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Government subsidy strategy in the order financing of agricultural supply chain under random output

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Abstract: The enthusiasm of farmers in production has been restricting the development of China's agricultural economy. In order to guide the sustainable development of agricultural economy, the government has adopted various strategies of subsidizing farmers, among which the representative strategies include subsidizing the loan interest of farmers and purchasing agricultural insurance for farmers. Based on the strategy of the government providing loan interest and premium subsidy for farmers, this paper establishes the order financing model in the agricultural supply chain composed of farmers, core agricultural enterprises and the government, and explores the relatively optimal subsidy strategy of the government under different subsidy funds. It is found that in the strategy of subsidizing interest and premium, when the government subsidy funds can only meet one subsidy, and the discount rate is high, the difference between the high and the insurance output rate is small, and the primary subsidy interest is more conducive to improving the production enthusiasm of farmers; otherwise, the primary subsidy premium is more conducive to improving the production enthusiasm of farmers. In addition, in the strategy of simultaneously subsidizing interest and premium, when the probability of disaster event is large, the government should use all the limited funds for the purchase of agricultural insurance; otherwise, the government should use all the limited funds for the discount of bank loans.

1. Introduction

Food safety is an important basis for maintaining human health and social stability. Ensuring food supply is an important work of all governments worldwide. Since 2004 and 2024, the no. 1 central document has focused on the issues of "agriculture, rural areas and farmers" for 20 consecutive years, and issued a series of preferential policies to encourage the development of agriculture, rural areas and farmers.

Compared with the traditional manufacturing supply chain, agricultural production is susceptible to uncontrollable factors such as natural disasters, leading to problems such as random randomness, "small production, large market"and so on. Kazaz found that by expanding the purchase source of agricultural products, the production cost of olive oil can be effectively reduced, thus improving the

profit of the whole supply chain[1]. Further, Anderson, by analyzing the relationships between yield, fertilizer use, and weather, they provide useful insights into the optimization of the agricultural supply chain[2]. In addition, Zhang et al. noted that the cultivation of agricultural products is limited by seasonality, and it is difficult for farmers to flexibly adjust their production plans according to market demand[3]. Chen et al. found that when the production cost of high-value agricultural products is low, farmers with low agricultural output rate choosing the order contract agricultural model can effectively improve their income [4]. Qin Kaida and other scholars have comprehensively considered the randomness of market demand and output in agricultural production, and deeply studied the impact of the pricing mechanism of "following the market, guaranteed purchase" on farmers' production decisions. They found that compared with the traditional wholesale price purchase mechanism, the pricing mechanism can effectively alleviate the production risks of farmers, and thus promote the increase of farmers' income[5]. Similarly, Feng Chun et al. also discussed the production decision of farmers under the condition of the uncertain market demand and output of agricultural products. They compared the optimal planned production volume of risk-averse and risk-neutral farmers, which provided a useful reference for farmers to make decisions under different risk preferences[6].

The emergence of order agriculture alleviates this problem to a certain extent, aiming to "plant what the market needs". Farmers organize and arrange the production of agricultural products according to the orders signed between them or the rural organizations they work in and the growers of agricultural products. However, due to the general lack of funds for farmers and other agricultural production and operation entities, non-bank ideal lending objects and other problems, farmers' enthusiasm for production is not high. Supply chain financing is timely. Under the "farmer + company" type of order agricultural supply chain financing, banks and other financial institutions regard the core enterprises or leading enterprises in the order agricultural supply chain as well as their upstream and downstream enterprises as a whole. Zhou proposed through analysis that in the aspect of agricultural finance innovation, the most critical is supply chain finance[7], Renee and Gashayie believe that order financing in agricultural supply chain finance is the final solution for small farmers to solve their financial problems[8-9]. Federgruen Believe that order agricultural supply chain financing can benefit all parties in the agricultural product supply chain[10].

The government plays an irreplaceable role in promoting the development of order agricultural supply chain financing. The government adjusts the market through relevant incentive measures, such as production fund subsidies, price support and other means, mainly in the form of direct subsidies, tax reduction, discount loans, subsidy premium, establishment of risk compensation and other forms. Vercammen and Fan have also stressed that government agricultural subsidies can play a positive role in increasing farmers' income, and reducing poverty[11-12]. Wang Jingjing pointed out that the government's loan discount to farmers has become one of the important means to support agriculture in many places[13]. On the basis of considering the government tax subsidies to retailers, Nie Tengfei and other scholars studied the decision-making of agricultural supply chain composed of one supplier and one retailer, and found that government subsidies helped improve the profit level of the overall supply chain[14]. From the perspective of agricultural insurance and credit interconnection, foreign scholar Hill analyzed the positive role of this model in reducing credit risk, improving the ability of farmers to obtain loans, and promoting the progress of agricultural technology[15]. Tadesse et al. believe that compared with farmers 'self-insurance, "bank-insurance" interaction can effectively transfer risks, expand loans to farmers, weaken the risk allocation of farmers' self-choice, and encourage farmers to choose more advanced agricultural technologies[16].

