STUDY ON THE PREMIUM RATE DETERMINATION OF SUGARCANE INCOME IN GUANGXI UNDER "FUTURES + INSURANCE"*

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Abstract

Based on the development status and demand of sugar cane in Guangxi, using the unit yield data from 2009 to 2019 of sugar cane in Guangxi and its 14 cities and the transaction price of white sugar contract and spot price data of Zhengzhou Commodity Exchange, this paper studies the formulation of sugar cane income insurance rate under "insurance + futures" from an empirical perspective. Based on the spline function, this paper firstly forecasts the unit yield of sugar cane and white sugar price then fits the marginal distribution of the prediction sequence, uses the copula continuous function to connect the unit yield of sugar cane and white sugar price distribution, and finally uses the Monte Carlo simulation to determine the sugar cane income insurance premium rate under different guarantee levels. The research shows that there are differences in sugar cane income insurance rates in different cities under different security levels. According to this circumstance, some suggestions on the development of sugar cane income insurance in Guangxi are given.

Keywords: Income insurance, Premium rate determination, Spline function, Copula function,

Introduction

In recent years, more attention has been paid to China's agricultural insurance. The "No. 1 central document" successively issued in 2016-2018 emphasizes the importance of innovation and development of crop income insurance. Subsequently, target price insurance system, price index insurance Income insurance and full cost insurance have successively entered the pilot and promotion stage. Since the crop income insurance can reduce the risk caused by the output and the price at the same time and protect the income of growers, it will be an important part of establishing and perfecting the agricultural insurance system in the future (An Yi, Fang Rui, 2016).

Guangxi is the largest sugar cane producing area in China. Its sugar cane output has ranked first for 20 consecutive refining process seasons, accounting for two-thirds of the whole country. The sugar industry has become the most dominant leading industry in Guangxi. However, Guangxi is an area with frequent and repeated disasters. Drought, typhoon, low temperature, freezing damage, forest fire and agricultural diseases and insect pests occur frequently. Extreme natural disasters like these cause huge losses to sugarcane production, destructively affect the economic interests and local finance of sugarcane farmers in Guangxi, and exert a direct impact on the safety of national sugar supply. Agricultural insurance, a universal means of agricultural risk management in the world, has the functions of economic compensation and financing. .

As an emerging financial derivative to hedge risks, the income insurance is a product based on economic theory and combined with modern mathematics, statistics, finance and other disciplines. The income insurance means that the risks of output, price and income are transferred from the farmers to the insurance companies, and the insurance companies make

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profits by charging a certain premium. In order to disperse risks, the insurance companies transfer risks to the futures market, thus forming a "futures + insurance" model.

The operation mechanism of "insurance + futures" mode is as follows:

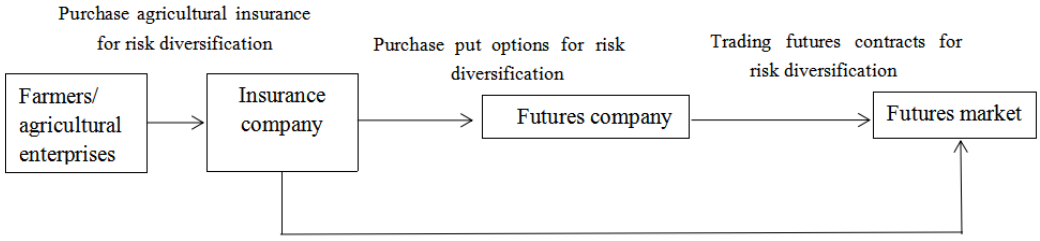

Figure1.The operation mechanism of "insurance + futures" mode

Guangxi sugarcane insurance has played a positive role in protecting the interests of sugarcane farmers and stabilizing sugarcane planting. Therefore, the sugarcane insurance in Guangxi should gradually upgrade from the current cost and price to the income insurance. The sugarcane income insurance under the "insurance + futures" mode can be a useful attempt to carry out crop income insurance in Guangxi. However, because China is still in the initial stage of agricultural data collection, information platform construction and income insurance, the calculation of income insurance premium rate is the technical bottleneck in the implementation of income insurance. At present, there is no futures product corresponding to sugar cane in China, and the trading platform mainly trades in white sugar. Therefore, how to link the spot and futures price of white sugar with the price of sugarcane sold by farmers and how to calculate the premium rate of sugar cane income insurance is the core problem to solve the design of sugar cane income insurance.

