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Crop Insurance Premium Design Based on Survival Analysis Model

Erda Wang[a], Yang Yu[a], Bertis B. Little[b], and Zuozhi Li[a,] *

[a]*Center for risk management research, School of Management, Dalian University of Technology, Dalian, Liaoning，China*

[b]*Center for Agribusiness Excellence, Tarleton State University, Stephenville, Texas, USA*

Abstract

Survival Analysis method has been commonly used in biology, medical science, and human life insurance studies but it is rarely applied in agricultural insurance research. The main objective of this study is to explore the appropriateness of the Survival Analysis model for the crop insurance program design. Our analysis was mainly focused on the catastrophic risk premium rate estimates under the condition of 70% yield coverage for rice, corn and sorghum in Panjin of Liaoning province, China. The results indicate that the estimated premium rates for each crop are consistent with the currently prevailed crop insurance premium rate in Panjin.

Keywords: Crop insurance; Survival analysis; Risk Management; Premium rate; Government supported crop insurance

1. Introduction

Chinese agriculture faces a significant challenge because the population exceeds one-fifth that in the World, but holds only 10% of the arable land. An important limitation is that China has only one quarter of the average world water resources per person [1], which is a major risk factor in agricultural production. Agriculture production risks of crop failure or decreased yields are caused mainly by adverse weather events (drought, excess precipitation, floods), followed in small part by pests, diseases, and fire. Few economic sectors are as vulnerable to climatic (stochastic) variation [2, 3]. Government intervention to provide assistance to agriculture was widely adopted in China since its foundation in 1949, but assistance programs have not been data driven [4-6]. Chinese agriculture has experienced losses from frequent natural disasters every year. Significant amounts of governmental disaster relief funds are appropriated to mitigate crop and livestock loss to help farmers recover from their production shortfalls. Historically, the effectiveness of different forms of government assistance (ad hoc disaster relief, emergency loans, crop insurance) has not been systematically analyzed, and are not empirically driven [7]. The major handicap in China is the lack of data and analysis on which to base a risk management program [8-11]. More importantly, the

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* Corresponding author. Tel.: +86-411-84707090; fax: +86-411-84707090.
E-mail address: edwang@dlut.edu.cn.

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risks have not been quantitatively evaluated. Agricultural risk management in China has concentrated on ad hoc disaster relief (direct payments, loans) and catastrophic loss assistance (crop insurance).

China has initiated the agricultural insurance policy experiment but needs a successful agricultural insurance program design. Chinese premier Wen has repeatedly emphasized to “strengthen and expand the scope of agricultural insurance program and to do well empirical study for policy insurance program since 2003. In recently closed third session of 11th China National People’s Congress, Premier Wen again pointed out to accelerate agricultural insurance program development. This means that the Chinese central government has a strong resolute to implement agricultural insurance program. In fact, up to the end of 2009 there are 16 provinces and autonomous regions including Xinjiang Production and Construction Group which had initiated agricultural insurance program experiment. However, designing an actuarially based crop insurance program is one of the most challenge tasks. Minimally the design has these important requisites: (1) sufficient participation; (2) appropriate rate making; (3) data driven program design; and (4) actuarial analysis. Participation in the program must be increased; currently participation in the national agricultural insurance is very low, approximately 1-2% of farmers. An equally important issue is “how much financial support should the central government and local governments including province, city and county provide” and “what kind of insurance coverage is needed.” Thirdly, an effective national agricultural risk management plan that can guide insurance for millions of small scale, low technology farms needs to be designed based upon empirical data.

Data availability is the pivotal issue in designing and implementing a successful crop insurance program for China [12-14]. Crop insurance programs have a long history but most crop insurance products in China were oversimplified with a flat premium rate, invariant indemnity, and arbitrary rates not based on actuarial analysis. Lack of connection between risks and insurance costs violates the basic tenets of crop insurance product designs [15-17]. Successful and sustainable insurance programs rely inherently on adequate risk assessment to set premium rates and long-term planning for extreme risk exposure (i.e., 100 year events) and financing needs (establish adequate reserve funds) [18, 19].

