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Government Subsidy Mechanism of Contract Farming Supply Chain under Uncertain Acquisition Price

Fang Li[1,*], Nannan Zhang[1], Hairong Wang[1], Keyi Ma[1], Yuna Zhu[1], Shanshan Wang[2]

[1] College of Science, Tianjin University of Commerce, Tianjin 300134, China

[2] Mofan Primary School in Jinghai District, Tianjin 301600, China

[*]Corresponding Author: 2279169395@qq.com

Abstract

Against the backdrop of deep integration between the digital economy and rural revitalization strategies, agricultural supply chains face dual challenges of uncertain purchase prices and insufficient production funding. This study constructs a two-tier supply chain Stackelberg game model integrating agricultural cooperatives and e-commerce platforms, analyzing the impact of government production cost subsidies on supply chain decisions and profitability. The findings reveal that centralized decision-making yields higher social welfare than decentralized approaches. While government subsidies incentivize increased production, they may depress purchase prices, creating a U-shaped effect on farmers 'and e-commerce platforms' profits with a critical subsidy intensity threshold. The paper recommends implementing targeted subsidies and enhancing supply chain coordination to improve overall efficiency and farmers' income.

Keywords

Order Agriculture; Government Subsidy; Stackelberg Game; Stochastic Price; Optimal Decision.

1. Introduction

Against the backdrop of rapid digital economy development, the modernization of agricultural supply chains has become a key driver for high-quality agricultural development and rural revitalization. In recent years, the innovative "cooperative + e-commerce + consumer" supply chain model has gained widespread adoption. By integrating production, sales, and consumption phases, this model reduces intermediary distribution costs, boosts farmers' income, and provides consumers with more convenient purchasing channels, achieving a win-win outcome for all stakeholders.

However, this model still faces numerous challenges in practice. Agricultural production has long cycles and high capital requirements, often leaving farmers short of working capital. Thus, government subsidies become a crucial safeguard for the model's sustainable development[1]. By providing financial support and tax incentives, the government can boost cooperative growth and address gaps in various agricultural sectors[2].

The existing researches are mostly focused on manufacturing industry [3] and green supply chain [4], but the discussion on the effect of government subsidies on the order decision of agricultural supply chain is relatively insufficient. Especially under the condition of random fluctuation of agricultural product price, the related mechanism needs to be further explored.

To address this, the study develops a Stackelberg game model for the "cooperative-e-commerce" two-tier supply chain under both subsidized and unsubsidized conditions. It analyzes optimal decision-making strategies and profit margins in centralized versus

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decentralized scenarios, while revealing the impact of government subsidies across supply chain segments through comparative analysis. The findings provide valuable insights for policymakers to formulate agricultural support policies and optimize supply chain structures, carrying significant theoretical and practical implications.

2. Problem Description and Model Assumptions

2.1. Problem Description

This study investigates a two-tier supply chain system integrating agricultural cooperatives and e-commerce platforms. Farmers produce agricultural products, which are then supplied to e-commerce platforms at wholesale prices ω, and these platforms subsequently distribute them to the market at retail prices. The government subsidizes $s*C_1*Q$ to reduce farmers' marginal costs, incentivizing production expansion. E-commerce platforms enhance their market premium pricing power through corporate social responsibility (CSR). The research addresses key questions: How do government subsidies influence production incentives and output? What are the strategic interactions between farmers and e-commerce platforms? What are the nonlinear effects of subsidies on profits for both parties? How do subsidy effects differ under centralized versus decentralized decision-making?

2.2. Symbol Explanation

Table 1. Symbol Explanation

symbol	Explanation
Q	E-commerce order volume
p	retail price
ω	Purchase price
C_0	constant cost
C_1	variable unit cost
C_2	Cost of e-commerce distribution
π_f, π_r	Profits of farmers and e-commerce businesses
x	random market price
s	Government subsidy coefficient
a, b	parameters of demand function

2.3. Model Assumptions

(1) It is assumed that farmers tend to choose the higher price between the purchase price ω and the market price x in order to avoid the risk of market price fluctuation, with the purchase price set at $\max\{\omega, x\}$ [5].

(2) Government subsidies directly reduce marginal costs without any implementation delay.

(3) The inverse demand function of agricultural products is $p = a - b*Q$.