Based on the data of the sugar cane yield per unit area, the white sugar futures price and the spot price in Guangxi, taking the rainfall and the white sugar import as influencing factors, this paper uses spline function to carry out OLS regression to generate sugar cane yield per unit area and white sugar futures price prediction series, and uses normal distribution equal probability distribution to fit the marginal distribution of yield prediction series and white sugar futures price prediction series respectively, The joint distribution function of sugar cane yield and white sugar price is established by copula method. Then, the insurance premium rate of sugar cane income in Guangxi under different guarantee levels is calculated by using the Monte Carlo simulation method and the rate determination formula. Finally, relevant suggestions are given according to the rate determination results.

Literature Review

Since the United States implemented the pilot of crop income insurance under "insurance + futures" in 1996, scholars have carried out a lot of research on the implementation conditions and advantages of crop income insurance. Meuwissen and Hurine (1998) believes that the rich and available crop yield and price data are the necessary conditions for the implementation of crop income insurance. The research of Mahul (2010) shows that the most important premise for the generation of the income insurance is perfect public finance and regulatory policies. As for the implementation results of the pilot income insurance, Hennessy et al (1997) found that the income insurance reduces the supply cost and improves the redistribution efficiency. Sun Rong and Li Yaru (2016) believe that the "insurance + futures" model can improve the grain

production capacity, ensure the stability of national grain prices and reduce the fluctuation of national grain output. Li Yaru et al (2017) from the perspective of the reform of agricultural products price, proposed the "insurance + futures" model, which is suitable for food crops with the lowest purchase price, agricultural products with temporary storage policy and agricultural products subsidized by producers.

The core of studying the income insurance lies in the calculation of the premium rate. Copula method is a principal method at present, which is mainly used for marginal distribution of price and output. The United States, as the first country to use the futures market to disperse agricultural risks, its main crop income insurance is based on the price of agricultural futures contract when measuring the marginal distribution of price. Stokes (2000) held that insurance acts like a put option, and insurance companies can use options with different strike prices as their risk management tools (Mahul O.2003), Due to this similarity, , to assume that the futures price follows a certain distribution is a commonly method in the process of calculating income insurance premium. As to the determination of target yield, most foreign scholars depended on the actual historical yield method (APH). Botts and Boles (1958) believed that the APH which is based on the premise that the yield obeys the normal distribution can be applied to the formulation of crop insurance premium rate. In later studies, Wu (2012) proposed a flexible nonparametric density estimation method, which uses short panel data from adjacent geographical units to estimate crop yield distribution.

Currently, most of the research on sugar cane insurance in Guangxi mainly focuses on the policy insurance and the regional output insurance. For example, Lu Yefei and Liu Quanyue (2017) studied the pilot work of sugar cane price index insurance in Guangxi. What's more, Tang Jincheng and Cao Yanan (2013) analyzed in detail the development of sugar cane planting insurance in Guangxi. Liao Xueping et al. (2014) assessed the risk of yield disaster loss in the main sugarcane producing areas in Guangxi. For example, Ma Gaiyan (2018) divided the risk areas of Regional Yield Insurance of sugarcane in Guangxi according to the regional yield characteristics of sugarcane in Guangxi; Lu Wanjia and Fu Weiyan (2021) analyzed the feasibility and product design of sugar cane income insurance in Guangxi according to its development of sugar cane insurance. Despite the above research conducted by so many researchers, there is few relevant literature on the rate determination of sugar cane income insurance. Therefore, an in-depth study on the rate calculation of Guangxi sugar cane income insurance is extremely important and significant theoretically and practically.

To recap, it can be seen from the above literature that the research on the formulation of crop income insurance premium rate under the "insurance + futures" model in China still has a lot to dig into. There mainly exists the flowing problems: firstly, most of the research on crop yield distribution made by Chinese scholars mainly adopted the actual historical yield method, that is, APH. Nevertheless, the APH ignores the impact of other factors on yield on the one hand, on the other hand, the historical production belongs to noise sequence, in which errors are easily made; Secondly, as for the employment of price data, either futures data or spot data is generally considered, and few literature can take both into consideration at the same time; Thirdly, at present, the pricing of crop income insurance is mostly based on Copula method, but the indicators for the selection of Copula method are not unified, leading to the incomplete analysis of the dependence between price and yield due to improper selection of Copula function, resulting in low estimated rate.