Based on the basis of the above literature research, according to the characteristics of agricultural production and the reality, we further assume that farmers will be subject to financial constraints

and the uncertainty of agricultural output, and analyze the choice of government subsidy strategy in the order agricultural supply chain financing. At the same time, in order to reduce the pressure of farmers loans and reduce the risk of bank loan loss, this paper introduces the government subsidies for farmers, interest and insurance cost two subsidy strategy, build the government, farmers, agricultural enterprises three stage Stackelberg dynamic game model, and analyzes the government subsidies to the partners of the supply chain optimal decision. Finally, the paper obtains the optimal subsidy strategy under different subsidy funds.

2. Basic model construction

2.1 Problem description

This chapter mainly considers how the government should make decisions to maximize the total subsidy of the society under a certain amount of total government subsidy funds. Considering a single farmer with scarce funds and a single agricultural enterprise with relatively abundant funds, the main and subordinate game among the government, among which the government is the leader, the agricultural enterprise is the sub-dominant, and the farmers are the follower. First, the discount rate is decided by the government, then the agricultural enterprises propose the purchase price of agricultural products according to the discount rate of the government, and finally the farmers decide the input and output according to the government discount rate and the purchase price of the enterprise q (Figure 1).

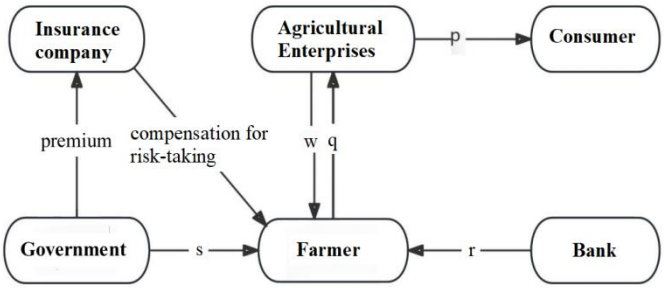

Figure 1: The order agricultural supply chain financing decision system under the loan interest and premium subsidy

2.2 Basic assumptions and parameter Settings

(1) The initial capital of farmers constrained by capital is 0, and they need to borrow from banks when carrying out agricultural production activities. Based on Lin and Xiao's setting of the bank interest rate, assume that the bank is in a risk-neutral market and set the bank interest rate to a fixed value r[17]. Agricultural enterprises are more abundant and do not need to borrow money. Among them, although the bank interest rate does not participate in the supply chain decision-making, but it also has a certain impact on the decision of all parties.

(2) The production cost of farmers is $c(q)=cq^2$. According to the research results of Tirole et al., due to the limited capacity of the producer, the marginal cost of the production is bound to increase when the production increases to a certain extent, so the scale is generally uneconomical in agricultural production. Therefore, the quadratic function $c(q)=c_1q+cq^2$ is a common practice for many scholars to set the agricultural production cost. Among them, c_1 means the production cost of the production unit of agricultural products, such as the purchase of seeds, fertilizers, pesticides and other agricultural production materials, c is the cost coefficient of farmers in the process of

agricultural production. Accordingly, this paper also assumes that the agricultural production cost function is $c(q)=c_1 q+cq^2$. At the same time, in order to simplify the calculation and does not affect the general, this paper refers to the research of Ye Fei et al., that is $c_1=0$, the production cost of farmers is $c(q)=cq^2$.

(3) The agricultural products market is a fully competitive market, and the company can only sell all the purchased agricultural products at the market price p. Among them, the sales price function of agricultural products is $p=a-bxq$. Agricultural enterprises simply package the agricultural products purchased from farmers and sell them in the market, a,which is the suffocating price, that is, the highest price that consumers are willing to pay, b,which is the price elasticity coefficient.

(4) Due to natural disasters, accidental disasters, disease transmission and other black swan events will reduce the output of agricultural products, making the input output rate uncertain. Therefore, the yield rate is set as a discrete random variable $x=x_j\ (j=h,l)$. When there is no disaster, $x=x_h$,the farmers can repay all the bank loans at this time. When the disaster occurs, $x=x_l<x_h$,the farmers cannot repay all the bank loans without external help. And set the probability of no disaster occurrence is k, and the probability of disaster occurrence is $1-k$, so the expected output rate is $\mu=kx_h+(1-k)x_l$.

(5) The government provides financial fund subsidies for farmers to alleviate the financing difficulties of farmers. There are two help policies: one is to provide the subsidy of bank loan interest for farmers, including the discount interest rate $s\in[0,1]$; the other is to buy agricultural insurance for farmers, and the insurance company bears the losses caused by farmers' production losses. The total fund that the government is willing to provide for farmers is m, one part is used to subsidize the loan interest of farmers,$1-\theta$,and the other part is used to purchase loan guarantee insurance for farmers, and the proportion is θ.

