The Application and Modification of Delegation – Agent Model in Agricultural Insurance

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Abstract The delegation – agent models in agricultural insurance are established both under the circumstances of information symmetry and information asymmetry. Insurers choose effort level $-a^*$ according to the first order optimal condition of $\int\{v(\pi-s(\pi))+\lambda_{11}[u(s(\pi))]f_a(\pi,a^*)\}d\pi=\lambda_{11}c'(a^*)u(s(\pi))$ at the present stage when the information is symmetric. While the information is asymmetric, the first order optimal condition changed into $\frac{v'(\pi-s(\pi))}{u'(s(\pi))}=\lambda_{21}+\mu_{21}(1-\frac{f_a(\pi,a)}{f(\pi,a)})$. In other words, the higher the output, the more and more income of insured. The paper also modifies the models, when the information is symmetric, the insurers determine the effort level of insured $-a^*$ based on the first order optimal condition of $\int\{v(\pi-s(\pi))+\lambda_{12}[u(s(\pi))]f_a(\pi,a^*)\}d\pi=\lambda_{12}h'(a^*)u(s(\pi))$; to the contrary, the first order optimal condition would change into $\frac{v'(\pi^*-s(\pi^*))}{u'(s(\pi^*))}=\lambda_{22}+\mu_{22}(1-\frac{f_a(\pi,a)}{f(\pi,a)})-\frac{\lambda h(a)}{f(\pi,a)}-\frac{\mu h'(a)}{f(\pi,a)}$. The results show that the insured and the insurers would both benefit from the insurance when the effort cost function related to the expectation of the insured (agricultural producers). If the insured manage the objects of insurance more seriously, the rate of disasters would be lowered. Therefore, the insurance claimed against the insured would be lessened, and the benefits of the insurers would be increased at last.

Key words Agricultural insurance, Delegation – agent model, Moral hazard, Modification, China

Agricultural insurance is a kind of insurance providing guarantees for agricultural producers engaged in farm production and fish breeding and poultry raising when they get losses in the process of production by natural calamities and accidents. For peasants lived at the mercy of the elements, there is nothing more than natural disaster to make them distressed and unalternative. According to statistics, natural calamities bring about more than 100 billion yuan losses every year in our country, the population in calamities are more than 0.2 billion. Among them, peasants are the foremost sufferers[1]. All along, this kind of expenses is burdened by state and local civil administration department, and also a small part from public and enterprises' donation. This model not only costs a great deal of financial resources from the state, but also goes against formation of sound agricultural risk prevention system. Related experts point out that we should establish agricultural insurance mechanism and set up agricultural insurance companies as soon as possible, and use more social strength to resolve agricultural insurance. But in recent years, development of agricultural insurance in our country meets great obstructions, for instance, premiums declining, insurance kinds reducing and so on. One of the reasons of this circumstance is moral hazard issue of agricultural insurance in the condition of information asymmetric (Agricultural producers use their awareness of objects of insurance and master this advantage to loosen management of insured object). In order to avoid the behavior, the author will analyze it using delegation-agent model.

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1 Establishment of model

We suppose that action is on behalf of one – dimensional random variable of continuous type of effort level of managing crops and poultry, and make θ be external random variable (called "natural state", such as natural calamities, infectious diseases and so on) which out of control of agent and principal (insurance company). a and θ codetermine the output $\pi(a,\theta)$ (direct ownership belongs to principal). Supposing that π is strictly increasing concave function of a, that is $\frac{\partial\pi}{\partial a}>0, \frac{\partial^2\pi}{\partial a^2}<0$, it shows that output improve along with increase of effort level, but the improved rate is declining; And π is strict increasing function of θ, that is $\frac{\partial\pi}{\partial\theta}>0$, it shows that the bigger θ, described random environment is more beneficial to output. Here, π can be explained as the output of crops of agricultural producers. The utility function of principal and agent—*v-N-M* is respectively established as $v(\pi-s(\pi))$ and $u(s(\pi))-c(a)$, $s(\pi)$ is settlement of claims to agricultural producers from insurance company, $v'>0, v''\leqslant 0; u'>0, u''\leqslant 0$. It means principal and agent are both risk averter or risk neutral, $c(a)$ is disutility or effort cost generated by efforts. When $c'(a)>0, c''(a)>0$, it means a is bigger, then disutility or cost of effort is bigger, and the increased rate is incremental. On the basis of the above hypothesis, Mirrlees and Holmstrom put forward using "parameterized distribution formulation"[2-4] to summarize the following model.