Determination of Premium Rate of Sugar Cane Income Insurance in Guangxi

1. Data Sources

Having reviewed and summarized the research on the pricing of income insurance both from abroad and at home, it can be learned that either in the most popular income security insurance in the United States (RP) or in China's current income insurance, the determination of output and price and the relationship between output and price are the most important factors in pricing, which affect the final rate calculation. Nevertheless, most scholars at home currently use copula to simulate the joint distribution of unit yield and price by fitting the historical unit yield data and historical price data,which on the one hand, will ignore the impact of other factors on per unit yield and price. For example, the occurrence of different natural disasters will have a great impact on per unit yield, and the changes in the international market will exert an influence on prices as well. On the other hand, the original sequence is a sequence with noise, and the marginal distribution large error caused by the original sequence happens all the time. Because the yield will be affected by different natural disasters, this paper introduces the precipitation data into the model. Apart from the factors of the domestic market, the fluctuation of import volume affects the price as well, therefore, the import volume data is also introduced into the model.

According to the above information, the white sugar price data in this paper comes from Zhengzhou Commodity Exchange, and the spot data derives from Guangxi pan sugar trading center http://www.gsmn.com.cn/gxtw/sjzx/index.html）. The unit yield data and rainfall data of sugar cane are from the statistical yearbook of Guangxi and its cities over the years. The white sugar import data are taken from the official data of the National Bureau.

1.1 Sugar Price Data

Combined the pricing experience of income insurance in the United States with the insurance terms of other products (rice and corn,) launched in China at this stage, it can be seen that the futures price should be used as the pricing basis for the determination of the expected price, which will help to reduce the adverse selection risk of farmers and control the underwriting risk. In order to take the maximum possible revenue loss into account in the process of calculating the rate determination, the spot price can not be ignored on the basis of the expected price. Thus, the maximum price in the spot price and futures price is taken as the corresponding price. The purchase of sugar cane measures the income of the growers in terms of the actual weight (ton) of sugar cane, and the corresponding futures product is white sugar. But the ratio between the price of white sugar and the purchase price of sugar cane can be regarded as a constant.

The planting period of sugarcane in Guangxi is generally from February to March, the growth period is from May to October, and the harvest period is from November to January. As to the harvest price (actual price), this paper, therefore, selects the average monthly settlement price of futures contracts expiring from November of the next year to January of the next year of Zhengzhou Commodity Exchange. As for the expected price, it selects the average monthly settlement price of futures contracts from May of the next year to October of the underwriting year of Zhengzhou Commodity Exchange. Then the maximum value of the receipt price and the expected price is taken as the white sugar futures price of the current year. Likewise, the spot price of white sugar can be calculated by using the same time span. And the maximum of spot price and futures price is taken as the white sugar price of the current year.

In terms of time span, the data from 2009 to 2019 are taken in this paper for empirical research. The unit of price data is yuan / ton.

1.2 Sugar Cane Yield Data

The unit yield data in this paper are from the statistical yearbook of Guangxi . Unit yield = yield / sowing area. In order to calculate whether the rates in different cities differ or not, this paper selects the data from 2009 to 2019 in Guangxi and other cities.Unit yield data, the unit of unit yield data: ton / mu.

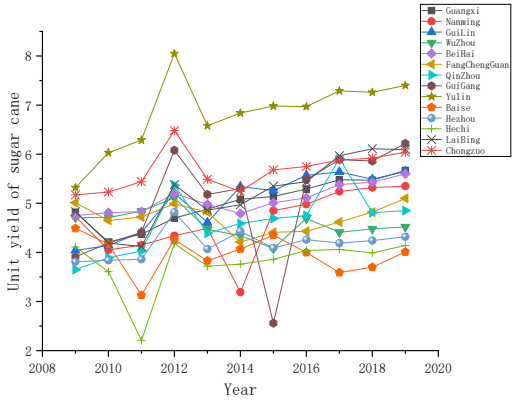

Figure 2. the changing chart of sugar cane yield per unit area in Guangxi and its 14 cities

1.3 Rainfall Data

Considering the planting characteristics of sugar cane, its planting areas are generally those with less rain and difficult irrigation operation. Drought has a huge effect on its yield among all the natural disasters. Therefore, the rainfall is taken into account when predicting the yield. As the rainfall mainly affects the yield of sugar cane in the first half of the growth period but its impact is small after the sugar cane volume reaches a certain degree in the later stage, the rainfall data in this paper is the average one in the first 7 months of sugar cane planting period.