In the present investigation, an actuarially-based pilot crop insurance program for rice, corn, and sorghum is developed for Panjin City of Liaoning province in China.

2. Methods and Materials

2.1 Study area

Panjin city is located in the central-west of Liaoning province of northeastern China. It is situated between 121°-122° east longitude and 40°-41° north latitude. The city consists of two districts (Shuangtai district and Xinglong district) and two counties (Panshan county and Dawa county) with the population of 1.243 million. The area belongs semi moisture temperate zone of monsoon climate with a typical four seasons of spring, summer, fall and winter, where the annual highest rainfall and temperature occur at the same season. In general, the area has comfortable temperature and plenty of sunlight. The annual average daily temperature is 8.6°C with 170-frost–free days, 627 mm of annual precipitation, and 2,700 hours of accumulate sun shining.

There are a total of 214,000 rural households in Panjin with the vast majority of them locates in Panshan and Dawa counties where the major cropping agriculture takes place. Crop production is very important to Panjin’s economy. There are a total of 132,706 ha of arable land which accounts for 24% of the City’s total land area. In comparison with the cultivated land area owned by a typical Chinese farmer, the average farm household in Panjin operates a relatively larger cultivated land area: 0.62 ha per household and 0.22 ha per rural capita. In terms of the structure of cropping agriculture, the area grows 106,667 ha of rice, 13,333 ha of corn, 3,337 ha of soybeans, and 3,334 ha of sorghum, with each accounting for 84%, 11%, 3%, and 2%, respectively. The area has reasonable crop productivity. From 1986 to 2007, the average crop yield was 9,146 kg/ha for rice, 5,276 kg/ha corn, 5,076 kg/ha sorghum, and 4,226 kg/ha soybeans, respectively. Farmers’ household survey indicates that the most important concern over the crop production in the area is the yield risk caused by annual yield variation. Historical statistics shows that over the last twenty years there were 21,367 ha of cropland suffered from natural disasters annually and the most important types of disasters include flooding, drought, pest, hail, and wind with each causing 45%, 37%, 11%, and 1% of crop yield losses, respectively, each year.

2.2 Analytical methods

Agricultural data for 1986 to 2008 were provided by Panjin Statistical Bureau at the city level. Data are at the crop, type, and practice level for rice, corn, and sorghum. Data included: (1) total arable acres, (2) yields, (3) daily weather, (4) type of rice crop disease and pest damages, and (5) commodity prices by year. Yield data were detrended for county-specific rainfall and year to detect the annual yield fluctuation of each crop, then Survival analysis model is used to determine the yield insurance premium rate under different levels of coverage.

For the survival function:
Let t be time, T* denote the survival time; assume T* > 0, and,

$$S(t) = \Pr[T^* > t] = 1 - \Pr[T^* < t] = 1 - F(t) \tag{1}$$

where F(t) is CDF of T* assuming that $S(0) = 1$; $S(\infty) = 0$ and if $t_1 < t_2$, then

$$S(t_1) > S(t_2) \tag{2}$$

where S(t) is the probability of survival at time t conditional on a specific crop survival to time t.

Losses at these levels were modeled under a survivor and proportional hazards model. The procedure produces the crop-specific proportional hazard function:

$$h_i = \lim_{\delta \to 0} \frac{\Pr[t_1 \le T^* < t_2 + \delta \mid T^* \ge t_1]}{\delta} \tag{3}$$

where h_i is crop specific and δ is the proportion censored. $\delta_i = 1$ if failure i.e., $t_i = T_i^*$; and 0 if right censored, i.e., $T_i = C_i$. The hazard is the instantaneous rate of failure at time where T* = t conditional on survival to time t, so that the following holds:

$$S(t) = \exp\left\{ -\int_0^t h(\tau)d\tau \right\} \tag{4}$$

and

$$h(t) = -\frac{d(S(t))/dt}{S(t)} \tag{5}$$

The exact time of failure of a given crop type is not known, and some crops will not fail by the end of the interval. Therefore, right censoring will be applied and computations account for this.