$$F=\max_{a,s(\pi)}\int v(\pi-s(\pi))f(\pi,a)d\pi \qquad (1)$$

$$s.t.\ (IR)\int u(s(\pi))f(\pi,a)d\pi - c(a) \geqslant \bar{u} \quad (2)$$

$$(IC)\int u(s(\pi))f(\pi,a)d\pi - c(a) \geqslant \int u(s(\pi))f(\pi,a')d\pi - c(a),\ \forall a' \in A \quad (3)$$

Among them, Formula (1) is objective function; Formula (2) is participation constraint(1*R*); Formula (3) is incentive compatibility. Principal's issue is choosing a and $s(\pi)$ to maximize its own expected utility under the condition of satisfying constraint condition.

1.1 Model under information symmetry Under the condition of information symmetry, the action of insured – a or natural state – θ can be observed by principal. Then, insurers give rewards and punishment to insured through observed a. Incentive mechanism is established according to a. So incentive compatibility is unnecessary this moment.

We will discuss in the follow that the optimum allocation of output π determine by action a under the circumstance of symmetry of information.

Given out effort level a, output $\pi(\theta)$ is a simple random variable, the issue changes into selection $s(\pi)$ of optimal model constituted by (1) – (2). Constituting lagrangian function:

$$L(s(\pi)) = \int v(\pi - s(\pi))f(\pi,a)d\pi - \lambda_{11}[\int u(s(\pi))f(\pi,a)d\pi - c(a) - \bar{u}] \quad (4)$$

So we get the first order condition of $s(\pi)$:

$$-v'(\pi - s^*(\pi)) + \lambda_{11}u'(s^*(\pi)) = 0 \quad (5)$$

That is:

$$\frac{v'(\pi - s^*(\pi))}{u'(s^*(\pi))} = \lambda_{11} \quad (6)$$

Through Formula (6), we can get optimal contract $s^*(\pi)$. Under general condition, the specific form of optimal contract $s^*(\pi)$ relies on change of risk aversion[3-4,5]. Similarly, we can get option form of optimal contract a^*. Derivate a in lagrangian function , we can get:

$$\int\{v(\pi - s(\pi)) + \lambda_{11}[u(s(\pi))]f_a(\pi,a^*)\}d\pi = \lambda_{11}c'(a^*)u(s(\pi)) \quad (7)$$

The insurer just chooses a^* according to the first order optimal condition of Formula (7).

1.2 Model under information asymmetry Under the condition of information asymmetry, the action of insured-a or natural state-θ cannot be observed by principal. Then, insurers give rewards and punishment to insured through observed output π. And supposing that to all the π, if $a > a'$, we get $F(\pi,a) < F(\pi,a')$, that is the first-order random dominance of distribution function[3]. According to the research of Mirrlees and Holmstrom, incentive compatible constraint can be replaced by first order condition:

$$\int u(s(\pi))f_a(\pi,a)d\pi = c'(a) \quad (8)$$

Using the method of first order condition, the insurers issues change into:

$$\max_{s(\pi)} \int v(\pi - s(\pi))f(\pi,a)d\pi \quad (9)$$

$$s.t.\ (IR)\int u(s(\pi))f(\pi,a)d\pi - c(a) \geqslant \bar{u} \quad (2)$$

$$(IC)\int u(s(\pi))f(\pi,a)d\pi = c'(a) \quad (10)$$

Using Lagrange's multiplier, the first order condition of above optimal issue is:

$$\frac{v'(\pi - s(\pi))}{u'(s(\pi))} = \lambda_{21} + \mu_{21}\left(1 - \frac{f_a(\pi,a)}{f(\pi,a)}\right) \quad (11)$$

It is stated in Formula (11), if features of mono likelihood ratio[5] are set up and $f_a(\pi,a)/f(\pi,a)$ is increasing function of π, then $\partial s(\pi)/\partial\pi > 0$. The optimal incentive contract $s^*(\pi)$ must be increasing function of π, that is more output, more income of insured.