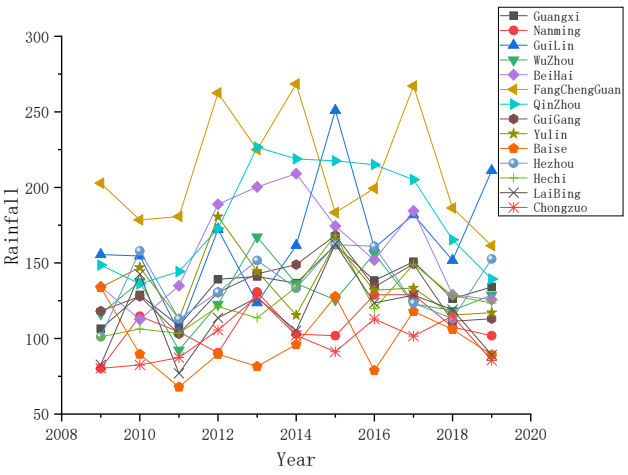

Figure 3 the changing chart of Rainfall in Guangxi and its 14 cities

1.4 The White Sugar Import Data

Although the sugar cane in Guangxi accounts for two-thirds that of the country's, which still can not meet China's demand. It is necessary for China to import a large amount of white sugar every year. To figure out whether the import volume of white sugar has a certain impact on the white sugar futures and spot price data, this paper takes the white sugar import volume into the model when predicting the white sugar price.

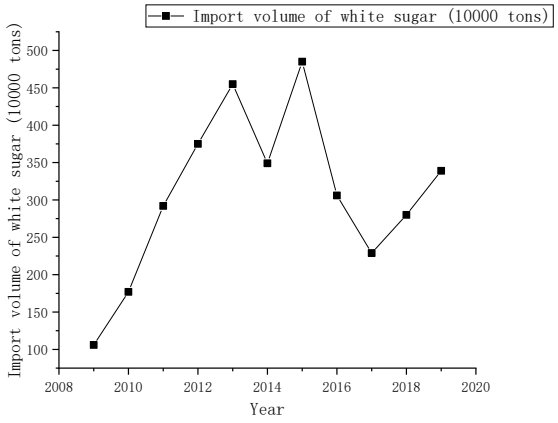

Figure 4 China's sugar imports from 2009 to 2019

2. Prediction Model of Sugar Yield and White Sugar Futures Price Based on Spline Function

In order to make clear the influence of rainfall and import factors on sequence prediction and rate calculation, the following four models are established in this paper:

Model I:

The model is simple and only considers the impact of time on sugar cane yield and white sugar futures price. The unit yield data of sugar cane Y_t and the white sugar futures price of the current year P_t only consider the impact of time on the yield,

$$Y_t = \alpha + \beta(t - t_0) + \varepsilon_t, t = t_0, ..., T \text{ (equation 1)}$$

$$\hat{Y}_{T,t} = \hat{\alpha} + \hat{\beta}(T - t_0) + \hat{\varepsilon}_t, t = t_0, ..., T \text{ (equation 2)}$$

$$P_t = \gamma + \eta(t - t_0) + \mu_t, t = t_0, ..., T \text{ (equation 3)}$$

$$\hat{P}_{T,t} = \hat{\gamma} + \hat{\eta}(T - t_0) + \mu_t, t = t_0, ..., T \text{ (equation 4)}$$

Where Y stands for the yield per unit area of sugarcane, P represents the futures price of white sugar, equations 1 and 3 are the construction model, and equations 2 and 4 are the sequence prediction formulas.

Model II:

On the basis of model I, the rainfall is put into equations 1 and 2 to build a sugar cane yield prediction model based on spline function, as a result the white sugar futures price is consistent with the model.

$$Y_t = \alpha + \beta_1(t - t_0) + \beta_2 S(RF_t) + \varepsilon_t, t = t_0, ..., T \text{ (equation 5)}$$

$$\hat{Y}_{T,t} = \hat{\alpha} + \hat{\beta}_1(T - t_0) + \hat{\beta}_2 S(RF_T) + \hat{\varepsilon}_t, t = t_0, ..., T \text{ (equation 6)}$$

$$P_t = \gamma + \eta(t - t_0) + \mu_t, t = t_0, ..., T \text{ (equation 7)}$$

$$\hat{P}_{T,t} = \hat{\gamma} + \hat{\eta}(T - t_0) + \mu_t, t = t_0, ..., T \text{ (equation 8)}$$

In this model Y is the yield per unit area of sugar cane, RF is the average rainfall during sugar cane planting, and S is the spline function. Equations 5 and 6 are construction models, and equations 7 and 8 are sequence prediction formulas.

Model III:

On the basis of model I, China's white sugar import is added to Equations 3 and 4 to build a white sugar futures price prediction model based on spline function. The white sugar futures price is consistent with the model.