(4) The government provides the farmers with the productive subsidy. The subsidy coefficient is s, the total subsidy cost is $s \cdot C_1 \cdot Q$, the subsidy form includes the agricultural machinery production service, the agricultural technical support and training, the pesticide reduction technology, the unified prevention and control of the disease and insect pests, etc[6].

(5) Assume that both farmers and e-commerce platforms are risk-neutral, and their goal is to maximize their expected profits.

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(6) The unit variable cost of farmers is significantly higher than that of large-scale producers.
(7) Based on the research findings of Ye Fei et al. [7]on Zhanjiang Farm, the probability of a bumper harvest is relatively high. Therefore, we assume that the bankruptcy risk of farmers is not considered and sudden external shocks (such as epidemics or natural disasters) are ignored.

3. Model Establishment and Solution

3.1. Centralized Decision-Making

Under centralized decision-making, agricultural cooperatives and e-commerce platforms operate as an integrated system, aiming to maximize overall supply chain profits (i.e., social welfare). Total social welfare $SW^{i,j}$ comprises both farmers' profits $\pi_f^{i,j}$ and e-commerce platform profits $\pi_r^{i,j}$, where $i=\{NF,F\}$, NF repsresents the model without government subsidies, F represents the model with government subsidies, $j=\{C,D\}$, C denotes centralized decision-making, and D represents decentralized decision-making. The comprehensive model is thus defined as $SW^{i,j}=\pi_f^{i,j}+\pi_r^{i,j}$, where $T^{NF}=0$.
(1) No Government Subsidy Model (NF Model)
Create a decision model:

$$\begin{aligned}\max_{Q^*} SW^{NF,C} &= \pi_f^{NF,C}+\pi_r^{NF,C}\\ &=(a-b*Q)*Q-(C_1+C_2)*Q-C_0\\ &=-b*Q^2+(a-C_1-C_2)*Q-C_0\end{aligned}$$

Proposition 1: Under centralized decision-making and without government subsidies, the optimal order quantity for e-commerce is $Q^{NF,C*}=\frac{a-C_1-C_2}{2*b}$, with the social welfare $SW^{NF,C*}=\frac{(a-C_1-C_2)^2}{4*b}-C_0$ at this point being.
(2) There is a government subsidy model (F model)

$$\begin{aligned}\max_{Q^*} SW^{F,C} &= \pi_f^{F,C}+\pi_r^{F,C}\\ &=(a-b*Q)*Q-[C_1*(1-s)+C_2]*Q-C_0\\ &=-b*Q^2+(a-C_1*(1-s)-C_2)*Q-C_0\end{aligned}$$

Proposition 2: Under centralized decision-making with government subsidies, the optimal order quantity for e-commerce is $Q^{F,C*}=\frac{a-C_1*(1-s)-C_2}{2*b}$, and the social welfare is $SW^{F,C*}=\frac{[a-C_1*(1-s)-C_2]^2}{4*b}-C_0$.

3.2. Decentralized Decision Making

Under decentralized decision-making, agricultural cooperatives and e-commerce platforms make independent decisions. The sequence of decisions is as follows: the e-commerce platform responds to the purchase price ω set by the agricultural cooperative, then determines the order

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quantity Q . The solution is approached using backward induction, starting with the optimization of the e-commerce platform's strategy.

(1) No Government Subsidy Model (NF Model)

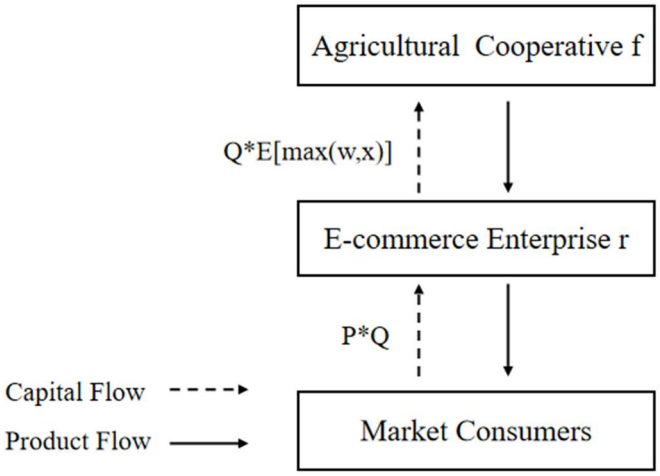


Fig. 1 Independent Mode of Secondary Supply Chain (NF)