2 Modification of model

2.1 Modification under information symmetry In agricultural insurance, if insured get settlement of claims from insurance company, there will be corresponding income. Then insured can use the income to manage object of insurance, and insurance company also know the behavior of insured. At this moment, cost function of expenses of insured can be supposed as $C = h(a)u(s(\pi))$. That is connecting expensive cost of insured with its achievable effectiveness. $h(a)$ can be explained as the proportion of investment of insurance in acquired effectiveness after insuring. For example, to the crop farmers, it should fertilize and crop-dusting on time, to poultry farmers, it should give animals preventive inoculation on time, so $0 \leqslant h(a) \leqslant 1$. Then, the delegation-agent model change into:

$$F_1 = \max_{a,s(\pi)} \int v(\pi - s(\pi))f(\pi,a)d\pi \quad (12)$$

$$s.t.\ (IR)\int u(s(\pi))f(\pi,a)d\pi - h(a)u(s(\pi)) \geqslant \bar{u} \quad (13)$$

Constructing lagrangian function:

$$L(s(\pi),a) = \int v(\pi - s(\pi))f(\pi,a)d\pi - \lambda_{12}[\int u(s(\pi)f(\pi,a)d\pi - h(a)u(s(\pi)) - \bar{u}] \quad (14)$$

The first order condition $s(\pi)$ is obtained:

$$-v'(\pi - s^*(\pi)) + \lambda_{12}[u'(s^*(\pi)) - h(a)u'(s^*(\pi))] = 0 \quad (15)$$

That is:

$$\frac{v'(\pi - s^*(\pi))}{u'(s^*(\pi))(1 - h(a))} = \lambda_{12} \quad (16)$$

The above formula can change into

$$\frac{v'(\pi - s(\pi^*))}{u'(s^*(\pi))} = \lambda_{12}(1 - h(a)) \quad (17)$$

From formula (17), we can know that, when $h(a) = 0$, insured don't invest their own object of insurance after insuring, formula (17) is formula (6) under information symmetry. The proportion of marginal utility of income of insured and insurers is still positive number, and has nothing to do with output π and natural state θ. But it is not a constant, it is decreasing with increment of $h(a)$. So the incentive contract and optimal contract decided by formula (17) not only relies on change of risk aversion but also connects with effort cost in management of object of insurance by insured.

Make derivation of a in the above lagrangian function $L(s(\pi), a)$:

$$\int\{v(\pi - s(\pi)) + \lambda_{12}[u(s(\pi))]f_a(\pi,a^*)\}d\pi = \lambda_{12}h'(a^*)u(s(\pi)) \quad (18)$$

Insurers determine effort level a^* of insured by first order of formula (18).

2.2 Modification under information asymmetry Supposing cost function of insured is the same as that in "**2.1**", the model at this moment change into:

$$F_2 = \max_{s(\pi)} \int v(\pi - s(\pi))f(\pi,a)d\pi \quad (19)$$

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3.4 The insurance company should improve the service quality and foster the positive image of insurance companies In the primary stage, the quality of personnel involved in the insurance industries should be improved and their comprehensive quality and business abilities should be enhanced through training. The insurance company should provide no less than 30 hours' training for the agents of micro insurance and the agents should be provided with certificates by the Insurance Regulatory Bureau. The training should cover the basic knowledge about insurance, relevant regulatory requirements, marketing of micro insurance, service and claims and so on. In the second place, much attention should be paid to the service quality of insurance company, especially to the problems of the timeliness and full compensation in the process of claims. At the same time, the practices and procedures should be simplified. Only by good services, can insurance company attract peasant households, and then further improve the sustainable development of rural micro insurance. In the last place, the image of insurance company should be well forged. For example, the insurance company can launch the "service month" activities and take the social responsibilities boldly. In addition, the insurance company can take setting up scholarships in rural middle and primary schools into consideration, as well as the system of donating for disaster-hit area. Good image of a company is the foothold of it.

