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Research on Agricultural Product Supply Chain with Mixed Option Contract Considering Shortage and Waste Aversion Preference

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Abstract: Based on the mixed option contract, this paper studies the decision-making of shortage averse enterprise or waste averse enterprise and waste averse cooperative respectively. It is proved that the risk preference coefficient has an impact on the option ordering strategy and the total profit of agricultural product supply chain. The results show that when enterprises have shortage aversion preference and cooperatives have waste aversion preference, the option order quantity of enterprises increases with the increase of preference coefficient, and the profit of agricultural product supply chain decreases with the increase of preference coefficient; When both enterprises and cooperatives have waste aversion preference, the option order quantity of enterprises and the profit of agricultural product supply chain decrease with the increase of preference coefficient.

1. Introduction

As a risk aversion means widely used in the futures market, option can not only reduce the impact of output and price fluctuations on suppliers, but also reduce the impact of demand and price fluctuations on retailers. At present, most of the studies on agricultural product supply chain only consider the risk preference of enterprises, default that cooperatives are risk neutral, there are few literatures considering both risk attitudes, and there are few studies on waste aversion and shortage aversion. In a few literatures on waste and shortage preference, revenue sharing contract, repurchase contract and flexible quantity contract are mostly used. Option contract can not only consider the shortage cost, but also reflect the flexibility of repurchase contract and flexible quantity contract. This paper assumes that every farmer participating in the cooperative is waste averse and plays games with shortage averse and waste averse enterprises respectively, and studies the impact of different psychological behavior combinations on the ordering strategy of decision makers.

2. Problem Description and Model Establishment

The research object is the secondary agricultural product supply chain composed of cooperatives and enterprises. The whole game process between waste averse cooperatives and shortage averse or waste averse enterprises under the mixed option contract is divided into lead time and sales period. During the lead time, the cooperative shall formulate the option purchase price o, option execution

price E and wholesale price w according to the existing technical conditions and production capacity; The enterprise forecasts the market demand according to the previous sales data, random demand x, e (x)= μ. Determine the wholesale price order quantity QW and option order quantity Q0. During the sales period, the enterprise exercises a certain amount of options according to the actual demand of the market. When only considering the contract market, the output provided by the cooperative can just meet the quantity purchased by the enterprise at the wholesale price and the total amount of options purchased. Due to the uncertain market demand, the enterprise may face product shortage or surplus.

2.1 Mixed Option Contract Model of Agricultural Products with Two Risk Preference Combinations under Decentralized Decision-Making

hypothesis β 1(β 1> 0) and α 1(α 1> 0) respectively the stock out aversion coefficient of the enterprise and the waste aversion coefficient of the cooperative, β 1 and α The larger the, the more enterprises hate shortage, and the more cooperatives hate waste. Ue1(Π E (q)) represents the utility function of shortage averse enterprises, UF1(Π F (q)) represents the utility function of waste averse cooperatives. The expected utility function of enterprises and cooperatives under decentralized decision-making, such as E [UE1](Π e(q))],E[Uf1(Π F (q))].

E[Ue1(Πe(q))]

$$=pS(q0+qw)-eN(q0+qw)-oq0-gL(q0+qw)-\beta 1\int_{q_0+q_w}^{\infty}[x-(q_0+q_w)]f(x)dx+vIe(q0+qw)-wqw$$

$$=(p+g-w)qw+(p+g-e-o)q0-g\mu-(p+g-e)\int_0^{q_0+q_w}F(x)dx-(e-v)\int_0^{q_w}F(x)dx$$

$$-\beta 1\int_{q_0+q_w}^{\infty}[x-(q_0+q_w)]f(x)dx \qquad (2.5)$$

E[Uf1(Πf(q))]

$$=oq0+eN(q0+qw)+wqw-c(q0+qw)+vIf(q0+qw)-\alpha 1\int_0^{q_0+q_w}[(q_0+q_w)-x]f(x)dx$$

$$=(o+e-c)q0+(w-c)qw-(e-v)\int_{q_w}^{q_0+q_w}F(x)dx-\alpha 1\int_0^{q_0+q_w}[(q_0+q_w)-x]f(x)dx \qquad (2.6)$$

Proposition 1: e [UE1](Π E (q))] is a concave function about Q0 and QW, and the optimal option order quantity is $Q0^* = F^{-1}\left(\frac{p+g+\beta_1-e-o}{p+g-e+\beta_1}\right) - F^{-1}\left(\frac{e+o-w}{e-v}\right)$, and the optimal wholesale price order quantity is $QW^* = F^{-1}\left(\frac{e+o-w}{e-v}\right)$

Inference 1: the total order quantity of shortage aversion enterprises increases with the increase of shortage aversion coefficient, unit product market retail price and shortage cost, and decreases with the increase of unit option purchase price and unit option exercise price.