(6) The insurance company provides agricultural insurance for the farmers after collecting the premium. When the farmers suffer from the disaster, the insurance company shall pay compensation, the amount is related to the loss, set as $\eta wq(x_h-x_l)$, and has the upper limit related to the premium βm, which means the insurance compensation coefficient is the insurance rate $\eta\in(0,1)$, $\beta>1$.

(7) The payment for selling agricultural products obtained by the farmers is preferentially used to repay the bank loans. When the farmers cannot repay all the bank loans, they apply for bankruptcy and the bank cannot recover all the loans.

(8) In the operation process of the agricultural supply chain of this order, there is no moral hazard for farmers and agricultural enterprises. That is in other words, all the production funds (bank loans) obtained by farmers are all used for agricultural production, and agricultural enterprises will also purchase all agricultural products from farmers at the price stipulated in the contract w.

In this paper, the substandard a,c respectively represents farmers and agricultural enterprises, the upper standard "*" represents the optimal solution, and the substandard N,A,B respectively indicates the subsidy policy of subsidizing loan interest and the subsidy policy of purchasing agricultural insurance for farmers. The substandard $1,2$ respectively indicates the situation that the government subsidy funds are sufficient and insufficient. Some model parameter symbols in this chapter are shown in Table 1 below:

Table 1: Symbol definition

Symbol	Paraphrase
w	Purchase price of an agribusiness
q	Farmers' input of agricultural production
$c(q)$	The production cost of the farmers
c	The cost coefficient of farmers' efforts in the process of agricultural production
x	Random yield rate of agricultural production
r	banker's call rate
m	Government subsidy funds
s	The government subsidizes the subsidy rate of loan interest
p	The selling price of agricultural products on the market
π_{aN}	Farmers' profits
π_{cN}	Profits of the agricultural enterprises
$1-k$	The probability of agricultural disasters, such as the probability of natural disasters, insect disasters and other natural disasters
a	Choking prices, the highest price consumers are willing to pay for produce
b	Price elasticity coefficient
η	Insurance compensation coefficient
β	premium rate
μ	The desired yield of agricultural products, where $\mu = kx_h + (1-k)x_l$
CS_j	consumers' surplus
θ	The portion of the government subsidies used for buying agricultural insurance

3. Decision analysis of order financing in agricultural supply chain

3.1 The government is fully funded

At this point, both subsidies can be met. At this time, the government funds are set as m_1, and satisfied $\eta wq(x_h - x_l) \le \beta\theta m_1$, $srcq^2 \le (1-\theta)m_1$ and the decision goal function of farmers at this time is:

$$\begin{aligned} &\arg\max_q \pi_{a1} = wq\mu - cq^2(1+r) + \eta wq(x_h - x_l)(1-k) + srcq^2(1-k) \\ &s.t. \quad \eta wq(x_h - x_l) \le \beta\theta m_1 \\ &\qquad srcq^2 \le (1-\theta)m_1 \end{aligned} \tag{1}$$

The decision objective function of agricultural enterprises is:

$$\arg\max_w \pi_{c1} = \mu q(a - w - bq\mu) \tag{2}$$

Based on the reverse induction method, the solution is first, the agricultural enterprise decides the purchase price w_1', so that π_{a1}, q the first and second order guidance respectively,

$\frac{\partial \pi_{a1}}{\partial q} = w_1'\mu - 2cq(1+r) + \eta w_1'(x_h - x_l)(1-k) + 2srcq(1-k)$, $\frac{\partial^2 \pi_{a1}}{\partial q^2} < 0$ so there is a unique one $q_1' = \frac{w_1'\left[\mu + \eta(x_h - x_l)(1-k)\right]}{2c(1+r) - 2src(1-k)}$, $\frac{\partial \pi_{a1}}{\partial q} = 0$ and the profit of farmers reach the maximum value at this time. q_1' Will be inserted into equation (2), and let the first and second order guide, $\frac{\partial \pi_{c1}}{\partial w} = \frac{\mu\left[\mu + \eta(x_h - x_l)(1-k)\right]}{2c(1+r) - 2src(1-k)}\left(a - 2w - \frac{b\mu w_1'\left[\mu + \eta(x_h - x_l)(1-k)\right]}{c(1+r) - src(1-k)}\right)$, $\frac{\partial^2 \pi_{c1}}{\partial w^2} < 0$,there is a unique time $\frac{\partial \pi_{c1}}{\partial w} = 0$ that the profit of the agricultural enterprise reaches the maximum w_1^*. Finally, the optimal input of the farmers is obtained, and the results are as follows:

The optimal production input of the peasant household is:

$$q_1^* = \frac{a\left[\mu + \eta(x_h - x_l)(1-k)\right]}{4\left[c(1+r) - src(1-k)\right] + 2b\mu\left[\mu + \eta(x_h - x_l)(1-k)\right]} \tag{3}$$

The optimal purchase price of agricultural products provided by agricultural enterprises is:

$$w_1^* = \frac{a\left[c(1+r) - src(1-k)\right]}{2\left[c(1+r) - src(1-k)\right] + b\mu\left[\mu + \eta(x_h - x_l)(1-k)\right]} \tag{4}$$

At this time, the optimal profit of the farmers is:

$$\pi_{a1}^* = \frac{a^2\left[c(1+r) - src(1-k)\right]\left[\mu + \eta(x_h - x_l)(1-k)\right]^2}{4\left\{2\left[c(1+r) - src(1-k)\right] + b\mu\left[\mu + \eta(x_h - x_l)(1-k)\right]\right\}^2} \tag{5}$$

The optimal profit of agribusiness is:

$$\pi_{c1}^* = \frac{a^2\mu\left[\mu + \eta(x_h - x_l)(1-k)\right]}{8\left[c(1+r) - src(1-k)\right] + 4b\mu\left[\mu + \eta(x_h - x_l)(1-k)\right]} \tag{6}$$

From the constraints and funds, the government does not need to consider the allocation of funds.

$$\theta m_1 \geq \frac{\eta a^2(x_h - x_l)\left[c(1+r) - src(1-k)\right]\left[\mu + \eta(x_h - x_l)(1-k)\right]}{2\beta\left\{2\left[c(1+r) - src(1-k)\right] + b\mu\left[\mu + \eta(x_h - x_l)(1-k)\right]\right\}^2},$$

$$(1-\theta)m_1 \geq \frac{src a^2\left[\mu + \eta(x_h - x_l)(1-k)\right]^2}{4\left\{2\left[c(1+r) - src(1-k)\right] + b\mu\left[\mu + \eta(x_h - x_l)(1-k)\right]\right\}^2}$$

In order to analyze the influence of government discount rate on the decision-making and optimal profit of farmers and agricultural enterprises in case 1, the optimal decision value and the optimal profit value respectively guide the discount rate, and obtain: $\frac{\partial q_1^*}{\partial s} > 0$, $\frac{\partial w_1^*}{\partial s} < 0$, $\frac{\partial \pi_{c1}^*}{\partial s} > 0$, $\frac{\partial \pi_{a1}^*}{\partial s} = \frac{rca^2(1-k)\left[\mu + \eta(x_h - x_l)(1-k)\right]^2\left\{2\left[c(1+r) - src(1-k)\right] - b\mu\left[\mu + \eta(x_h - x_l)(1-k)\right]\right\}}{4\left\{2\left[c(1+r) - src(1-k)\right] + b\mu\left[\mu + \eta(x_h - x_l)(1-k)\right]\right\}^3}$. At that time,

$2c(1+r)-2src(1-k)-b\mu\left[\mu+\eta(x_h-x_l)(1-k)\right]\geq 0$, yes, $\frac{\partial \pi_{a1}^{*}}{\partial s}\geq 0$, the optimal profit of farmers increased with the interest rate, $2c(1+r)-2src(1-k)-b\mu\left[\mu+\eta(x_h-x_l)(1-k)\right]<0$ yes, $\frac{\partial \pi_{a1}^{*}}{\partial s}<0$ the optimal profit of farmers decreased with the increase of the interest rate.

Therefore, the following theorem can be obtained:

Theorem 3.1: When the government subsidizes and purchases agricultural insurance for farmers at the same time, and the government's subsidy funds are sufficient, the higher the government's subsidy rate, the higher the input and production of farmers, the lower the purchase price of agricultural products by agricultural enterprises, and the higher the profits of agricultural enterprises. The profits of farmers first increase and then decrease.

3.2 Government funds are limited and the subsidy interest shall be met first

At this time, the government funds are satisfied, $srcq^2\leq(1-\theta)m_2$ and the decision objective functions of farmers are as follows:

$$\begin{aligned}&\arg\max_{q}\pi_{a2}=wq\mu-cq^2(1+r)+\beta\theta m_2(1-k)+srcq^2(1-k)\\&s.t.\quad srcq^2\leq(1-\theta)m_2\end{aligned}\tag{7}$$

The decision objective function of agricultural enterprises is:

$$\arg\max_{w}\pi_{c2}=\mu q(a-w-bq\mu)\tag{8}$$

The solution is obtained:

The optimal input and output of farmers is:

$$q_2^{*}=\frac{a\mu}{4\left[c(1+r)-src(1-k)\right]+2b\mu^2}\tag{9}$$

The optimal price for agricultural products purchased by agricultural enterprises is:

$$w_2^{*}=\frac{a\left[c(1+r)-src(1-k)\right]}{2\left[c(1+r)-src(1-k)\right]+b\mu^2}\tag{10}$$

The optimal profit of the farmers at this time is:

$$\pi_{a2}^{*}=\frac{a^2\mu^2\left[c(1+r)-src(1-k)\right]}{4\left\{2\left[c(1+r)-src(1-k)\right]+b\mu^2\right\}^2}+\beta\theta m_2(1-k)\tag{11}$$

The optimal profit of agribusiness is:

$$\pi_{c2}^{*}=\frac{a^2\mu^2}{8\left[c(1+r)-src(1-k)\right]+4b\mu^2}\tag{12}$$

From the constraints and capital comparison, that is $(1-\theta)m_2\geq\frac{srca^2\mu^2}{4\left\{2\left[c(1+r)-src(1-k)\right]+b\mu^2\right\}^2}$,

$\theta m_2 < \dfrac{\eta\mu a^2\left(x_h - x_l\right)\left[c\left(1+r\right)-src\left(1-k\right)\right]}{2\beta\left\{2\left[c\left(1+r\right)-src\left(1-k\right)\right]+b\mu^2\right\}^2}$, satisfied

$\theta_2 < \min\left\{\dfrac{\eta\mu a^2\left(x_h - x_l\right)\left[c\left(1+r\right)-src\left(1-k\right)\right]}{2m_2\beta\left\{2\left[c\left(1+r\right)-src\left(1-k\right)\right]+b\mu^2\right\}^2}, 1-\dfrac{src a^2\mu^2}{4m_2\left\{2\left[c\left(1+r\right)-src\left(1-k\right)\right]+b\mu^2\right\}^2}\right\}$ at this time.

When the government funds are less, the smaller θ_2, until $\theta_2 = 0$ then the government funds can only meet the discount.

In order to analyze the influence of the government discount rate on the decision-making and profit of farmers and agricultural enterprises in case 2, the optimal decision value and the optimal profit value are respectively asked to guide the discount rate, and obtain: $\dfrac{\partial q_2^*}{\partial s} > 0$, $\dfrac{\partial w_2^*}{\partial s} < 0$, $\dfrac{\partial \pi_{c2}^*}{\partial s} > 0$, $\dfrac{\partial \pi_{a2}^*}{\partial s} = \dfrac{rca^2\mu^2\left(1-k\right)\left\{2\left[c\left(1+r\right)-src\left(1-k\right)\right]-b\mu^2\right\}}{4\left\{2\left[c\left(1+r\right)-src\left(1-k\right)\right]+b\mu^2\right\}^3}$

So, get

$$2\left[c\left(1+r\right)-src\left(1-k\right)\right]-b\mu^2 \geq 0, \frac{\partial \pi_{a2}^*}{\partial s} \geq 0, 2\left[c\left(1+r\right)-src\left(1-k\right)\right]-b\mu^2 < 0, \frac{\partial \pi_{a1}^*}{\partial s} < 0.$$

Theorem 3.2: At that time, yes, the profits of farmers increased with the increase of the interest rate; at that time, the profits of farmers decreased with the interest rate. Therefore, when the government discount rate is higher, the production input of farmers is higher, the lower the purchase price of agricultural enterprises, the higher the profit of agricultural enterprises, and the profit of farmers will first increase and then become smaller.

3.3 Government funds are limited m_3 and the primary premium is met

$$\eta wq\left(x_h - x_l\right) \leq \beta\theta m_3$$

At this time, the government funds, at this time, the farmer decision goal function is:

$$\begin{aligned} &\arg\max_q \pi_{a3} = wq\mu - cq^2\left(1+r\right)+\eta wq\left(x_h - x_l\right)\left(1-k\right)+m_3\left(1-\theta\right)\left(1-k\right) \\ &s.t. \quad \eta wq\left(x_h - x_l\right)\left(1-k\right) \leq \beta\theta m_3 \end{aligned} \tag{13}$$

The decision objective function of agricultural enterprises is:

$$\arg\max_w \pi_{c3} = \mu q\left(a - w - bq\mu\right) \tag{14}$$

The optimal production input of farmers is as follows:

$$q_3^* = \frac{a\left[\mu+\eta\left(x_h - x_l\right)\left(1-k\right)\right]}{4c\left(1+r\right)+2b\mu\left[\mu+\eta\left(x_h - x_l\right)\left(1-k\right)\right]} \tag{15}$$

The optimal purchase price for an agribusiness is:

$$w_3^* = \frac{ac\left(1+r\right)}{2c\left(1+r\right)+b\mu\left[\mu+\eta\left(x_h - x_l\right)\left(1-k\right)\right]} \tag{16}$$