$Y_t = \alpha + \beta(t - t_0) + \varepsilon_t, t = t_0, ..., T$ (equation 9)

$\hat{Y}_{T,t} = \hat{\alpha} + \hat{\beta}(T - t_0) + \hat{\varepsilon}_t, t = t_0, ..., T$ (equation 10)

$P_t = \gamma + \eta(t - t_0) + \eta_2 S(IM_t) + \mu_t, t = t_0, ..., T$ (equation 11)

$\hat{P}_{T,t} = \hat{\gamma} + \hat{\eta}(T - t_0) + \hat{\eta}_2 S(IM_T) + \hat{\mu}_t, t = t_0, ..., T$ (equation 12)

Model IV:

On the basis of model I, the rainfall is added to equations 1 and 2, and China's white sugar import is added to Equations 3 and 4. The impact of rainfall on output and the impact of white sugar import on its futures price are added.

$Y_t = \alpha + \beta_1(t - t_0) + \beta_2 S(RF_t) + \varepsilon_t, t = t_0, ..., T$ (equation 13)

$\hat{Y}_{T,t} = \hat{\alpha} + \hat{\beta}_1(T - t_0) + \hat{\beta}_2 S(RF_T) + \hat{\varepsilon}_t, t = t_0, ..., T$ (equation 14)

$P_t = \gamma + \eta(t - t_0) + \eta_2 S(IM_t) + \mu_t, t = t_0, ..., T$ (equation 15)

$\hat{P}_{T,t} = \hat{\gamma} + \hat{\eta}(T - t_0) + \hat{\eta}_2 S(IM_T) + \hat{\mu}_t, t = t_0, ..., T$ (equation 16)

3. Calculation of Net Premium Rate

At present, Copula method and Monte Carlo simulation method are the advanced and prevalent premium determination methods in crop income insurance. This paper uses the research methods of mainstream scholars for reference to fit the distribution of unit yield of sugar cane and white sugar futures price. When fitting the distribution of unit yield of sugar cane, Two models (considering time trend and considering time trend and rainfall) are adopted, while as to fitting the distribution of white sugar futures price two models (considering time trend and import volume) are adopted. OLS is used to estimate and the sum sequence $\hat{Y}_{T,t}$ and $\hat{P}_{T,t}$ are acquired according to model 1 to model 4, which are applied to determine the marginal distribution. For the marginal fitting of output, five distributions such as logistic are employed for fitting, and the effectiveness of fitting is tested by KS. Consequently, the one with the smallest KS is selected as the marginal distribution of output.

According to Goodwin (2000), the log-normal pair is applied to test whether the quasi combination test for the $\hat{P}_{T,t}$ is significant or not. Three common Copula Functions are firstly selected to obtain the relevant statistics. Then, according to the minimum rank and the sum test statistics(namely cramervon Mises statistics), the appropriate copula function is used to associate the price with the output to obtain the joint distribution of price and output. Finally, the net premium rate of income insurance is gained by random sampling and by the bootstrap method. Firstly, using model 1 or 3 and model 2 or 4, we can use spline function to fit the sequence of sugar cane yield in Guangxi. Model 1 and model 3 only regard time as

explanatory variables, while the average precipitation during planting are included in model 2 and model

4. Therefore, it can be seen that the sugar cane yield in Guangxi has a certain time trend. Using time as the explanatory variable, the interpretation is accurate, which shows that time has a effect on the unit yield of Guangxi. On this basis, when the precipitation is used in spline function estimation, the gap between the estimated value of yield and the observed value is bridged and the fitting accuracy is improved, indicating that both time and precipitation have a significant effect on yield estimation. Thus, adding them to the model can improve the accuracy of yield estimation.

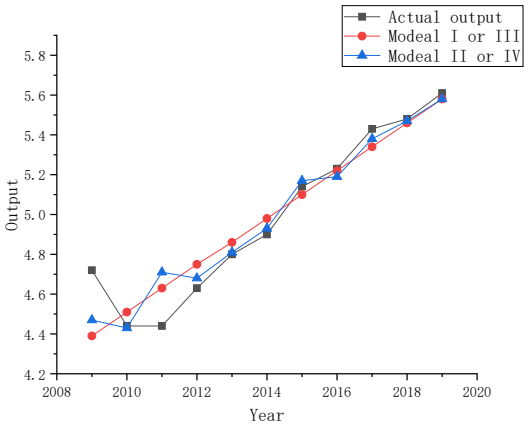

Figure 5 The fitting value of sugar cane yield in Guangxi estimated under different models is compared with the original value

