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Agriculture and Agricultural Science Procedia 1 (2010) 354–363

Agriculture and Agricultural Science Procedia

International Conference on Agricultural Risk and Food Security 2010

Analysis of the main interests of agricultural insurance main body based on the perspective of evolutionary game

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Abstract

The CPC Central Committee Document No. 1 several times in the State Department stated that we will steadily push forward agricultural insurance policy the experimental work to speed up the development of various forms, multi-channel agricultural insurance. Agricultural insurance, however, due to natural disasters, leading to high-risk nature of the wishes of farmers and insurance companies, low purchase and show a high rate of "effective demand is insufficient, insurance products is in short supply" situation, the effectiveness of the agricultural insurance, risk compensation cannot fully achieve. In this paper, under the condition of bounded rationality analytical framework of evolutionary game model, from the farmers, insurance companies and mutual relations between the government proceed to analyze how to revise its strategy between the three options in order to achieve a balanced process. Then according to the balanced game model solution, we propose some policy recommendations to optimize the level of three well-beings .

Keywords: policy-oriented agricultural insurance; game analysis; government subsidies

1. INTRODUCTION

Agricultural insurance due to natural disasters caused by high-risk nature of the low purchase intention of farmers, insurance companies and the state of high rates of absence related policy constraints to varying degrees, the development of agricultural insurance. Despite an early start of China's agricultural insurance, agricultural insurance premium income accounted for the proportion of property insurance premiums less than 5%, the diagram reflects the development of China's agricultural insurance. Agricultural insurance in China for more concentrated study of the development of institutional policy, You-hai Fei(2005) is based on welfare economics perspective make the way out of institutional innovation is the development of China's agricultural insurance; Jia-zhi Xie and Zhen Zhou (2009) Analysis of Agricultural Catastrophe Insurance of the main groups in the process of dynamic changes in gene replication, come to insurance companies and the insured does not exist among farmers so that the two sides and stable strategy; Zhong-ming Tan and

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2210-7843 © 2010 Published by Elsevier B.V.
doi:10.1016/j.aaspro.2010.09.044

Yong-mou Xu (2009) explored the conditions of government intervention in agricultural insurance, risk-compensation for participation in the main game behavior, obtained Government's involvement in agricultural insurance, conducive to social well-being improve. This article uses the game's ideological evolution of the main benefits of participation in the dynamic analysis, from the expectations of farmers involved in agricultural insurance proceeds, insurance supervision and inspection of how the Government will provide policy incentives and subsidies to arrive three options to achieve their own utility maximization strategy, this as the development of agricultural insurance policy recommendations.