Inference 2:the fixed order quantity of out of stock averse enterprises decreases with the increase of wholesale price.

Proposition 2: from the perspective of cooperatives, it is expected that the quantity ordered by enterprises at the wholesale price is $Q_W^* = F^{-1}\left(\frac{e+o-w}{e-v}\right)$;

The option purchase quantity is $Q0^* = F^{-1}\left(\frac{e+o-c}{e-v+\alpha_1}\right) - F\text{-}1\left(\frac{e+o-w}{e-v}\right)$

Proposition 3: when o $= \frac{c-v}{p-v+g}\left(p+g+\beta_1-e\right)$ is satisfied, agricultural product supply chain coordination.

3. Numerical Analysis

Let the market demand obey the normal distribution d ~ n (20, 42), and according to the assumptions in the second part, set the parameters of the whole agricultural product supply chain as follows: P = 21, w = 17, e = 16, C = 10, v = 6, g = 1, o = 2. The risk preference coefficient of enterprises and cooperatives is β I ~ [0,10] and α i~[0,10]. The overall profit statement of supply chain under different risk preference factors is calculated by MATLAB 2019 software, as shown in tables 1 and 2.

Table 1 Income of Shortage Averse Enterprises and Waste Averse Cooperatives under Decentralized Decision-Making

β1=α1	Πf	Πe	Πf+Πe
0	135.82	64.25	200.08
1	132.40	63.46	195.86
2	129.57	62.81	192.38
3	127.15	62.26	189.41
4	125.04	61.78	186.82
5	123.17	61.36	184.53
6	121.49	60.99	182.47
7	119.97	60.65	180.62
8	118.58	60.34	178.92
9	117.30	60.06	177.36
10	116.11	59.81	175.92

Table 1 considers the total income of enterprises and cooperatives and the total income of the supply chain when the degree of shortage aversion of enterprises is the same as the degree of waste aversion of cooperatives. We can see that in the special case of the same degree of aversion of enterprises and cooperatives, when both sides are risk neutral, the total profit of the supply chain is the largest. With the enterprise shortage aversion factor β 1 and cooperative waste aversion factor α 1, the total profit of the supply chain decreases.

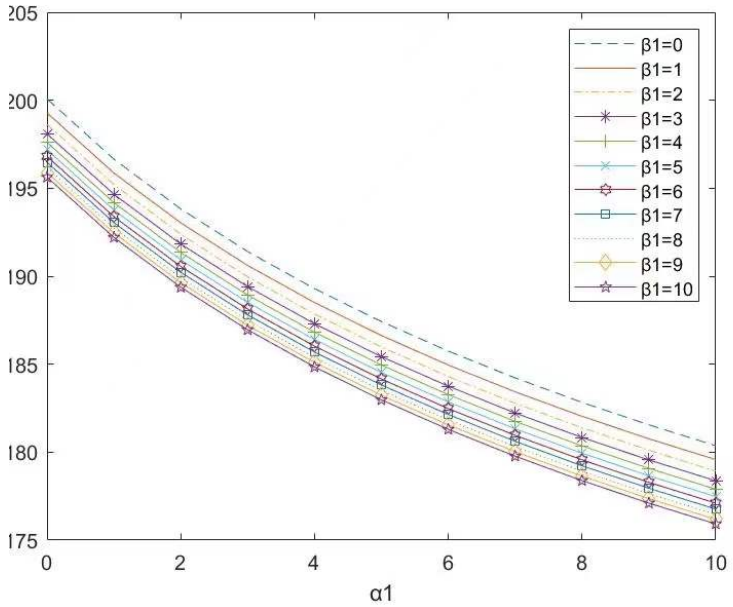

Fig.1 B 1 and A 1. Impact on Total Profit of Supply Chain

Figure 1 shows the impact on the total profit of the supply chain under different combinations of shortage aversion factor and waste aversion factor. The overall change trend is the same as when the aversion of enterprises and cooperatives is equal. Therefore, we can conclude that when both enterprises and cooperatives are risk neutral, the total profit of the supply chain is the largest. With the enterprise shortage aversion factor β 1 and cooperative waste aversion factor α 1, the total profit of the supply chain decreases, which is also consistent with the conclusion of inference 1.