Similarly, the price of white sugar is predicted by using models 1 to 4. The diagram above shows the real value of white sugar price and the price fitting value estimated under different models. Models 1 and 2 merely use time as the explanatory variable to estimate the price of the last year, that is 2019, while the impact of white sugar import on its price on the basis of models 1 and 2 is added in models 3 and 4. It can be seen from diagram 7, in the linear time model, time has little explanatory effect on the price of white sugar. In contract, the import volume has a significant influence on it. After spline function estimation by considering the import volume of white sugar as the explanatory variable, the volatility of white sugar price is effectively simulated, thus the estimated white sugar price is closer to the real value, which shows that the import volume has a significant impact on the fluctuation of white sugar price. Therefore, due to its impact on the price, the import volume should be introduced to the determination of marginal distribution.

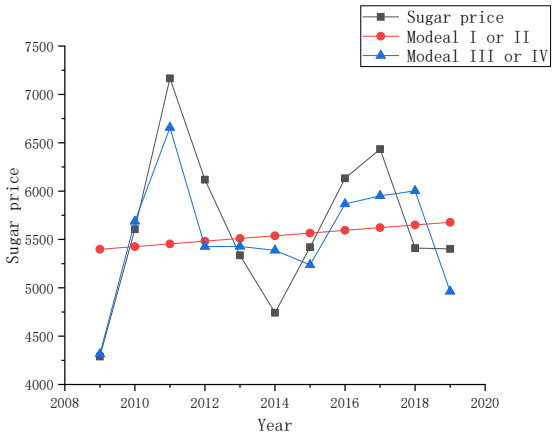

Figure 6 Comparison between the fitting value of sugar price data estimated under different models and the original value

After obtaining the data series, it is necessary to fit the marginal distribution of Guangxi sugar cane unit yield data series and white sugar price series. In this paper, five distributions such as logistic are tested by KS test statistics to fit the unit yield data series. According to results of the goodness of fit test, it shows that the fitting effect of normal distribution is the best. For the determination of the probability distribution of sugar price data, the price data is generally assumed to obey the log-normal distribution. Therefore, this paper tests whether the log-normal distribution is significant or not by using three ways.

The copula models to be selected in this paper include Frank Copula and Clayton copula in Normal Copula. Cramer-von Mises statistics is selected according to Pakyari (2012), that is, to measure the gap between the empirical copula function and the estimated copula function. In this paper, three kinds of Cramer von Mises statistics corresponding to copula are used. The smaller the statistics, the higher the goodness of fit. Assuming that the test statistics corresponding to j copula of the i model is recorded as S_{ij}, generally, the smaller the test statistics, the higher the goodness of fit. The rank recorded of S_{ij} in $S_{i1}, S_{i2}, \ldots$ is r_{ij}. The small Copula in $\sum_i r_{ij}$ is select to performs the fitting of the joint distribution. The table below lists the Cramer von Mises statistics corresponding to different copulas. According to it, Clayton copula with the smallest rank sum is chooses for fitting.

Table 1 Cramer-von Mises statistics corresponding to different copulas (Guangxi)

	Normal Copula	Frank Copula	Clayton Copula
Model I	0.1975	0.1878	0.1515
Model II	0.3143	0.3018	0.1990
Model III	0.1322	0.1252	0.1237
Model IV	0.2455	0.2387	0.2150
Rank Sum	12	8	4

This paper uses the relevant program package of R language to generate 10000 random arrays with the consistent

corresponding copula distribution function, and uses the inverse function to calculate the corresponding combination of simulated price and simulated unit yield data, and takes the product of the two as the sample data of income. The steps are as follows:

Through the copula package of R language, 10000 pairs of random variable groups (u,v) subject to [0,1] uniform distribution are generated, and the variable groups obey the corresponding copula function with parameter 1.

The random number of unit yield and price of sugar cane is obtained through the inverse function method of random simulation. The unit yield and price are multiplied to obtain the sample data X of simulated income. Then bootstrap is used to sample and calculate the net premium rate. In this paper, when the income sample data is simulated, the net premium is calculated by referring to the formula given by Goodwin (1998):

$$Expeted\quad loss=Prob(x<\alpha\hat{X})[\alpha\hat{X}-E(x|x<\alpha\hat{X})] \quad \text{（equation 17）}$$

$$r(\text{Net rate})=\frac{Expeted\quad loss}{\alpha\hat{X}} \quad \text{（equation 18）}$$

In the above formula, α stands for the income guarantee level selected for farmers. $\hat{X}$ is the expected income (average value of income samples), $\alpha\hat{X}$ is the guaranteed income, and the compensation trigger condition is that the actual income level is lower than the guarantee level.