Create a decision model:

$$\max_{\omega^*} E(\pi_f^{NF,D}) = E[\max(\omega, x)] * Q - (C_0 + C_1 * Q)$$

$$s.t. \quad \max_{Q^*} E(\pi_r^{NF,D}) = (a - b * Q) * Q - E[\max(\omega, x)] * Q - C_2 * Q$$

When the purchase price is uncertain, there are

$$B - \int_{\omega}^{B} F(x)dx = E[\max(\omega, x)]$$

Proposition 3: Under decentralized decision-making and no government subsidies, the optimal order quantity for e-commerce is $Q^{NF,D*} = \frac{a - C_2 - C_1}{4 * b}$, and the optimal order price for agricultural cooperatives is $\omega^{NF,D*}$, where satisfies the equation $\omega + \int_0^{\omega} F(x)dx = \frac{a - C_2 + C_1}{2}$. In this case, the profit of agricultural cooperatives is $\pi_f^{NF,D*} = \frac{(a - C_2 - C_1)^2}{8 * b} - C_0$, and the profit of e-commerce is $\pi_r^{NF,D*} = \frac{(a - C_1 - C_2)^2}{16 * b}$.

(2) There is a government subsidy model (F model)

including production costs $C(Q) = C_0 + C_1 * Q$, market prices $p = a - b * Q$, and government subsidies sC_1Q.

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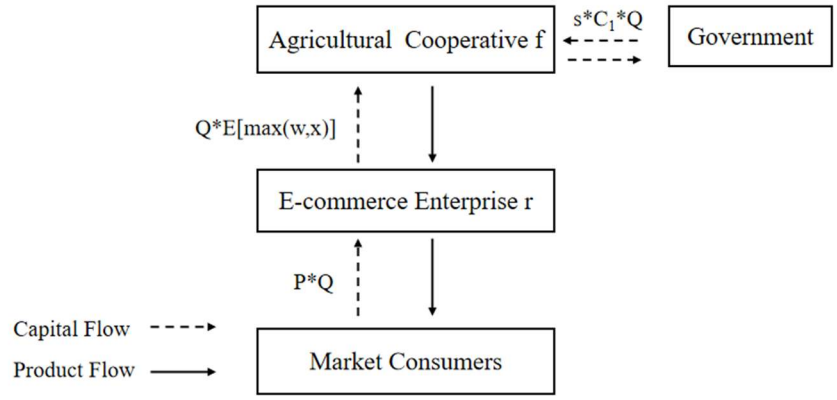


Fig. 2 Secondary Supply Chain Model with Government Subsidies (F)

Create a decision model:

$$\max_{\omega^*} E(\pi_f^{F,D}) = Q * E[\max(\omega, x)] - C_0 - C_1 * Q + s * C_1 * Q$$

$$s.t. \quad \max_{Q^*} E(\pi_r^{F,D}) = p * Q - E[\max(\omega, x)] * Q - C_2 * Q$$

Proposition 4: Under decentralized decision-making with government subsidies, the optimal order quantity for e-commerce is $Q^{F,D*} = \frac{a - C_2 - (1-s) * C_1}{4b}$, and the optimal order price for agricultural cooperatives is $\omega^{F,D*}$, where satisfies the equation $\omega + \int_0^{\omega} F(x)dx = \frac{a - C_2 + (1-s) * C_1}{2}$. In this case, the profit of agricultural cooperatives is $\pi_f^{F,D*} = \frac{[(a - C_2 - (1-s) * C_1]^2}{8b} - C_0$, and the profit of e-commerce is $\pi_r^{F,D*} = \frac{[(a - C_2 - (1-s) * C_1]^2}{16b}$.

4. Result Analysis

4.1. Comparative Analysis of Different Decision-making Models

Conclusion 1: The social welfare is higher than the optimal profit sum of agricultural cooperatives and e-commerce in decentralized decision-making.