Crop specific actuarial tables are constructed from the survival function:

$$\hat{S}(t) = \prod \hat{p}_j \; for\, t \in \left[t_j, t_{j+1}\right] \tag{6}$$

where $\hat{p}_j = (n_j - m_j)/n_j$ is the estimated probability of surviving interval $[t_j, t_{j+1}]$ conditional on survival up to $t_{j.}$

Exponential regression was used to directly compute the survival probabilities (i.e., 1 – probability of failure) computed under the hazards model, deriving the classic "exponent" used in actuarial risk analysis. The exponential distribution is essentially the time between two consecutive Poisson events with intensity λ events per unit time such that the time sustained between failure times, and if we let X be the distribution of interval time, and x is the time after which the second event occurs. In the instance where X > x, then the probability is Pr (X > x) = 1 – F(x) where F(x) is the CDF of X (i.e., no Poissson events have occurred before time x). Hence the probability of no events is: $\Pr(0) = e^{-\lambda x}$ which yields the function:

$$1 - F(x) = e^{-\lambda x} \tag{7}$$

Given $F(x) = 1 - e^{-\lambda x}$, if and only if $x > 0$, and $\lambda > 0$, the derivative of $f(x) = dF(x)/dx$ gives the probability distribution function $\lambda\, e^{-\lambda x}$ for all $x > 0$. Where λ is replaced by 1/δ, $f(x) = 1/\delta\, e^{-x/\delta}$ if $x > 0$, and $\delta > 0$. If time at the event (i.e., crop loss of a given level) is t0 then the probability of time at the event x > t0 is:

$$\Pr(X > t_0) = 1 - \Pr(X < t_0) = 1 - F(t_0) = e^{-\lambda t}{}_0 \tag{8}$$

Thus, the exponential regression model used to compute the waiting time between crop failure events is:

$$\ln(Y) = \ln(b_0) + b_1 t_0 \tag{9}$$

where Y is the waiting time between crop failure events, i.e. survival probability, b_0 is the intercept and b_1 is the exponential regression coefficient. If this is implemented in this application to crop insurance, then survival probability under a specific level of crop yield loss becomes:

$$Y = b_0 \times \mathrm{EXP}(b_1 t_0) \tag{10}$$

The model is tested using a Monte Carlo simulation extrapolated to 100 years and cycled 10,000 times to produce a stable solution, and a historical (empirical) simulation. The Monte Carlo solution is compared to the empirical analysis. The functions can be compared using a log rank test because censoring precludes using the Wilcoxon ranks sum test. Using data from two samples:

$$(T_{ij}, \delta_{ij}) \text{ for } i = 1, 2 \text{ and } j = 1, 2, \ldots, n$$

The null hypothesis to be tested is:

$$H_0 : S_1(t) = S_2(t)$$

where

$$S_j(t) = \Pr[T_j^* > t] \quad for\ \ j = 1, 2 \tag{11}$$

The logrank test of the H_0 is:

$$X_1 = \frac{(O_1 - E_1)^2}{V_1} \quad \sim \chi 2 \tag{12}$$

where

$$E_1 = \sum_{j=1}^{k} E_{ij} \tag{13}$$

$$O_1 = \sum_{j=1}^{k} m_{ij} \tag{14}$$

$$V_1 = \sum_{j=1}^{k} V_{ij} \tag{15}$$

where E_1, O_1 are the expected and actual crop yields at time T, and V_1 is the variance.

3. Study results

3.1 Crop risk loss rate measurement

Statistical tests indicate that each of the three crop yield’s survival probability (1-risk loss probability) complies with the exponential distribution. All three estimated regression equations (Eq.10) (one for each crop) have significant F-statistic at $P<0.01$. The model coefficients (Eq.10) are utilized to derive values of survival function for each of the three crops under 65%, 70%, 75%, 80%, and 85% yield coverage. Then, Cox regression model is used to generate survival curve and compute the correspondent survival probabilities.

The yield loss probability is computed based on deductable rates of 35%, 30%, 25%, 20%, and 15%, i.e., (1-survival rate). The number of years that crop loss risk occurrence under a specific insurance coverage can be determined by the intersection point between the survival curve and a correspondent horizontal line that represents the level of insurance coverage for a particular crop (Table 1).