At this time, the optimal profit of farmers is divided into:

$$\pi_{a3}^{*}=\frac{ca^{2}(1+r)\left[\mu+\eta(x_h-x_l)(1-k)\right]^{2}}{4\left\{2c(1+r)+b\mu\left[\mu+\eta(x_h-x_l)(1-k)\right]\right\}^{2}}+m_3(1-\theta)(1-k) \tag{17}$$

The optimal profit of agribusiness is:

$$\pi_{c3}^{*}=\frac{a^{2}\mu\left[\mu+\eta(x_h-x_l)(1-k)\right]}{8c(1+r)+4b\mu\left[\mu+\eta(x_h-x_l)(1-k)\right]} \tag{18}$$

From the constraints and capital comparison, that is $\theta m_3 \geq \frac{\eta ca^{2}(1+r)(x_h-x_l)\left[\mu+\eta(x_h-x_l)(1-k)\right]}{2\beta\left\{2c(1+r)+b\mu\left[\mu+\eta(x_h-x_l)(1-k)\right]\right\}^{2}}$, $(1-\theta)m_3<\frac{srca^{2}\left[\mu+\eta(x_h-x_l)(1-k)\right]^{2}}{4\left\{2\left[c(1+r)-src(1-k)\right]+b\mu^{2}\right\}^{2}}$, satisfied $\theta_3 \geq \max\left\{\frac{\eta ca^{2}(1+r)(x_h-x_l)\left[\mu+\eta(x_h-x_l)(1-k)\right]}{2m_3\beta\left\{2c(1+r)+b\mu\left[\mu+\eta(x_h-x_l)(1-k)\right]\right\}^{2}},1-\frac{srca^{2}\left[\mu+\eta(x_h-x_l)(1-k)\right]^{2}}{4m_3\left\{2\left[c(1+r)-src(1-k)\right]+b\mu^{2}\right\}^{2}}\right\}$ at this time. When the government subsidy is less, the greater θ_3, until the government subsidy can only meet $\theta_3=1$, the purchase of agricultural insurance for farmers.

Theorem 3.3: When the government funds are limited and the subsidy premium is mainly met, the government investment in the bank loan discount interest is small, and the proportion of funds allocated is small. The discount rate is mainly affected by the total amount of funds and the bank interest rate, that is $s_3=\frac{m_3(1-\theta_3)}{rcq_3^{*2}}$.

4. Analysis of government decision-making in different circumstances

As we all know, the financial funds of the government are regarded as the public resources of the society. Therefore, the government should start from the maximization of the overall social interests, and take measures to subsidize the loan interest of the farmers and the subsidy of the agricultural insurance premium, so as to encourage all partners to create more value for the society, and maximize the social welfare. Therefore, this chapter mainly from the perspective of the overall social welfare maximization decision analysis, including social welfare for order agricultural supply chain on the interests of the main participants, namely "social welfare = farmers + agricultural enterprises + consumer surplus", farmers and agricultural enterprises belong to the operating entities, so the two with its expected profits represent their respective interests, consumers to consumer surplus to measure their interests CS_j. In addition, the total social welfare also needs to deduct the government paid insurance premiums for agricultural insurance for farmers and loan interest subsidies. Therefore, the total social welfare is $U_j=\pi_{aj}+\pi_{cj}+CS_j-L_j$, ($j=N,A,B$, respectively, no government subsidy, government subsidy loan interest, government subsidy premium)

CS_j represents the consumer surplus and L_j represents the cost of government subsidies to farmers at the event of the disaster. Let the consumer surplus be $CS_j=E_j\left[\int_0^{xq^{*}}(a-bxq)d(xq)-\mu q^{*}\left(a-b\mu q^{*}\right)\right]=\frac{1}{2}bq_j^{*2}\cdot E\left(x^{2}\right)$, where $E\left(x^{2}\right)=kx_h^{2}+(1-k)x_l^{2}$, Comparing

different situations, it is not difficult to get $CS_1 > CS_3 > CS_4$, so the more adequate the government subsidies, the greater the consumer surplus.

Combined with the above analysis, the following situations can be obtained according to the adequacy of government funds.