Proof: When there are no government subsidies, there is

$$\frac{\pi_f^{NF,D*} + \pi_r^{NF,D*}}{SW^{NF,C*}} = \frac{\frac{(a - C_2 - C_1)^2}{8 * b} - C_0 + \frac{(a - C_1 - C_2)^2}{16 * b}}{\frac{(a - C_1 - C_2)^2}{4 * b} - C_0} < 1$$

When there are government subsidies, there are...

$$\frac{\pi_f^{F,D*} + \pi_r^{F,D*}}{SW^{F,C*}} = \frac{\frac{[a - C_1 * (1-s) - C_2]^2}{8 * b} - C_0 + \frac{[a - C_1 * (1-s) - C_2]^2}{16 * b}}{\frac{[a - C_1 * (1-s) - C_2]^2}{4 * b} - C_0} < 1$$

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So, $\pi_f^{F,D*} + \pi_r^{F,D*} < SW^{F,C*}$, $\pi_f^{NF,D*} + \pi_r^{NF,D*} < SW^{NF,C*}$, Conclusion 1 is confirmed.

Conclusion 1 It is shown that in decentralized decision-making, each member only pursues its own profit maximization, which leads to the loss of overall efficiency and the failure to reach the optimal profit.

4.2. Result Analysis of Uncertain Acquisition Price

Conclusion 2:

$$E[\max(\omega, x)] = \frac{a - C_2 + C_1}{2} = \omega + \int_0^{\omega} F(x)dx$$

Clearly, when farmers 'financial constraints are disregarded, decentralized e-commerce platforms tend to sell all purchased agricultural products. In Model A, the e-commerce platform's purchase price exhibits an inverse relationship with the market wholesale price when the average wholesale price $\bar{x}$ is high. This occurs because the platform lowers its purchase price to mitigate the high expected purchase price caused by the elevated average wholesale price, thereby maintaining the expected purchase price at a specific level to maximize its profit. It is also evident that under equilibrium decision-making, the profits of all entities in the contract farming supply chain remain unaffected by the average wholesale price. Therefore, when financial constraints are ignored, farmers' production decisions need not consider the empirical distribution function of random market wholesale prices. It is evident that decentralized decision-making results in overall supply chain efficiency losses compared to centralized decision-making.

4.3. The Impact of Unit Input Cost on the Equilibrium Results of Agricultural Supply Chain is as Follows

(1) The government has not implemented any subsidies for agricultural products.

$$\frac{\partial E^{NF,D}[\max(\omega, x)]}{\partial C_1} > 0; \frac{\partial Q^{NF,D*}}{\partial C_1} < 0$$

$$\frac{\partial \pi_f^{NF,D*}}{\partial C_1} = \frac{C_2 + C_1 - a}{4b}; \frac{\partial^2 \pi_f^{NF,D*}}{\partial C_1^2} = \frac{1}{4b} > 0$$

$$\frac{\partial \pi_r^{NF,D*}}{\partial C_1} = \frac{C_2 + C_1 - a}{8b}; \frac{\partial^2 \pi_r^{NF,D*}}{\partial C_1^2} = \frac{1}{8b} > 0$$

The increase of fixed cost leads to the increase of purchase price, but the increase of fixed cost directly reduces the production enthusiasm and leads to the decrease of output.

The profit of agricultural cooperatives is sensitive to cost: the cost increase directly reduces the profit.

Critical threshold: When $C_1 < a - C_2$, profits decrease as costs increase; after exceeding the threshold, they start to rise (the portion above the threshold is not considered).

In the short term, rising costs for e-commerce businesses may drive efficiency gains and profit growth. However, if the cost increase exceeds the tolerance threshold in the long run, both parties will face profit declines (excluding the portion exceeding the threshold).

(2) The government provides subsidies for agricultural products.

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$$\frac{\partial E^{F,D}[\max(\omega,x)]}{\partial C_1}>0;\frac{\partial Q^{F,D^*}}{\partial C_1}<0$$

$$\frac{\partial \pi_f^{F,D^*}}{\partial C_1}=\frac{C_2+(1-s)C_1-a}{4b};\frac{\partial^2 \pi_f^{F,D^*}}{\partial {C_1}^2}=\frac{1}{4b}>0$$

$$\frac{\partial \pi_r^{F,D^*}}{\partial C_1}=\frac{C_2+(1-s)C_1-a}{4b};\frac{\partial^2 \pi_r^{F,D^*}}{\partial {C_1}^2}=\frac{1}{4b}>0$$

The subsidies sC_1Q directly offset part of the costs, changing the critical condition as $C_1<\frac{a-C_2}{1-s}$ and mitigating the negative impact of rising costs. Moreover, the subsidies significantly raise the cost tolerance threshold, thereby reducing the profit decline under the same cost increase.