Table 1. probabilities of basic risk and catastrophic risk losses under various levels of yield coverage

Level of coverage	65	70	75	80	85	65	70	75	80	85
	Basic risk loss					Catastrophic risk loss				
Rice	.014	.056	.067	.100	.143	.000	.029	.029	.042	.056
Corn	.043	.063	.083	.100	.125	.030	.042	.048	.045	.045
Sorghum	.056	.063	.083	.111	.143	.038	.038	.043	.059	.067

Notice that the annual basic loss risk probability should be identical within the years of interval between one event to the next, thus the predicted basic risk probability is 1 divided by the number of years’ interval between two loss events under a specific level of insurance coverage. Catastrophic loss is defined as the yield loss in a particular crop production cycle which exceeds a fifty percent. The loss rate is determined in the same way as it is done for the basic loss probability. The exact number of years that occur as the magnitude of crop yield loss exceeds 50% can be easily identified based on the intersection point between survival curve and a horizontal line which represents 50% crop yield loss. The results are listed in Table 1.

3.2. Determining actuarially based crop insurance premium rate

Ideally, a pure crop insurance premium rate should cover both basic risk loss and catastrophic risk loss. However, the current one flat crop insurance premium rate under policy crop insurance program in China does not give consideration to catastrophic risk losses. Obviously, this is not consistent with actuarial theory and internationally common practices. Thus, here we are proposing a comprehensive crop insurance premium rate setting, which is comprised of four parts: basic risk premium, catastrophic risk premium, reserve fund, and management fees. The first two items are socalled pure premium rate, or loss risk rate which is co-shared by the government and insured farmers. Farmers only pay part of it, i.e., the portion that is left over after the governmental subsidy. The other two parts are completely subsidized by the governments. A common practice is that each category is appropriated based on a 20% pure insurance premium cost. The estimated rates of loss risks presented in Table 1 can be directly used to calculate pure crop insurance premium (Table 2).

Table 2. Estimated pure crop insurance premium rates for rice, corm, and sorghum

Crop type	Coverage (%)	Base rate	Cat.[‡] rate	Pure rate	Crop type	Coverage (%)	Base rate	Cat. rate	Pure rate
Rice	65	.014	.000	.014	Rice	80	.100	.042	.142
Corn		.043	.030	.073	Corn		.100	.045	.145
Sorghum		.056	.038	.094	Sorghum		.111	.059	.170
Rice	70	.056	.029	.085	Rice	85	.143	.056	.199
Corn		.063	.042	.105	Corn		.125	.045	.170
Sorghum		.063	.038	.101	Sorghum		.143	.067	.210
Rice	75	.067	.029	.096					
Corn		.083	.048	.131					
Sorghum		.083	.043	.126					

[‡] catastrophic

It is an unexpected coincidence that the results of actuarially based premium rate are very consistent with the currently established premium rate standard in Panjin. Using 70% of rice and corn yield insurance coverage as an example, the estimated pure premium rates are 8.5% and 10.1% verses to the currently prevailed rates of 8% and 10%, respectively. This may suggest that the survival analysis model is a very reasonable method for actuarially based crop insurance premium rate estimation.

4. Breakdown of crop insurance premium rate

4.1 Breakdown of crop insurance premium

In light of the fact that the current Chinese crop insurance program does not give any consideration to crop product revenue under multiple levels of crop yield insurance program, thus, here we are referring to the U.S. crop insurance program. For instance, if a farmer selects 65% and 70% yield insurance coverage, the government will provide 59% pure premium rate subsidy; for those who select 75%, 80%, and 85% yield insurance coverage, the rates of government subsidy are 55%, 48%, and 38% of pure premium rate, respectively. Subtraction of the government subsidy from the pure premium rate, the amount left over becomes the farmers’ share of the premium cost. Premium share of each category is listed in Table 3.