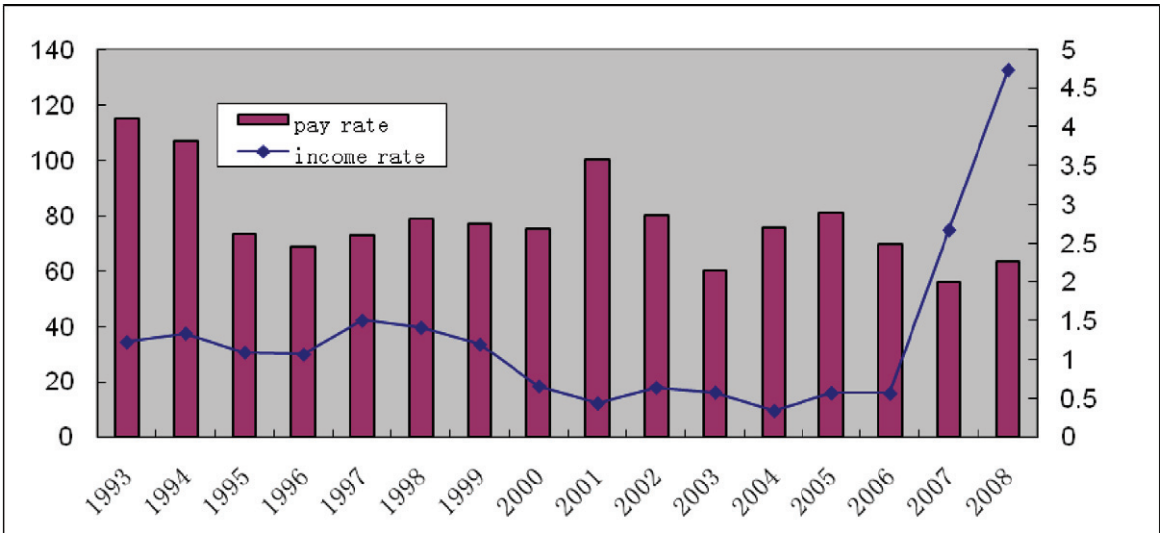

Figure 1 China's agricultural insurance payment rate and proportion analysis

Data Source: National Bureau of Statistics Web site over the years, "China Statistical Yearbook," China Insurance Regulatory Commission Web site property insurance operating income data.

The figure we can see from the agricultural insurance due to the characteristics of high payment rates, the average payment rate of over 78%, insurance companies, business risks and operating costs due to the lack of depth the higher the positive nature of the agricultural insurance business. Agricultural insurance accounts for the proportion of property insurance has been in a relatively low level, until 2006 at the 1% from top to bottom, and the downward trend. With the advancement of new countryside construction, stable agricultural production and implementation of policies to increase income of the farmers, agricultural insurance, property insurance accounts for only a rapid increase in the proportion to 4.5% or so.

2. EVOLUTIONARY GAME THEORY

Evolutionary game theory is a new method of economic research, which will be evolutionary game theory analysis and dynamic combination of process analysis, assuming that the individual for a limited rationality, adaptive learning ability. The real economic life, the individual in learning, decision-making ability of different actors will not resort to a fully rational and optimal strategy under the conditions, but in learning, imitating and to optimize their own decisions. Optimization of individual behavior in a repeated game of competition and cooperation was gradually stabilized, its strategy adjustment process can be "selection strategy to choose a new strategy → evolution → re-evolution" description. The main process is evolutionary stable strategy and replication dynamics equations; because the basic idea of biological evolution is similar to that game analysis is often referred to as "evolutionary game theory."

Maynard Smith expressed in his book "Evolution Game" the 2 * 2 game evolutionary stable strategy ESS mathematical formulations. Set up a group in a particular individual, its strategy space S in the selection of a strategy s_1 , Its rival to take a different strategy for s_2 . Its earnings $u(s_1, s_2)$. If the optional strategy for all s_1 and s_2 one of the following conditions are met, claimed it as evolutionary stable strategy (ESS) [b].

① $u(s_1, s_1) > u(s_2, s_1)$ that s_1 is the best strategy on its own.

② $u(s_1, s_1) = u(s_2, s_1)$ And $u(s_1, s_2) > u(s_2, s_2)$.

That is, if the s_2 on s_1 an equivalent alternative strategy, and the s_1 on s_2 one of the best strategy, then they must have a ratio. Replication dynamic equation (RDE) [c] is to analyze a specific strategy in a population were used in the frequency of the number or frequency of the differential equation, when the strategic options results above-average level, the choice of the strategy groups in the whole population the proportion would be upgrade.

3. EVOLUTIONARY STABLE STRATEGY GAME MODEL ANALYSIS

In accordance with the number of research groups in different evolutionary game is divided into two main categories [d] Single-group symmetry dynamic game with multi-group asymmetric dynamic game. One group of dynamic game objects which apply to the study group contains only one state, groups of individuals have the same set of pure strategies and income conditions, carried out between individuals is symmetric game; multi-group study of non-symmetric games the object contains a number of groups, different groups of individuals have different sets of pure strategies, the average earnings of different groups and different evolutionary rate between different groups of individuals of non-symmetric games.