4.4. The Comparison between the Government's Non-implementation and Implementation of Agricultural Product Subsidies on the Equilibrium Results of the Agricultural Supply Chain is as Follows

Conclusion 3:

$$\Delta E[\max(\omega,x)]=E^{F,D}[\max(\omega,x)]-E^{NF,D}[\max(\omega,x)]=\frac{-s*C_1}{2}<0;$$

$$\Delta Q=Q^{F,D^*}-Q^{NF,D^*}=\frac{s*C_1}{4b}>0;$$

$$\Delta \pi_r=\pi_r^{F,D^*}-\pi_r^{NF,D^*}>0;$$

(1) For agricultural cooperatives: Government subsidies directly increase the income per unit of agricultural products, thereby boosting their optimal profit. Simultaneously, these subsidies may stimulate production growth ($Q^{F,D^*}>Q^{NF,D^*}$), while market oversupply leads to lower purchase prices ($E^{NF,D}[\max(\omega,x)]>E^{F,D}[\max(\omega,x)]$). In summary, the combined effects of direct subsidy benefits and economies of scale result in a significant increase in the optimal profit of agricultural cooperatives ($\pi_f^{F,D^*}>\pi_f^{NF,D^*}$).

(2) For e-commerce businesses: government subsidies boost their profits ($\pi_r^{F,D^*}>\pi_r^{NF,D^*}$) by lowering the purchase price of agricultural products ($E^{NF,D}[\max(\omega,x)]>E^{F,D}[\max(\omega,x)]$).

4.5. The Impact of Agricultural Product Subsidies from Government Units on the Equilibrium Results of the Agricultural Supply Chain is as Follows

Conclusion 4:

$$\frac{\partial Q^{F,D^*}}{\partial s}>0;\frac{\partial E^{F,D}[\max(\omega,x)]}{\partial s}<0$$

(1) Impact on agricultural production Q

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$$\frac{\partial Q^{F,D^*}}{\partial s} > 0$$

Q increases as s increases, the government subsidy strength, the increase of the government unit agricultural products subsidy amount, the incentive to $\Delta \pi_f = \pi_f^{F,D^*} - \pi_f^{NF,D^*} > 0$; expand the market production scale, the increase of agricultural products output;

(2) The impact on the order price $E[\max(\omega, x)]$

$$\frac{\partial E^{F,D}[\max(\omega, x)]}{\partial s} < 0$$

$E[\max(\omega, x)]$ decreases as s increases, the subsidy will lead to the increase of the production and the increase of the market supply. The increase of the supply will lead to the decrease of the purchase price of the agricultural products.

(3) The Influence of Agricultural Products Cooperative on Profit π_f

$$\frac{\partial \pi_f^{F,D^*}}{\partial s} = \frac{[a-(1-s)C_1 - C_2]^* C_1}{4b}; \frac{\partial^2 \pi_f^{F,D^*}}{\partial s^2} = \frac{C_1^2}{4b} > 0;$$

$$when \quad s < \frac{C_1 + C_2 - a}{C_1}, \frac{\partial \pi_f^{F,D^*}}{\partial s} < 0;$$

$$when \quad s > \frac{C_1 + C_2 - a}{C_1}, \frac{\partial \pi_f^{F,D^*}}{\partial s} > 0;$$

Key Threshold Analysis of Government Subsidies for Agricultural Cooperatives

At $s < \frac{C_1 + C_2 - a}{C_1}$, $\frac{\partial \pi_f^{F,D^*}}{\partial s} < 0$, the subsidy was insufficient to cover the combined impact of production costs and market risks, and increasing the subsidy would lead to a decline in the profits of agricultural cooperatives due to overproduction.

At $s > \frac{C_1 + C_2 - a}{C_1}$, $\frac{\partial \pi_f^{F,D^*}}{\partial s} > 0$, when the subsidy exceeded the critical value, the direct benefit and scale effect dominated, and the profit of agricultural cooperatives increased significantly with the increase of subsidy.

The impact of government subsidies on the profits of agricultural cooperatives is U-shaped:

1) In the initial phase, when subsidies are insufficient, the reduction in purchase prices caused by increased production offsets the subsidy benefits.

2) After the threshold is breached, the marginal returns of subsidies increase (with positive second-order derivatives), and the profits of agricultural cooperatives enter a phase of rapid growth.