Table 3. Breakdown of premium rate under various levels of yield coverage

Crop	Pure premium rate	Pure premium rate subsidy [a]	Cat. premium subsidy [b]	Rate of premium subsidy[a+b]	Premium rate paid by a farmer [c]	Reserve fund [d]	Mgt. fee [e]
				65% coverage			
rice	.014	.008	.000	.008	.006	.003	.003
corn	.073	.043	.012	.055	.018	.015	.015
sorghum	.094	.055	.016	.071	.023	.019	.019
				70% coverage			
rice	.085	.050	.012	.062	.023	.017	.017
corn	.101	.060	.017	.077	.024	.020	.020
sorghum	.101	.060	.016	.076	.025	.020	.020
				75% coverage			
rice	.096	.053	.013	.066	.030	.019	.019
corn	.131	.072	.022	.094	.037	.026	.026
sorghum	.126	.070	.019	.089	.037	.025	.025
				80% coverage			
rice	.142	.068	.021	.089	.053	.028	.028
corn	.145	.070	.023	.093	.052	.029	.029
sorghum	.170	.082	.031	.113	.057	.034	.034
				85% coverage			
rice	.199	.076	.035	.111	.088	.040	.040
corn	.170	.065	.028	.093	.077	.034	.034
sorghum	.210	.080	.042	.122	.088	.042	.042

a = pure premium rate with 65%, 70%, 75%, 80%, and 85% coverage multiplies by government rate of subsidy for pure premium rate. Notice that the government subsidy for pure premium rate is 59% under both 65% and 70% coverage; and 55%, 48%, and 38% under 75%, 80%, and 85% coverage, respectively. b=catastrophic risk rate under a specific level of selected coverage × (1-pure premium subsidy rate). For example, with respect to 65% level of coverage in corn, catastrophic subsidy = .030×(1-0.59)=0.012; a+b = government shared premium rate subsidy, i.e., the sum of basic premium rate and catastrophic premium rate; c = farmers actually paid premium; and d,e = pure premium × 20%.

4.2 Pricing mechanism for policy crop insurance

The breakdown of each category of premium shown in Table 3 can be directly used to compute premium price in per hectare basis under various levels of coverage. Notice that the second column (Revenue coverage) in Table 4 (a& b) reflects three levels of the last 4-year average product price coverage: 60%, 80% and 100%, respectively. For the sake of space saving, here only rice and corn insurance premium charge results are presented.

Table 4a. Premium charges on rice insurance under various levels of yield coverage (￥/ha)

Level of coverage	Revenue coverage	Gov't premium subsidy[a]	Premium paid by farmer[d]	Reserve fund[c]	Management fee[b]
.65	7,020	63	42	21	21
.70	7,560	469	174	129	129
.75	8,100	535	243	156	156
.80	8,640	769	458	245	245
.85	9,180	1,019	808	365	365
.65	9,360	84	56	28	28
.70	10,080	625	232	171	171

.75	10,800	713	324	207	207
.80	11,520	1,025	611	327	327
.85	12,240	1,359	1,077	487	487
.65	11,700	105	70	35	35
.70	12,600	781	290	214	214
.75	13,500	891	405	259	259
.80	14,400	1,282	763	409	409
.85	15,300	1,698	1,346	609	609

[a] The governmental premium subsidy = revenue coverage × rate of premium subsidy, which is commonly shared by central government, provincial, city, and County governments; [b,c] revenue coverage × 20% pure premium rate; [d]farmer’s premium = crop revenue coverage × farmer’s premium rate.

Table 4b. Premium charges on corn insurance under various levels of yield coverage (￥/ha)

Level of coverage	Revenue coverage	Gov’t premium subsidy[a]	Premium paid by farmer[d]	Reserve fund[c]	Management fee[b]
.65	5,265	290	95	77	77
.70	5,670	437	136	115	115
.75	6,075	571	225	159	159
.80	6,480	603	337	188	188
.85	6,885	640	530	234	234
.65	7,020	386	126	102	102
.70	7,560	582	182	153	153
.75	8,100	761	300	212	212
.80	8,640	804	449	251	251
.85	9,180	854	707	312	312
.65	8,775	483	158	128	128
.70	9,450	728	227	191	191
.75	10,125	952	375	265	265
.80	10,800	1,004	562	313	313
.85	11,475	1,067	884	390	390

[a] The governmental premium subsidy = revenue coverage × rate of premium subsidy, which is commonly shared by the central government, provincial, city, and County governments; [b,c] revenue coverage × 20% pure premium rate; [d]farmer’s premium = crop revenue coverage × premium rate paid by farmer.