Through random simulation, the rates are finally calculated by using the above models I to IV under different guarantee levels of 60% to 100% , which are shown in the table below.

Table2 determination results of Guangxi sugar cane income insurance rate under different guarantee levels

Guarantee level							
	100%	95%	90%	85%	80%	70%	60%
Model I	4.81%	2.69%	1.30%	0.46%	0.14%	0.03%	0.00%
Model II	4.97%	2.92%	1.40%	0.59%	0.18%	0.05%	0.00%
Model III	3.68%	1.74%	0.67%	0.19%	0.05%	0.01%	0.00%
Model IV	3.78%	1.76%	0.69%	0.20%	0.05%	0.00%	0.00%

Table 2 shows the income insurance rate calculated by Bootstrap. It can be seen from the table that under different guarantee levels, the rate obtained by estimating output through model II is the highest, by contract the rate obtained by model III is the lowest, but there is little difference with model IV, which manifests that for the determination of insurance rate of sugar cane income in Guangxi, on the basis that the import volume is included in the estimation of white sugar futures price, the impact of rainfall on output fluctuation doesn't interfere a lot with the determination of final rate. By making a comparison between model I and model II, it can be found that the impact of rainfall on output will lead to different results of final rate when the import volume is not controlled. While by making a comparison between model 1 and model III, the result of determination of the final rate will be significantly reduce by adding the import volume as the control variable, which indicates that the import volume is an important factor that leads to the price fluctuation of domestic sugar futures. Therefore, it can be seen that for

the whole Guangxi sugar cane income insurance, the national white sugar import has bigger influence on Guangxi sugar cane than rainfall. The possible reason is that the average rainfall is relatively high in Guangxi, so there is little differences about the rainfall among regions in it. With the improvement of irrigation, Rainfall and other weather factors have little impact on crop planting and harvest. Moreover, sugar cane is a drought resistant crop. However, the import volume has huge impact on the price of domestic sugar and the income of growers, which is an important reason for income fluctuation. When determining the rate, the impact of this factor should be fully considered.

3.4 Analysis on the Calculation Results of Net Rates in Guangxi and other Cities

Table3 summary of rate determination results of Guangxi and its cities

Region	Guangxi	Nanning	Liuzhou	Guilin	Wuzhou	Beihai	Chongzuo	Yulin
Highest rate model	Model II	Model II	Model II	Model I	Model I	Model I	Model I	Model I
Lowest rate model	Model III	Model IV	Model IV	Model IV	Model III	Model IV	Model IV	Model IV
Maximum rate at 100% level	4.97%	4.77%	7.25%	5.75%	6.34%	5.23%	6.45%	6.99%
Minimum rate at 100% level	3.68%	3.14%	5.54%	3.20%	4.99%	3.70%	4.82%	3.99%
Region	Qinzhou	Guigang	Baise	Hezhou	Hechi	Laibin	Fangchenggang	
Highest rate model	Model I	Model III	Model II	Model II	Model III	Model II	Model II	
Lowest rate model	Model IV	Model IV	Model IV	Model IV	Model IV	Model IV	Model IV	
Maximum rate at 100% level	7.38%	8.74%	5.43%	5.36%	7.37%	5.16%	5.42%	
Minimum rate at 100% level	5.63%	4.87%	3.42%	4.11%	5.58%	4.67%	4.16%	

Space limited, this paper will not present the rate calculation results of each city. Tables 3 is the summary results of rate calculation of Guangxi and its each city. It can be seen from the table that the net insurance rate calculated by copula and Monte Carlo simulation shows that under different models, the average is 6.28% when the guarantee level is 100% and the maximum rate of sugar cane in Guangxi and all its cities ranges from 4.77% to 8.74. While when and the minimum rate ranges from 3.14% to 5.63%, the average is 4.29%. and when the security level is 70% in most areas, the net rate is 0. As the security improves, the rate will increase accordingly. The rate calculation results show that in the process of calculating the income insurance rate in different regions of Guangxi, due to various factors such as local output, geographical location and climatic conditions, the rate of each county and city is different. Therefore, the regional differences should be taken into account in the actual trial process. Taking Guangxi as an example, no matter which model is used for prediction, when

the security level increases from 95% to 100%, the net rate increases by 2 percentage points, and from 90% to 95%, the net rate increases by more than 1 percentage point, which demonstrates that the risk of the income insurance of farmers is still high, and the risk is higher to maintain 100% of farmers' income at 95%. Through the rate calculation of the whole Guangxi and its different cities, model I or model II is the one that can calculate highest rate, among which model I accounts for 6 and model II for 7, which indicates that rainfall has relatively less impact on yield and rate determination. After adding the import volume into the model, the calculated net rate is obviously reduced, and the model with the lowest net rate is basically model IV, which shows that after comprehensively taking the rainfall and import volume into consideration, the risk factors are reduced followed by the increase of the prediction accuracy, resulting in the reduction of net rate accordingly.