(4) The indirect impact on e-commerce profits

$$\frac{\partial \pi_r^{F,D^*}}{\partial s} = \frac{[a-(1-s)C_1 - C_2]^* C_1}{8b}; \frac{\partial^2 \pi_r^{F,D^*}}{\partial s^2} = \frac{C_1^2}{8b} > 0;$$

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$$when \quad s < \frac{C_1 + C_2 - a}{C_1}, \frac{\partial \pi_r^{F,D*}}{\partial s} < 0;$$

$$when \quad s > \frac{C_1 + C_2 - a}{C_1}, \frac{\partial \pi_r^{F,D*}}{\partial s} > 0;$$

Key Threshold Analysis of Government Subsidies for Agricultural Cooperatives

At $s < \frac{C_1 + C_2 - a}{C_1}$, $\frac{\partial \pi_r^{F,D*}}{\partial s} < 0$, the subsidies were insufficient, the increase of farmers' output was limited, and the decrease of purchasing cost was not enough to offset the risk of retail price falling due to the supply surplus.

At $s > \frac{C_1 + C_2 - a}{C_1}$, $\frac{\partial \pi_r^{F,D*}}{\partial s} > 0$, the positive effects of sufficient subsidies and significantly reduced procurement costs dominated, and the scale effect from increased production ensured e-commerce sales. Consequently, e-commerce profits rose with the increase in subsidies.

1) Policy implications:

Targeted subsidies: Governments need to ensure that subsidies are above a critical threshold, otherwise they may backfire.

Coordinated optimization: Subsidies should dynamically align with other supply chain parameters (e.g., market demand a, costs C_1, C_2) to prevent wasteful investments.

2) Supply chain collaboration:

When the threshold is exceeded, the subsidy creates a win-win scenario: cooperatives boost production and revenue, while e-commerce platforms benefit from cost savings and increased sales.

5. Numerical Simulation

To validate the above conclusions, we performed numerical simulations using MATLAB software with parameter values specified in Table 2. The parameters were rounded to reasonable ranges to ensure meaningful profit values. The market price x followed a uniform distribution U [m, n] (m=2, n=8). Table 3 presents the equilibrium results of models NF and F under different decision-making modes.

Table 2. Parameter Settings

parameter	a	b	C_0	C_1	C_2	s
sense of worth	15	1	1	2	1	0.2

Table 3. Equilibrium Results of Model NF and Model F under Different Decision-making Models

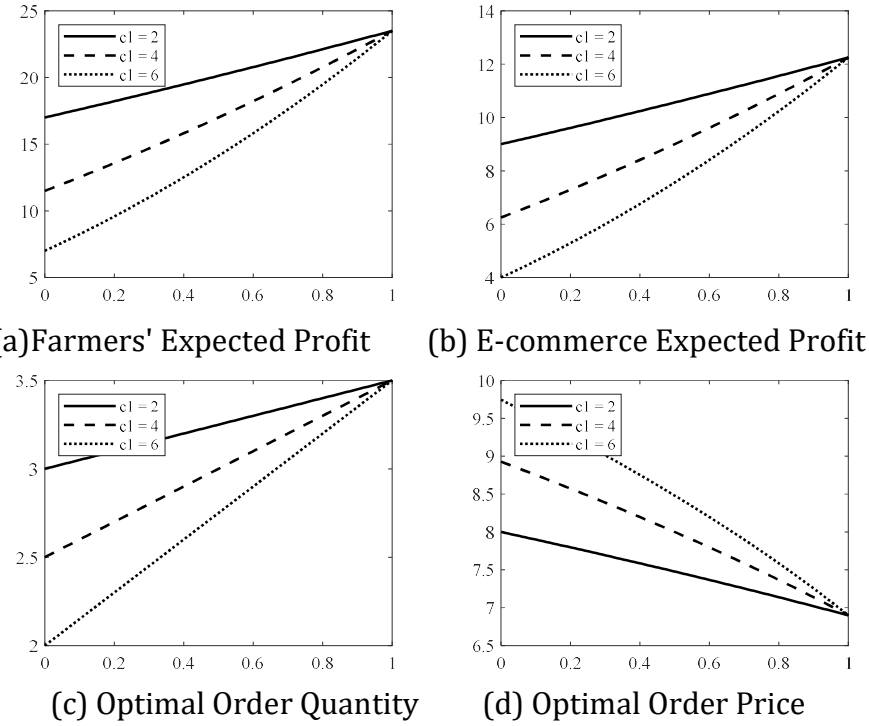
	model	Q^*	ω^*	SW^*	π_f^*	π_r^*
centralized decision making	model *NF*	6.00		35.00		
	model *F*	6.20		37.44		
disperse policy decision	model *NF*	3.00	8.00		17.00	9.00
	model *F*	3.10	7.80		18.22	9.61