4.3 Premium costs shared by the governments

Using the estimated premium price information presented in Tables 4, it is very convenient to find out how much total crop insurance subsidy costs are shared by the central, provincial, and city and county governments, respectively. To put those premium costs into perspective, let’s use 70% of crop yield and 100% of the last four year average product price coverage as a baseline to estimate the total premium cost shared by each entity. Suppose 80% cultivated crop land is insured, which translates into 85,334 ha, 10,666 ha, and 2,667 ha of rice, corn, and sorghum, respectively (Table 5). Expected liability represents averaged liability for each insured crop and it is calculated using program liability multiplied by the sum of basic risk and catastrophic risk probabilities presented in Table 1 and the results are 0.085 for rice, 0.105 for corn, and 0.101 for sorghum, respectively.

As shown in Table 5, it is expensive to set up a U.S. type of crop insurance program in Panjin area. For instance, with a 100% product price coverage, the total government costs reach as high as ￥76.54 mil for rice, ￥9.13 mil for corn, and ￥2.17 mil for sorghum. However, it is interested to note that of the total ￥76.54 mil of governmental subsidy for rice, ￥66.65 mil is attributed to government premium subsidy accounting for 87% of the total government costs, and ￥4.95 mil attributed to reserve and management fee which account for 13% total governmental costs. In other words, the governments subsidize 73% premium cost and 84% total program costs for rice crop insurance. Needless to say that the government financial burden will be much higher if the program participation rate is less than 80%.

Table 5 Premium costs shared between farmers and the governments under 70% yield and 100% product price coverage assuming 80% participation rate (￥1,000)

Crop type	Covered Area (ha)‡	Program liability	Expected liability	Premium paid by farmer	Gov't Premium subsidy	Reserve fund	Magt. fee	Total gov't costs
Rice	85,334	1,075,208	91,393	24,747	66,646	4,949	4,949	76,544
Corn	10,666	100,794	10,583	2,421	8,162	484	484	9,130
Sorghum	2,667	25,203	2,546	629	1,917	126	126	2,169

‡ total cultivated crop land area × .80.

5. Discussion and conclusions

The results of an empirical analysis of crop yield losses in Panjin，Liaoning Province of China (1986-2008) are used to design a crop insurance program that established the premium rates for five levels of crop yield insurance coverage and three levels of product price coverage for three crops: rice, corn, and sorghum. In the process, the survival model was used to estimate the crop yield loss risk probabilities, which are the key information required for insurance premium rate determination. The results suggest that it is essential to construct a multiple crop insurance coverage in order to improve the program participation rate in China. One of the main reasons bringing about a low crop insurance participation rate of the Chinese farmers is contributed to the prevailed universally single flat premium rate. Obviously, the sole premium rate can only suit one type of risk preference farmers, thus it greatly limits the development of crop insurance program in China.

Another key point deserves to be made here is that based on 44:32:24 ratio of the current crop insurance subsidy cost shares among the central, provincial, and city/county governments, commitment of the county government cost share becomes a weakest link in the process of the program implementation, which substantially restricts the crop insurance program development in Panjin and elsewhere in China. Farmers located in different counties could not equally benefit from the program subsidy provided by the central and provincial governments due to the fact that if a county financial department could not appropriate for the 24% share of premium subsidy cost, all farmers in the county would not be eligible for receiving the higher level of governments' financial supports for crop insurance program. Oral conversation this author had with the local crop insurance company representative reveals the fact that the lack of financial support from the local county governments has jeopardized the seemingly workable crop insurance program in Panjin area. Thus, it is critical for the policy makers to give careful thoughts over the financial conditions of the local county governments. It may be recommendable that some lenient financial support policy may be necessary in order to help farmers in those poor counties benefit from crop insurance subsidy provided by the central and provincial governments and at the same time to motivate their interests of participating in crop insurance program.