The Two Symmetric Games (between farmers)

Farmers groups, lower level of education, habits and customs are similar, inhabited by life evolving convergence of values. Individual farmers are accepting new things in the vulnerability to the impact of the surrounding farmers, and through learning and imitation to modify their own decisions. At the same time, farmers groups, access to information channels of a single, between the amounts of information has no significant difference, so assume that the game is symmetric between farmers game.

3.1.1 Model Assumptions and The Creation of It

Model evolutionary game the two sides use different strategies farmers groups, in order to simplify the analysis will use different strategies of rural households is assumed to be two games side: farmer and farmer , and for a limited rational actors.

Based groups involved in Game 2 of the utility function is $u(x) = -e^{-rx}$. As the absolute risk aversion can be $-u''(x)/u'(x)$ to define, because $u'(x) = re^{-rx}, u''(x) = -e^{-rx} \cdot (r^2)$, so $-u''(x)/u'(x) = r$ .Because r Value represents the parties in risk aversion, when the r = 0 when risk-neutral; as r >0 for the risk averse; as r <0 for the risk evader.

[b] Xiao-jun Yu, the evolutionary game analysis on high-speed driving [J], math practice and acknowledge 2009(6): 14-18

[c] D.Friedman, on economic applications of evolutionary game theory [J], J Evol Econ 1998(1):15-43

[d] Hang-Zhang and Yan-li Liu, evolutionary game analysis on our IPO system reform[J] Journey of CUFE 2009(12)48-52

Assumption of risk adverse farmers, their initial wealth W, the risk of loss probability π, and the property damage occurred as the L. When the farmers did not purchase insurance, the expected utility is as follows: $EU_1 = (1-\pi)U(W) + \pi U(W-L)$. When the farmers insured amount when the insurance K (meaning the event of a risk, the person can get K yuan), the premium rate for γ, then the required premium payment γK. So that insurance case, the farmer's property will be two kinds of results, no loss, wealth is $C_1 = W - \gamma K$; the event of loss, wealth is $C_2 = W - L + K - \gamma K$. In a fair premium rates, the consumers of its insured the amount of K, the expected utility as follows: $EU_2 = \pi U(W-L+K-\gamma K) + (1-\pi)U(W-\gamma K)$. Countries to promote the development of insurance industry incentives for farmers to buy the amount of A. In this connection, reference Jia-zhi Xie and Zhen Zhou (2009) analysis of [e,] when the random selection of two types of households are not at the same time will be different due to behavioral pressure to bear certain risks, and may interfere with the formation of pairs of existing decision-making. The choice of the definition cost of such intangible I, as a discrete variable whose value is 0 or I, two types of household decision-making behavior with the same 0. Farmers from the above parameters and assumptions constitute a group of payoff matrix is as follows.

Table 1 Farmers group game payoff matrix

Farmers 1 \ Farmers 2	Insurance	Not insured
Insurance	EU_2+A ,EU_2+A	EU_2+A,-I+EU_1
Not insured	-I+EU_1,EU_2+A	EU_1,EU_1

3.1.2 Farmers Groups, Gene Duplication and Evolutionary Stable Strategy Dynamic Equation

Farmers groups in select "insurance" side of the game proportion p, there are 1 - p of the game party "not insured." Then, using two kinds of strategy game party expected earnings and average expected income groups are as follows:

$$u_1 = p(EU_2 + A) + (1-p)(EU_2 + A) = EU_2 + A \quad (1)$$

$$u_2 = p(-I + EU_1) + (1-p)EU_1 = EU_1 - pI \quad (2)$$

$$\overline{u} = pu_1 + (1-p)u_2 \quad (3)$$

According to the expected profit be replicated dynamic equation:

$$F(p) = p(u_1 - \overline{u}) == p(1-p)(EU_2 + A - EU_1 + pI) \quad (4)$$

The copy of the first-order equation of dynamic equations is as follows:

$$F'(p) = (1-2p)(EU_2 + A - EU_1 + pI) + Ip(1-p) \quad (5)$$

3.1.3 Game Model Analysis of Equilibrium Solution

[e] Jia-zhi Xie , Zhen Zhou . Based on the limited rationality of agricultural catastrophe insurance, the main behaviour analysis and optimization [J]. Insurance Study .2009 (7) :76-83.