The comparison between model NF and model F shows that the total profit of model NF is lower than that of model F. Compared with the situation without subsidy, the order price is lower in

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model NF, while the order quantity, the optimal profit of farmers and the e-commerce company are all higher.

5.1. The Influence of s on the Expected Profit, Order Quantity and Order Price under Different C_1



(a)Farmers' Expected Profit (b) E-commerce Expected Profit

(c) Optimal Order Quantity (d) Optimal Order Price

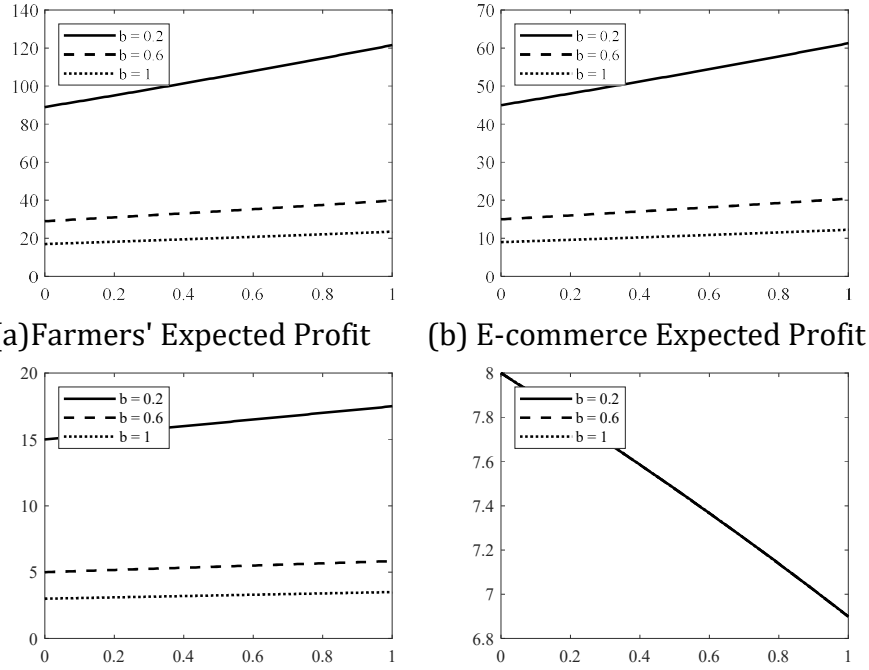
Fig. 3 Effects of s on expected profit, order quantity, and order price under different C_1 values

As shown in Fig. 3, under varying government subsidy coefficients (s), both the optimal expected profits and optimal order quantities of agricultural cooperatives and e-commerce platforms increase with rising s, while the optimal purchase price decreases. When the government provides only production subsidies to agricultural cooperatives, these funds directly reduce per-unit production costs. This cost reduction enables cooperatives to supply e-commerce platforms at lower wholesale prices, incentivizing them to increase orders for higher profits. Simultaneously, as cost pressures ease and sales volumes rise, cooperatives' profit margins expand proportionally.

Under different unit costs C_1 ,the optimal expected profit and the optimal order quantity of agricultural cooperatives and e-commerce decrease with the increase of cost, while the optimal order price increases with the increase of cost. When production costs C_1 for agricultural cooperatives rise, the unsubsidized cost increment forces them to raise wholesale prices to maintain profitability, which reduces e-commerce platforms 'procurement incentives and shrinks overall supply chain profits. This mechanism demonstrates that targeted subsidies to production entities can optimize source cost structures, enhance cooperatives' bargaining power, and indirectly drive downstream e-commerce market expansion, thereby achieving vertical supply chain synergy.