It was also recommended that the State Council, China's cabinet, and insurance companies should establish a catastrophe insurance system in the immediate future to improve the country's risk loss compensation plan. Using lessons learned in Panjin's crop insurance programs over the past several years and the history of the US crop insurance program, the largest problem for China in the near future is the management of adverse selection and low program participation rate. The same challenge faced the US crop insurance program in the 1980's and 1990's when adverse selection was pervasive [15, 19]. An additional problem was that prior and existing crop insurance programs in China were not empirically based analyses of risk. The third problem is the level of coverage. Given the choices, farmers may predictably opt to participate in different levels of coverage. One inducement that may work in boosting farmers' participation rate is to require participation in a crop insurance plan in order to be eligible for any other type of government supported program. Eligibility for any agriculture subsidy such as subsidies for seeds, fertilizer, agricultural machinery, and house electronic wares, etc. could demand farmers to buy crop insurance. Such inducements will have favorable outcomes.

References

1. Organization for Economic Co-operation and Development (OECD). Agricultural Policy Reform in China. Policy Brief, OECD, Observer, 2005.
2. Dsmukes, R. and J. Glauber. Crop and revenue insurance: premium discounts attractive to producers. Agricultural Outlook AGO, 2000, 269(3):4-6.
3. Glauber, J. and K.J. Collins. Risk management and the role of the federal government. Agricultural Management and the Role of the Government, 2004, 5: 143-183.
4. B.B. Little, E.D. Wang, Extreme Value Theory – Exponential Distributions: Design of a Chinese Crop Insurance Program, Proceeding for Applied Mathematics and Computing 5th International Conference Plovdiv, Bulgaria, 2008, Vol I: 201-206.
5. Tuo, G. Preface. Risk management and the role of the Federal Government, Agricultural Management and the Role of the Government – Intercommunication and Survey of Agricultural Insurance between China and the United States, published by China Financial Publisher, 2004: 7-12.
6. Wei, X. Incorporative System May Be Able to Resolve the Puzzle for Agricultural Insurance. International Finance Journal, (07) (2004):07.
7. Wang, E and Y. Yu. Co-integration analysis of the impact on policy-related subsidies in China's agricultural insurance market. [J]. China's rural economy, 2009, 4:13-19
8. Lin, Y. Restudy on Institution, technology and the development of Chinese Agriculture, P13, Peking University Publishing House, 2000.
9. Zhang, X. Theoretical discussion on agricultural insurance mode and its implementation strategy. The Theory and Practice of Finance and Economics, 2005, 26 (136): 39-42.
10. World Bank. World Development Report of Year 2003 – Persisting Development in the Changing World Improving Institutions, mode of increase and life quality, p.37, Beijing Chinese Finance and Economics Publishing House.
11. Yu, Y. and E. Wang. Current situation and new mode development of Liaoning agricultural insurance program. Scientific Management Research, 2009, 25(4):149-152.
12. Chen, C. Fighting against Natural Disasters via Crop Insurance Systems. http://www.xinnong.com/html /news/zhengce/2008.
13. Huang, W., and G. Liu. Thinking about Reforming Hunan's Agricultural Insurance Program. Finance and Economy, 2005, 20(98): 142.
14. Liu, R. Statistical Analysis on the Current Agricultural Insurance Situation. Statistical Research, 2004, 11: 37-40.
15. Just, R.E., L. Calvin, and J. Quiggin. Adverse selection in crop insurance: Actuarial and asymmetric information incentives. Amer. J. Agr. Econ. 1999, 81: 834-849.
16. Shen, L. A Literature Summary for Chinese Agricultural Insurance Theory and Empirical Study. Journal of Jiangxi Finance College, 2006 (19): 67-73.
17. Si, j. and S. Meng. Strategic Study on the Current Situation and Issues of Chinese Agricultural Insurance. Issues on Agricultural Economics, 2003(9):47.
18. Babcock, B.A., C.E. Hart, and D.J. Hayes. Actuarial fairness of crop insurance rates with constant rate relativities. Amer. J Agr. Econ. 2004(86): 563-575.
19. Wang, E, Y. Yang, B. B. Little, Z. Chen, and J. Ren. Empirically-Based Crop Insurance for China: A Pilot Study in the Jiangxi and Hunan Provinces. Y. Shi et al. (Eds.): MCDM, CCIS 35(2009): 588–594.