$F(p)=0$,then $p_1^*=0, p_2^*=1, p_3^*=(EU_1-EU_2-A)/I$ But it's not all evolutionary stable strategy. Suppose $m=EU_1-EU_2-A$ Comparison of the insured farmers expected return. Evolutionary stable strategy point of Criterion stability theorem that the differential equations as follows: $F(p)$ =0 and $F'(p^*)<o$.

Table 2 Discriminate evolutionary stable strategy

criterion	$F'(p_1^*)$	$F'(p_2^*)$	$F'(p_3^*)$	ESS
0<m<I	−	−	+	p_1^*, p_2^*
−I<m<0	+	−	−	p_2^*, p_3^*
m>I>0	−	+	−	p_1^*, p_3^*

When 0 <m <I, m> I> 0, the initial level of $p\in(0,p_3^*)$ Farmer groups will gradually choose not to insured;

When 0 <m <I, - I <m <0, the initial level of $p\in(p_3^*,1)$ Farmer groups will gradually choice of the insured.

Acts and choices of rural households vulnerable to the effects of the surrounding farm households choose to have a "herding" feature, so comparison of farmers by increasing the expected return, enhance their subjective satisfaction index can increase the enthusiasm of farmers to participate in agricultural insurance. At the same time, insurance companies should actively promote the importance of insurance as appropriate to reduce insurance rates and provide more suitable for the local crop varieties, agricultural insurance products, in order to attract potential farmers to participate in insurance.

3.2. Two Non-symmetric Games (between the insurer and the insured farmers)

Insurance companies and insurance farmers access to information is different information holdings are quite different. Insured farmers of their own level of risk have a clear understanding of buying insurance, there may be adverse selection or moral hazard. The high cost of insurance information on screening, monitoring and limited the risk of energy has resulted in its inability to fully recognize the risk status of the insured farmers, and thus are non-symmetric information game.

3.2.1. Model Assumptions and the Creation of It

Model the evolution of game two groups, insurance companies and farmers groups. Insurers and the insured farmers are limited rational economic agents, their behavior is based on self-interest in decision-making is to be achieved and guaranteed. In the insurance is running, each actor faces two kinds of different options, that is, insured farmers, farmers can implement a "positive" preventive measures to reduce the risk of loss occurs, when adopt a "negative" precautionary measures will increase the risk of losses incurred. The relative insurance companies in underwriting can be taken when the "Check" and "not check" strategy, the game is not in the two games side at the same time selection, strategic choice and benefit situation of non-symmetrical, and thus non-symmetric games.

Model parameters and assumptions are as follows: agriculture and economic benefits to the insured farmers

W, if to take active measures must be put into a preventive expenditures (In order to simplify the problem, does not differentiate between positive and negative differences between the benefits and assume the prevention expenditure for discrete variables, non-0 or a); Failure to take positive measures to belong to adverse selection, insurance companies in this case if they are found to the number of b, was sentenced to a fine and ordered to put d (d>a) the preventive expenditures, insurance companies check item non-discriminatory and cost per t; in the negative treatment of farmers and insurance companies do not verify, the insurance company not only lost a penalty and failed to timely detection of potential risks and potential losses caused by their own M, so the total loss of insurance companies are recorded as T (b, M), obviously it is an increasing function of b and M, this time farmers and thus to obtain the corresponding gains of additional utility V. If the insured farmers to actively prevent the insurance companies do not check, the insurance company had achieved a positive result will be the effectiveness of R. Parameters are positive, the resulting structure of the payoff matrix game parties are as follows:

Table 3 Game between the insurer and the insured farmers payoff matrix

Insurance \ Insured farmer	Negative	Positive
Check	b-t, W-b-d	-t, W-a
Do not check	-T(b,M), W+V	R, W-a

3.2.2. Insurance Companies and Insured Farmers Groups, Gene Duplication and Evolutionary Stable

Strategy Dynamic Equations

According to Nash equilibrium existence theorem: Every finite game has at least one Nash equilibrium, we can see from the payoff matrix, the model there is no pure strategy equilibrium solution, you can only get the mixed strategy Nash equilibrium solution. The probability-based insurance company check p, does not check the probability 1-p; insured farmers to treat the probability of a negative q, the probability of a positive treatment of 1-q.

Copy of the first-order equation of dynamic equations: $F'(p) = (1-2p)[q(b+T+R)-t-R]$ (6)

Farmers insurance group two game-side expectations of earnings and average expected income groups are as follows: $u_{21} = p(W-b-d)+(1-p)(W+V) = W+V-p(V+b+d)$ (7)

$$u_{22} = p(W-a)+(1-p)(W-a) = W-a \quad ;\overline{u}_2 = qu_{21}+(1-q)u_{22} \tag{8}$$

Groups of insured farmers adopt a "passive" strategy replication dynamics equation is:

$$F(q) = q(u_{21}-\overline{u}_2) = q(1-q)[V+a-p(V+b+d)] \tag{9}$$

Copy of the first-order equation of dynamic equations: $F'(q) = (1-2q)[V+a-p(V+b+d)]$ (10)

3.2.3. Game Model Analysis of Equilibrium Solution

We can get five equilibrium points from the above, they are:

$$(0,0),(0,1),(1,0),(1,1),(\frac{V+a}{V+b+d},\frac{t+R}{b+T+R})$$

The equilibrium point Jacobian matrix determinant and the trace below shows, for discrete dynamic systems, if and only if detJ> 0, trJ <0 when the equilibrium point of ESS.

Only when $T+b-t$ <0< $V+a$, the evolutionary stable strategy is (0,1), this time insurance companies do not check the negative treatment of the insured farmers may result in potential losses of insurance companies increased. Insurance companies should improve the efficiency of inspections and accurately grasp the level of risk farmers, farmers distinguish between the different risk indicators and to quantify and reduce insurance claims, exhibition industry, the fixed costs incurred damage. Insurance companies should be increased penalties for negative farmers, and actively help farmers to conduct risk prevention training to enhance the prevention of self-awareness of farmers. The resulting optimal insurance companies do not check the farmers to actively treat strategic choice.

3.3 Government Intervention and Farmers Groups and Insurance Companies, Game Analysis

Agricultural insurance products are quasi-public product attributes, and therefore need government transfer payments, to the participation of the main agricultural insurance to financial subsidies to encourage insurance companies to better provide agricultural insurance products and increase farmers' capacity to pay premiums. Objective of government policy to subsidize agricultural insurance market is to raise the enthusiasm of the participants, give full play to the Government to coordinate the capacity of the parties to enhance the level of social well-being. Policy-related subsidies to the game side are unilateral or multilateral subsidies, subsidies are as follows:

3.3.1. Model Assumes and its Establishment

Farmers' income households are assumed to inter-group analysis is the same game model. Insurance for the risk-neutral person, the insurance operating expenses for the Z, the number of insured for N. Insurance Agency expected profit from each insured as follows: $eu=\pi(\gamma K-K)+(1-\pi)\gamma K=(\gamma-\pi)K$. Then its total profits are $EU=N\cdot eu-Z$ .Government to increase the social welfare level, improve farmers insurance awareness, to provide multi-channel mechanism for risk diversification, for the amount of insurance premium subsidies for farmers A, pairs of insurance companies operating subsidy measures such as tax breaks B Nash equilibrium solution in order to enable farmers insurance , the insurance company underwriting there. The above parameters are integers, this time farmers groups and insurance company's payoff matrix as shown in table 4:

Table4 The payoff matrix when government intervention

Farmers \ Insurance	Underwriting	Not covered
Insurance	$EU_2+A, EU+B$	$EU_1, 0$
Not insured	$EU_1, -Z$	$EU_1, 0$

3.3.2. The Government to Intervene Insurance Companies and Farmers Groups, Gene Duplication and Evolutionary Stable Strategy Dynamic Equations

Assume that the probability of farmers' insurance p, the probability of insurance coverage q, farmers groups, two types of game-side expectations of earnings and average expected income groups are as follows:

$$u_{11} = q(EU_2 + A) + (1-q)EU_1, u_{12} = qEU_1 + (1-q)EU_1 = EU_1, \overline{u}_1 = pu_{11} + (1-p)u_{12} \quad (11)$$

A copy of the insured farmers when the dynamic equation and its first-order equation is:

$$F(p) = p(1-p)q(EU_2 + A - EU_1); F'(p) = (1-2p)q(EU_2 + A - EU_1) \quad (12)$$

The expectation and the average benefits of two parts in the insurance companies are:

$$u_{21} = p(EU + B) - Z(1-p); u_{22} = o; \overline{u}_2 = qu_{21} + (1-q)u_{22} = qu_{21} \quad (13)$$

A copy of the insurance company when the dynamic equation and its first-order equation are:

$$F(q) = q(u_{21} - \overline{u}_2) = q(1-q)[p(EU + B + Z) - Z]; F'(q) = (1-2q)[p(EU + B + Z) - Z] \quad (14)$$

3.3.3. The Analysis of the Game Model

When $F(p) = p(1-p)q(EU_2 + A - EU_1) = 0$ and $EU_2 + A - EU_1 \neq 0$, $p = 0,1$

When $F(q) = q(u_{21} - \overline{u}_2) = q(1-q)[p(EU + B + Z) - Z] = 0$, $q = 0,1; p = \dfrac{Z}{EU + B + Z}$

For the discrete dynamic systems, if and only if detJ> 0, trJ <0 when the equilibrium point for the ESS. Jacobian matrix is as follows:

Table5 Jacobian matrix Local Stability Analysis

Equilibrium	J determinant sign	J trace symbol	Stability
(0,0)	Z	-Z	ESS
(0,1)	-Z(EU_2+A-EU_1)	EU_2+A-EU_1-Z	unstable
（1,0）	0	EU+B	unstable
（1,1）	（EU2+A-EU1）·(EU+B)	-(EU_2+A-EU_1+EU+B)	unstable

When $EU_2 + A - EU_1 = 0$, equilibrium point（0,0） is the ESS farmer's insurance the same of expectation.

When $0 < EU_2 + A - EU_1 < Z$, equilibrium point（0,0）;(0,1) is the point of ESS;(0,1),(1,0).

When $EU_2 + A - EU_1 < 0 < Z$, equilibrium point（0,0）;(0,1) is the point of ESS;(1,0),(1,1).

Therefore, the state should increase subsidies for agricultural insurance development efforts in order to achieve (1,1) optimal stable point, this time insurance companies, farmers due to high expected return of voluntary insurance coverage.When the expected benefits and state subsidies, are greater than the

expected benefits of the insured farmers. Insurance companies for agriculture higher sunk costs of insurance to deal with insurance companies to give tax incentives to provide more extensive selection of insurance products for farmers, targeted design product categories. The Government should commission-agent mechanism design and reasonable size of the optimal subsidies, increase level of effort of insurance companies so as to promote the positive development of agricultural insurance companies.