4. Research Conclusions and Policy Recommendations

As one of the important agricultural industries in Guangxi, the development of sugar cane industry is related to the production and life of sugarcane farmers in Guangxi. The development of sugar cane income insurance will become an important means to ensure the healthy development of sugar cane industry. Income insurance can effectively stimulate farmers to buy insurance by providing more comprehensive protection. However, the lack of guarantee scope and the uncertainty of compensation are the key factors to affect farmers' insurance purchase. Based on the above analysis, this paper collects the unit yield data of sugar cane in Guangxi from 2009 to 2019, the white sugar futures data of Zhengzhou Commodity Exchange and the spot data of Guangxi pan sugar trading center. By constructing the copula method based on the spline function prediction model, this paper calculates the premium rate of sugar cane income insurance under different guarantee levels in Guangxi and its 14 cities. The results show that this method is effective. It also manifests that the white sugar import will affect white sugar price, resulting in price fluctuation, which will affect the calculation of final rate afterwards. By contract, the rainfall has little impact on the yield of sugar cane. The premium rate of income insurance is closely related to the guarantee level. Insurance companies which underwrite sugar cane income insurance also suffer higher risks, and higher premium rates will also affect the insurance purchase of the farmers. Therefore, when launching the pilot process of sugar cane income insurance, insurance companies and futures companies need to actively design their products, the government's policy support is needed as well.

Based on the above conclusions, this paper puts forward the following suggestions for the implementation and development of sugar cane income insurance:

(1) Improve the Sugar Cane Income Loss Database

The rate determination determines the effectiveness of the implementation of sugar cane income insurance, which needs a large number of high-precision output data and price data as support. The United States has a relatively perfect crop income loss database, and improves the efficiency of its collection through remote sensing and other high technologies. The data covers all counties and is managed by the agricultural department. Therefore the data transparent and the accuracy of rate calculation is guaranteed. At present, there is no systematic sugar cane income loss database in Guangxi, and the collection of sugar cane yield data is not systematic and scientific. Most sugar cane growers are currently still retail investors, which is also an important reason for the lack of data. Therefore, relevant statistical departments, competent departments and insurance companies should give full play to their respective advantages,

cooperate with each other, and build a relatively perfect information collection system based on the unit yield, price, cost and so on at the county level, so as to provide strong data support for the implementation of sugar cane income insurance.

(2) Improve the White Sugar Futures Market

The price of futures market has included the factors that affects the price, such as periodicity and long-term trend. It is more reasonable to determine the expected price of agricultural product insurance by the price of futures market. At present, the price discovery of sugar futures is poor, and the futures price is not closely related with the spot price which will surely lead to the deviation of rate determination and affect the function of sugar cane income insurance. Therefore, we should strictly regulate futures trading by means of law and strengthen the function of futures price discovery.

(3) Improve the Financial Subsidy Mechanism for Sugar Cane Income Insurance

Due to the high underwriting risk of sugar cane income insurance, the development of sugar cane income insurance needs government financial subsidies. On the one hand, a reasonable financial subsidy mechanism can reduce the operating pressure of insurance companies, which will encourage them to innovate sugar cane income insurance and effectively improve their service. Thus implementation of sugar cane income insurance is promoted. On the other hand, it of great benefit to encourage the farmers to buy the insurance as well. While making subsidy policies, it is necessary to strengthen the management of subsidy implementation, fully and comprehensively investigate the amount and standard of compensation paid by farmers to insurance companies, so as to protect the interests of farmers and combat repeated subsidies. It is also essential to achieve differentiated subsidies and favor large-scale growers and planting enterprises.

(4) Optimize Sugar Cane Income Insurance Services

When promote the sugar cane income insurance, the government should publicize the relevant insurance policies. The expectations of sugar cane growers for insurance can be summarized as the slogan: “wonderful services, simple procedures, timely compensation”. It significant for the insurance companies to improve the professional competence of their personnel and use advanced technology to measure and calculate the output verification in order to ensure the accuracy.

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