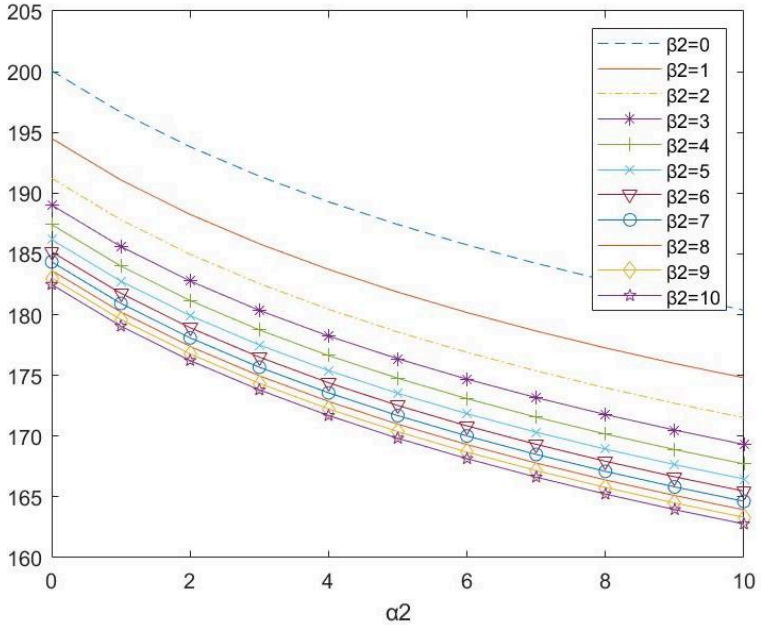

Fig.2 B 2 and A 2 Impact on Total Profit of Supply Chain

Figure 2 shows the impact on the total profit of the supply chain under different waste aversion factor combinations. The overall change trend is the same as when the aversion of enterprises and

cooperatives is equal. Therefore, we can conclude that when both enterprises and cooperatives are risk neutral, the total profit of the supply chain is the largest. With the development of enterprise waste aversion factor β 2 and cooperative waste aversion factor α 2, the total profit of the supply chain decreases. By comparing Figure 1 and Figure 2, it is not difficult to see that when the degree of waste aversion preference of cooperatives remains unchanged, enterprises with waste aversion preference are β 2 ∈ [0,2] has a greater impact on the total profit of the supply chain.

4. Conclusion

This paper studies a two-level agricultural product supply chain composed of enterprises and cooperatives. Among supply chain members, enterprises have shortage aversion preference or waste aversion preference, and cooperatives have waste aversion preference. Based on this condition, a hybrid option contract model is established, and the effects of preference factor, option purchase price, option exercise price and retail price on enterprise ordering strategy are proved. Then it further analyzes the impact of risk preference factors on supply chain profits, and finally comes to the following conclusions:

(1) When the enterprise has a shortage aversion preference and the cooperative has a waste aversion preference, in order to reduce the shortage risk, the optimal option order quantity increases with the shortage aversion coefficient β 1 increases with the increase of. For the dominant cooperatives, in order to coordinate the whole supply chain, it is necessary to consider the degree of shortage aversion preference in the formulation of option purchase price.

(2) When both enterprises and cooperatives have waste aversion preference, in order to reduce waste risk, the optimal option order increases with the waste aversion coefficient β 2 increases and decreases. For the dominant cooperatives, in order to coordinate the whole supply chain, the preference of enterprise waste aversion needs to be considered in the formulation of option purchase price.

(3) Under the mixed option contract model, the quantity purchased by enterprises at the wholesale price is only related to the wholesale price and is not affected by the risk preference coefficient. The purchase volume of wholesale price decreases with the increase of wholesale price.

(4) When both enterprises and cooperatives are risk neutral, the total profit of the supply chain is the largest. No matter which combination of enterprise and cooperative, the total profit of supply chain decreases with the increase of risk preference coefficient. When the degree of waste aversion preference of cooperatives remains unchanged, it is in β The preference of waste averse enterprises in the range of 2 ∈ [0,2] has a great impact on the total profit of the supply chain.

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