3.5 The support from the government should be strengthened to help poor peasants to affiliate to insurance Although the premium per peasant in per year is lower than 50 yuan, it is still difficult for some low income households to afford it. The micro insurance should be functioned as the policy-based insurance and the premium should be shared by the governments, the village collections, insurance companies and peasants themselves. At present, limited by the finance, it is unrealistic for the government to subsidize the micro insurance for all the low-income peasants. However, the government can try to develop the subsidies of micro insurance for special low-income peasants such as rural households with minimum needs, "households enjoying five guarantees" (free food, clothing, medical care housing and burial expenses), family members of servicemen and martyrs. Currently, the nation has expanded the new type rural cooperative medical care system in rural areas. Therefore, from the types of insurance, the government can provide subsidies of the death and disability insurance for the main labor force in low income families[3]. With the augmentation of the state finance, the government should strengthen the support to peasants and let the micro insurance fully display its functions of benefiting peasants.

References

[1] ANON. Actively promoting rural micro insurance of Hebei Province [EB/OL]. (2010-05-27). http://www.chinaacc.com/new/403_425/2010_5_27_xu53551915361725010295.shtml. (in Chinese).
[2] TUO GZ, WANG GJ, DUAN JX, *et al.* Innovation and development of insurance for agriculture, rural area and farmers[M]. Beijing: China Financial Publishing House, 2009:41. (in Chinese).
[3] LIANG T. Rural micro-life insurance[M]. Beijing: China Financial and Economic Publishing House, 2008:191. (in Chinese).
[4] TIAN AJ. Predicament and development of agricultural insurance in China[J]. Asian Agricultural Research, 2009, 1(1): 29-33.
[5] HUANG HG, LI FZ. The Enlightenment of Shangyang reform to agricultural innovation in China[J]. Journal of Anhui Agricultural Sciences, 2009, 37(4):464-466. (in Chinese).
[6] WANG ZY. Construction of the legal system of agricultural insurance in China[J]. Asian Agricultural Research, 2009, 1(1): 44-48.
[7] TIAN AJ. Research on the predicament and development of agricultural insurance in China[J]. Journal of Anhui Agricultural Sciences, 2009, 37(6):415-417, 427. (in Chinese).
[8] ZHANG CL. Legislative mode and framework of policy agricultural insurance[J]. Asian Agricultural Research, 2009, 1(6):38-43.

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$$s.t.\ (IR)\int u(s(\pi))f(\pi,a)d\pi - h(a)u(s(\pi)) \geqslant \bar{u} \quad (20)$$

$$(IC)\int u(s(\pi))f_a(\pi,a)d\pi = h'(a)u(s(\pi)) \quad (21)$$

Constructing lagrangian function, lagrangian percentages of participation constraint *IR* and incentive compatibility *IC* are respectively λ and μ, and then make derivation of $s(\pi)$:

$$\frac{v'(\pi^* - s(\pi^*))}{u'(s(\pi^*))} = \lambda_{22} + \mu_{22}\left(1 - \frac{f_a(\pi,a)}{f(\pi,a)}\right) - \frac{\lambda h(a)}{f(\pi,a)} - \frac{\mu h'(a)}{f(\pi,a)} \quad (22)$$

$s^*(\pi)$ can be decided by Formula (22), and it not only related to likelihood ratio $f_a(\pi,a)/f(\pi,a)$, but also related to management cost to object of insurance by insured.

3 Conclusion

In a word, when effort cost function is $C = h(a)u(s(\pi))$, insured (agricultural producers) associate the obtained effectiveness with management effort in object of insurance. The insured and the insurers would both benefit the insurance when the effort cost related to the achievable effectiveness. If the insured manage the objects of insurance more seriously, the rate of disasters would be lowered. Therefore, the insurance claimed against the insured would be lessened, and the benefits of the insurers would be increased at last.

References

[1] YANG M. Agriculture insurance cannot play a great role under frequent natural disasters[N]. Market News, 2005-10-09. (in Chinese).
[2] MIRRLESS J. The theory of moral hazard and unobservable behavior: Part I[M]. Mimeo. Oxford: Nuffield College, 1975.
[3] ZHANG WY. Game theory and information economics[M]. Shanghai: Shanghai People's Publishing House, 1996. (in Chinese).
[4] HOLMSTROM B. Moral hazard and observation[J]. Bell Journal of Economics, 1979, 10:74-91.
[5] PINDYCK RS, RUBINFELD DL. Microeconomics[M]. 6th ed. Beijing: Tsinghua University Press, 2005. (in Chinese).