4.1 The government is fully funded

The government expects the total welfare and its decision objective function are:

$$\arg\max_s U_1 = \pi_{a1}^{*} + \pi_{c1}^{*} + \frac{1}{2} b q_1^{*2} \cdot E\left(x^2\right) - src q_1^{*2}(1-k) - \theta m_1 \tag{19}$$

The solution is obtained:

$$s_1' = \frac{2\mu c(1+r) + b\left[\mu + \eta(x_h - x_l)(1-k)\right] \cdot E\left(x^2\right) - b\mu\eta(x_h - x_l)(1-k)\left[\mu + \eta(x_h - x_l)(1-k)\right]}{2rc(1-k)\left[2\mu + \eta(x_h - x_l)(1-k)\right]} \tag{20}$$

At that time, $2\mu c(1+r) + b\left[\mu + \eta(x_h - x_l)(1-k)\right]^2 E\left(x^2\right) - b\mu\eta(x_h - x_l)(1-k)\left[\mu + \eta(x_h - x_l)(1-k)\right] \le 0$ the government optimal discount rate $s_1^{*} = 0$, the fund allocation ratio $\theta_1^{*} = 1$; the government optimal discount rate $s_1' \ge 1$; the government optimal discount rate $s_1^{*} = 1$. At this time, $0 < s_1' < 1$,because the government has sufficient funds, $s_1^{*} = s_1'$, and the secondary safeguard measures for farmers' financing are not constrained by funds, so the government does not need to consider the allocation of funds in this case. In practice, the interest rate of farmers' loans to banks is generally not more than 10%, that is r, relatively small, which makes $s_1' > 1$, that is $s_1^{*} = 1$, the government needs to provide the maximum discount interest rate at this time to exempt all interest for farmers.

And, $s_1^{*} = s_1'$, at that time, combined with the previous article can get:

$$q_1^{*} = \frac{a\left[2\mu + \eta(x_h - x_l)(1-k)\right]}{4c(1+r) + 4b\mu\left[\mu + \eta(x_h - x_l)(1-k)\right] - 2bE\left(x^2\right)},$$

$$w_1^{*} = \frac{a\left[2c(1+r) + b\mu\eta(x_h - x_l)(1-k) - bE\left(x^2\right)\right]}{8\left\{2c(1+r) + 2b\mu\left[\mu + \eta(x_h - x_l)(1-k)\right] - bE\left(x^2\right)\right\}}$$

4.2 Government funds are limited and the discount interest will be met first

The government expects the total welfare and its decision objective function are:

$$\arg\max_s U_2 = \pi_{a2}^{*} + \pi_{c2}^{*} + \frac{1}{2} b q_2^{*2} \cdot E\left(x^2\right) - src q_2^{*2}(1-k) - \theta m_2 \tag{21}$$

The solution is obtained:

$$s_2' = \frac{2c(1+r) + bE\left(x^2\right)}{4rc(1-k)} \tag{22}$$

At that time, the government optimal discount rate, fund allocation ratio; the government optimal discount rate, fund allocation ratio. Obviously, due to the limited government funds and the primary

satisfaction of the discount interest, the less government funds, the more they need to concentrate the funds on the discount interest of bank loans, and the smaller the allocation ratio of funds. In particular, at that time, the government funds were only enough to discount interest, that is, the government no longer bought agricultural insurance for farmers.

4.3 Government funds are limited and insurance premiums are met first

The government expects the total welfare of the society to be $s_3 rcq_3^{*2} = (1-\theta)m_3$

$$U_3 = \pi_{a3}^{*} + \pi_{c3}^{*} + \frac{1}{2} bq_3^{*2} \cdot E\left(x^2\right) - m_3(1-\theta)(1-k) - \theta m_3 \tag{23}$$

At this time, I get the discount rate at this time:

$$s_3' = \frac{4m_3(1-\theta)\left\{2c(1+r) + b\mu\left[\mu + \eta(x_h - x_l)(1-k)\right]\right\}^2}{rca^2\left[\mu + \eta(x_h - x_l)(1-k)\right]^2} \tag{24}$$

Due to the limited funds, that is, the government optimal discount rate, so the government optimal discount rate at this time. Obviously, due to the limited government funds and the primary premium requirements, the less government funds, the more they need to concentrate the funds on the purchase of agricultural insurance, and the greater the allocation ratio of funds. In particular, at that time, the government only bought agricultural insurance without discount, at this time the government discount rate, the fund allocation ratio at this time.

5. Numerical analysis of the profit and total social welfare of all parties in the agricultural supply chain

As the profit of the order agricultural supply chain and the total social welfare are affected by multiple factors under different circumstances, the influence characteristics of several important factors should be further analyzed.

Under the above parameter settings. Under these conditions $s_1^{*} = s_2^{*} = 1$, $s_3^{*} = s_3' = 0.2248$, $s_4^{*} = s_4' = 0.3186$, further analysis was conducted on the impact of various important factors on the decision-making of various entities in the order agriculture supply chain. The probability of disaster events not occurring, insurance compensation coefficient, and high yield rate were changed respectively. Under this condition, change the probability k, insurance compensation coefficient η, high output rate x_h. As can be seen, when the probability of a disaster not occurring increases, under the four circumstances, the profit of the order agricultural supply chain and the total social welfare are increased, and the increase is different. For the government, when the probability of a disaster is small, with the largest total welfare benefits in case (1) That is, when disasters are prone to occur, the government should provide sufficient funds. When the probability of a disaster is not large, change to the maximum total welfare in situation (2) At this time, the government will use the limited funds for the secondary guarantee of farmer financing and limited for discount interest. When the insurance compensation coefficient is small, the government provides limited funds and adopts limited discount policy. When the insurance compensation coefficient is large, then the total social welfare is maximum in case 1, when the government provides sufficient funds. When the high yield increases, the profits of farmers in four situations increase first and then decrease, when the profits and the total social welfare increase, the government provides the limited funds and adopts the limited discount policy, or only provides less funds; when the high yield is large, when the total social welfare is the largest in situation 1, the government provides sufficient funds.