4. CONCLUSIONS AND RECOMMENDATIONS

Through the above analysis we can see game model, due to agricultural insurance, quasi-public product attributes, the game benefits from their own point of view side selection strategy, the corresponding strategy profile is not a social welfare optimum, resulting in unnecessary loss of welfare. The development of agricultural insurance in the government, insurance companies, the participation of farmers, through the interests of the parties Equilibrium Strategies gradually stabilized. At this stage to carry out agricultural insurance in China's slow emergence of supply and demand "double cold" situation, the agricultural insurance should be on how to carry out more effective as a means for farmers to provide agricultural disaster risk protection; this paper put forward the following policy recommendations:

4.1. Expediting the development of agricultural insurance, special laws and regulations

The Government's legal system in the development of relevant supporting policies and establish long-term mechanism is insufficient, so follow the example of agricultural insurance has been thoroughly carried out the U.S. and Japan combined with the status quo of China's agricultural development is conducive to steady economic growth and development of agricultural insurance, the legal system is imminent , so that China's agricultural insurance, the relevant preferential policies enjoyed by the parties restraint mechanism, the relevant bodies of the functions of the rule of law, a long-term.

4.2. Deep into the pilot agricultural insurance

Since 2004, the CIRC in agricultural development major provinces and cities have approved the Yangguang, Anhua, Anxin, Guoyuan and Anmeng five professional management of agricultural insurance company, as the insurance business through the optimization of the pilot. Professional agricultural insurance for farmers to provide more detailed agricultural insurance services, and promote the smooth operations of the claims and insurance exhibition industry in-depth development.

4.3. On a Voluntary Basis to Conduct an Appropriate Agricultural Insurance Compulsory

Yu-min Li, Yong-xi Du, Ting-tong Li[f] (2008) by constructing game model analysis, combined with the real national conditions and strength, research shows that the voluntary principle and the principle of full force is not suitable for policy-oriented agricultural insurance.Appropriate balance between the principle of a mandatory system of compulsory and flexibility of the current policy is conducive to the further development of agricultural insurance. China's farmers due to low education level, the insurance role of the lack of the necessary knowledge of the state to take appropriate enforcement of policies that can promote agricultural insurance, universal. Farmers suffered losses caused by disasters if timely access to appropriate compensation for insured farmers will increase the willingness of the insured farmers' incentives and insurance premiums to subsidize farmers can affect the behavior of other decision-making.

[f] Yu-ming Li, Yong-xi Du and Ting-tong Li, Insist on proper force principle, promote the agricultural development[J] Insurance Study 2008(1): 56-58

4.4. Construction of Multi-level Agricultural Insurance Risk Spreading Mechanism

High-risk agricultural insurance, which insurance company is difficult to bear alone the risk of loss, through reinsurance, the introduction of other insurance agencies to take risks. You-xiang Li [g]and Guo-wei Zhang(2004) summarized the re-insurance, agricultural insurance benefits, including the expansion of the original insurer underwriting capacity, enhance operational stability of the original insurer, risk diversification, reduce the operating costs of the original insurer to increase the funds available to primary insurers and commission income, the promotion of the original insurer to strengthen management and the promotion of the agricultural insurance against risks of eight aspects of the joint. Government forecasts of weather information in agriculture, to invest more for the farmers to provide accurate weather information to prevent the risk of disaster from happening. Agricultural insurance products, asset securitization, while the formation of linkage with the futures market to attract investors into the risk appetite, give full play to the capital market mechanism for risk diversification.

4.5. The Establishment of Agricultural Insurance Development Coordinating Organization

Established by the National Agricultural Insurance Development Planning Co-ordinating Committee on the development of agricultural insurance, the problems encountered in aggregated, mediation, provision for agricultural insurance, the risk of accumulated reserves, and accumulated in response to catastrophic agricultural losses, monitoring the development of national agricultural insurance subsidy funds the use of in-depth knowledge of the basic level, agricultural insurance, increase the enrolment rate of farmers and agricultural insurance.

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