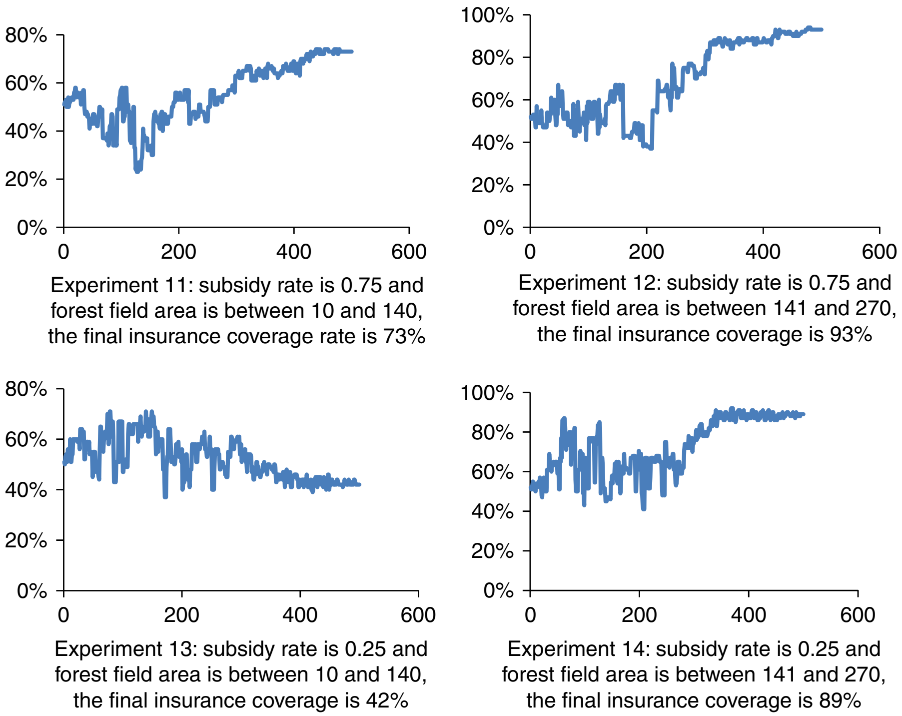


Figure 8.
Experiment results based on forest field area adjustment

7. Conclusions and suggestions

A major task to develop an insurance market is therefore to motivate a considerable amount of forest farmers to enter the market (Brunette *et al.*, 2015). It is necessary to research on the implementation strategy of insurance policy to expand the forest insurance coverage rate further. According to the simulation results above, conclusions and policy suggestions are as follows:

(1) When the insurance premium decreases and the subsidy from government increases, more forest farmers will purchase forest insurance. This can be explained by principles of economics: customers' demands to general commodities are inversely related to the price of commodities, that is to say, the cheaper commodities are and the higher demands will be. When the insurance premium decreases or the insurance subsidy increases, forest farmers will pay less money on forest insurance, which will increase the forest insurance coverage rate.

(2) The forest field area owned by forest farmer will affect the forest farmer's purchasing decision on forest insurance. When the area of forest land is larger and the quality of forest land is better, the greater the expected loss of farmers and the stronger the willingness to avoid risks in the case of disasters (Qin *et al.*, 2013). Supposing forest sales profit per mu is the same, the larger forest field area is, the higher income forest farmers, and also the higher re-planting cost will be. According to experiment results above, the larger forest field area owned by the forest farmer, the more tendency of purchasing forest insurance by the forest farmer will be.

In conclusion, at the primary stage of forest insurance implementation, it is difficult for the insurance company to lower the insurance premium. A high insurance premium lies in a small insured area. In fact, some studies have shown that the larger the insured area is, the lower the insurance premium will be (Holecy and Hanewinkel, 2006; Pinheiro and Ribeiro, 2013). Thus, the insurance subsidy from government is an important influence factor for forest farmers to decide to purchase forest insurance or not. According to simulation results, if the government provides 100 percent subsidy to the forest insurance premium, all forest farmers will join the forest insurance program and the insurance coverage rate will be 100 percent.

Moreover, according to simulation results, forest farmers with a large forest field area are more actively to purchase forest insurance than those with a small forest field area. At present, most of forest farmers in China possess a small-scale forest field area, and the Chinese Government has set up a forest insurance program for small-scale forest property holders (Dai *et al.*, 2015). Under this circumstance, the subsidy on forest insurance from government will be a positive impetus to the implementation of forest insurance.

In the future, with an expanding forest field area insured, the insurance premiums will be in a reasonable range (Brunette *et al.*, 2015). Meanwhile, with the expansion of the insured forest area and the upgrading and large-scale operation of forest farms, the forest sales profit will be the major income of forest farmers. At that time, forest farmers will be more willing to join the forest insurance program to transfer national disasters, and, then, the implementation of forest insurance no longer requires government subsidies for forest insurance premiums.

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