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5.2. The Influence of s on the Expected Profit, Order Quantity and Order Price under Different b



(a)Farmers' Expected Profit (b) E-commerce Expected Profit

(c) Optimal Order Quantity (d) Optimal Order Price

Fig. 4 Impact of s on expected profit, order quantity, and order price under different b values

As shown in Fig. 4, the analysis of how different government subsidy coefficients (s) affect the optimal expected profits, order quantities, and purchase prices for agricultural cooperatives and e-commerce platforms aligns with the findings from Figure 3. When demand sensitivity coefficients (b) vary, the optimal expected profits and order quantities of both entities decrease as b increases, while the optimal purchase price remains unaffected by b's value. When the price elasticity coefficient (b) rises, consumers become more sensitive to price fluctuations. This compels e-commerce platforms to lower prices to maintain sales, compressing marginal profits. Consequently, cooperatives are forced to reduce agricultural product orders simultaneously to mitigate overstock risks, resulting in a decline in both parties' optimal expected profits. The independence of the optimal purchase price from b indicates that supply chain pricing strategies are primarily constrained by rigid factors like production costs and market base prices. Government subsidy policies function through cost compensation mechanisms, enhancing supply chain members' risk resilience. They maintain reasonable order quantities during market demand fluctuations, preventing exacerbated supply-demand imbalances.

6. Research Conclusion

This study constructs and solves the Stackelberg game model of the two-level supply chain of agricultural cooperatives and e-commerce platforms under the government subsidies, and compares and analyzes the equilibrium results under various situations such as centralized and decentralized decision-making, and whether there are government subsidies. The following core conclusions are obtained:

(1) Decentralized Decision Making Has Efficiency Loss

The sum of profits of agricultural cooperatives and e-commerce platforms under decentralized decision-making is lower than the social welfare level under centralized decision-making,

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which indicates that decentralized decision-making leads to the overall efficiency of the supply chain not reaching the optimal level.

(2) The effect of government subsidies on the output and the purchase price is opposite

Government subsidies encourage farmers to expand production scale $\partial Q/\partial s > 0$ by reducing their marginal production cost, but at the same time, it leads to the increase of market supply and the decrease of the purchase price of agricultural products $\partial E[\max(\omega, x)]/\partial s < 0$.

(3) The relationship between profit and subsidy is U-shaped

The profit of agricultural cooperatives and e-commerce platforms shows a U-shaped relationship with the change of subsidy coefficient s. There is a critical subsidy level $s_0 = (C_1 + C_2 - a)/C_1$, when $s < s_0$, the increase of subsidy may lead to the decrease of profit because of the decrease of purchase price; when $s < s_0$, the scale effect and cost saving effect of subsidy are prominent, the profit will increase significantly.

7. Policy and Management Implications

Based on the above research conclusions, this paper puts forward the following specific and operational policy and management suggestions:

7.1. Suggestions for the Government

Implement a targeted subsidy mechanism

The government should ensure that the subsidy coefficient s exceeds the critical value, otherwise the subsidy may be invalid or even counterproductive. It is suggested to establish a dynamic subsidy adjustment mechanism linked with production cost and market demand to avoid "increasing production without increasing income".

Promote the collaborative optimization of supply chains

We should encourage agricultural cooperatives and e-commerce platforms to adopt the mode of centralized decision-making or contract coordination (such as profit sharing and risk sharing) to reduce the double marginal effect and improve the overall social welfare.

Strengthening long-term capacity building

The subsidy policy should be combined with long-term measures such as digital transformation of agricultural production, farmer skills training and quality control to enhance the endogenous power of the supply chain and reduce the dependence on external subsidies.

7.2. Suggestions for E-commerce Platforms

(1) Establishing the mechanism of information sharing and strategic cooperation

Actively sharing the market and production information with the cooperative, reducing information asymmetry, exploring the benefit sharing contract, so as to approach the efficiency of centralized decision-making and achieve win-win.

(2) Optimization of Procurement and Pricing Strategies

Under the background of government subsidies, we should make full use of the dividend of the decrease of the purchase price, expand the purchase scale reasonably, and improve the terminal premium ability through brand building and channel optimization.

7.3. Recommendations for Agricultural Cooperatives

(1) Focus on improving production efficiency and quality

While enjoying the government subsidy, we should invest resources in production technology innovation, quality control and cost management, and avoid the pursuit of output and neglect of benefit.

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(2) Actively participate in supply chain collaboration

Actively establish long-term partnerships with e-commerce platforms to jointly address market fluctuations, thereby enhancing bargaining power and risk resilience.

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