It can be seen from the above analysis that the probability of disaster non-occurrence and the high output rate have different effects on the maximum total social welfare in different situations. Therefore, it is necessary to further analyze the impact of the disaster non-occurrence probability and the high output rate on the maximum total social welfare in different situations. From Figure 2, the total social welfare of case 3 under the reference parameter is the minimum, so case 3 is not considered. When the disaster is small and the high yield is large, the total welfare in the situation 2 is the maximum, the government provides the limited funds and chooses the limited discount policy; when the probability of no disaster is small and the high yield is small, the total welfare in the situation 1 is the maximum.

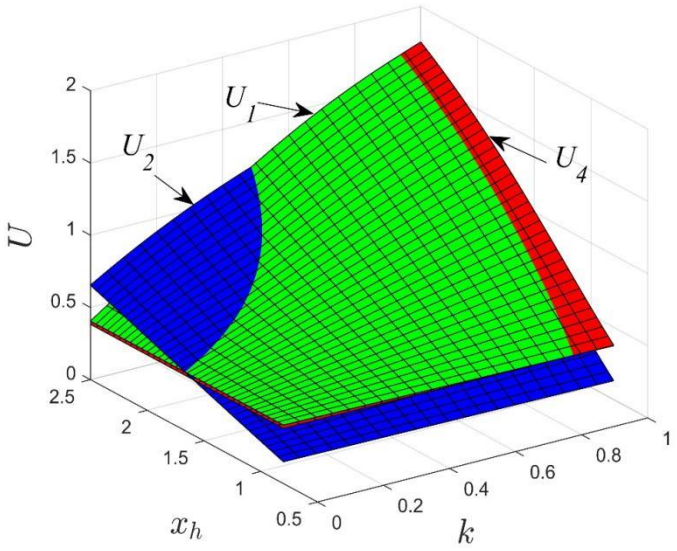

Figure 2: The impact of different disaster non-occurrence probability and high output rate on the total social welfare in the three situations

6. Conclusion

This paper studies the secondary order agricultural supply chain decision system composed of a single farmer with financial constraints and a single agricultural enterprise with relatively abundant funds in the random output environment, and comprehensively considers the problems of farmers' financial constraints, the random output of agricultural products, and the limitation of government subsidy funds.

The study found that: (1) when the subsidy funds are sufficient, the higher the discount rate of the government, the higher the input production of farmers, the lower the purchase price of agricultural products of agricultural enterprises, the higher the profit of agricultural enterprises, and the profit of farmers becomes first larger and then smaller. When the subsidy fund is limited and the primary subsidy interest is given, the higher the discount rate, the higher the production input of the farmers, the lower the purchase price of agricultural enterprises, the higher the profit of agricultural enterprises, the profit of farmers first larger and then smaller.(2) When the discount rate is high, the expected output rate is higher, the difference between the high output rate and the low output rate is small, and the insurance compensation coefficient is low, the primary subsidy interest is more conducive to improving farmers' enthusiasm for production.(3) when the government discount rate, sufficient funds and the primary subsidies interest two strategies, the optimal investment of farmers, agricultural enterprises, and the optimal price and the optimal investment is greater than limited

funds, limited funds when the optimal investment is greater than insufficient funds, sufficient funds when the optimal purchase price is less than the limited funds, funds limited when the optimal purchase price is less than the lack of funds.(4) When the probability of no disaster increases, or the high yield rate increases, or the expected yield rate increases, the optimal purchase price of the agricultural enterprise decreases in all four cases; when the insurance compensation coefficient increases, the optimal purchase price of the subsidized interest and the primary subsidy premium decreases, while the optimal purchase price of the primary subsidy interest remains unchanged. With the higher output rate, the optimal production input of farmers will decrease with the increase of disaster non-occurrence probability to increase with the probability of disaster non-occurrence, and the purchase price of agricultural enterprises will increase with the probability of disaster non-occurrence to decrease with the probability of disaster non-occurrence.

The above discussion results will help the government to make better decisions in the face of "agriculture, rural areas and farmers" issues, and also provide some reference for peer experts and scholars to study agricultural supply chain, order financing, order agricultural supply chain management, government subsidy strategy and other related theories. The underfunding of agribusiness can be further considered in future studies.

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