Agricultural E-commerce Supply Chain Decision-Making Considering Government Subsidies and Platform Social Responsibility

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Abstract. To mitigate the deterioration of agricultural products in e-commerce transactions, this study examines the factors of suppliers' investment in brand development for agricultural products and the fulfillment of social responsibility by e-commerce platforms. It establishes a fundamental Stackelberg model for secondary agricultural product e-commerce supply chains and analyzes and compares changes in profits and social welfare for suppliers and e-commerce platforms under different scenarios. The objective is to determine optimal subsidy strategies and rates when the government does not provide subsidies, only subsidizes suppliers, or only subsidizes e-commerce platforms. The findings indicate that government subsidies have a positive impact on both supplier brand development investments and platform social responsibility levels. Government subsidies encourage suppliers to enhance their brand building efforts while guiding platforms towards higher levels of social responsibility. When government subsidies are provided, there is an initial increase followed by a decrease in social welfare as the subsidy rate varies; however, when subsidies are exclusively given to suppliers, there exists a unique maximum value that maximizes overall social welfare. Therefore, it is recommended that the optimal subsidy strategy involves subsidizing suppliers to improve their level of brand development for agricultural products.

Keywords: Government subsidy; Platform social responsibility; Agricultural products e-commerce supply chain

1 INTRODUCTION

With the rapid development of Internet technology and e-commerce economy, e-commerce platform has become an indispensable medium for consumers to purchase agricultural products. In the central document No. 1 in 2024, it is pointed out that high-quality development projects of rural e-commerce should be implemented. According to the data of Tiktok e-commerce to help farmers, 4.73 billion monorong specialties were sold on the platform in 2023, and the number of farmers increased by 105% year-on-year. However, the phenomenon of spoilage of agricultural products

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occurs from time to time. On the one hand, consumers obtain agricultural product origin, brand, quality and other related information through the e-commerce platform, and the e-commerce platform fails to supervise the false information provided by the supplier, resulting in the agricultural products purchased by consumers are inconsistent with the description content of the e-commerce platform. On the other hand, there are some suppliers to fight a price war to seize the market share of agricultural products, which has a negative impact on the real characteristic brand of agricultural products, and the phenomenon of "bad money drives out good money". Therefore, it is of great practical significance to explore the development of agricultural products e-commerce supply chain.

At present, the research on the supply chain of agricultural products e-commerce has attracted much attention. Etumnu et al.[1] pointed out that the distribution of online ratings plays an important role in the information of e-commerce platforms. Guo and Lai et al.[2] discussed the profit coordination and optimization of agricultural product brand promotion under decentralized and centralized decision-making. Xu et al.[3] studied the interaction between platform blockchain technology strategy and channel encroachment decision in the secondary agricultural products e-commerce supply chain. "Based on a game theory model of the agricultural e-commerce supply chain, Lin Xiaogang et al.[4] explore the strategies provided by blockchain technology for e-commerce platforms in a hybrid sales mode, and find that supplying blockchain technology to enterprises under either mode is mutually beneficial for both parties." Yao Fengmin et al.[5] found that the altruistic preference behavior of e-commerce platforms is conducive to improving the overall performance of the supply chain system and improving the traceability ability of agricultural products.

As a trading link for agricultural products, e-commerce platforms should actively undertake corporate social responsibility. Zhang Chengtang et al.[6] built a low-carbon agricultural product supply chain dominated by e-commerce platform and found that the implementation of CSR on the platform could increase farmers' profits and reduce the carbon emissions of agricultural products at the same time, but would lead to a decline in their own profits. The platform will incur certain costs to fulfill corresponding social responsibilities. In the process of cooperation with suppliers, in order to strengthen information supervision and verification, purchase corresponding facilities and equipment and optimize personnel, etc., the cost burden of the platform will be increased and its own profits will be reduced. Government subsidies are an important means to encourage platforms to improve the level of social responsibility. Fan Jianchang et al.[7] explored a two-level supply chain game model based on channel power structure, and concluded that CSR commitment is conducive to improving product quality and market demand, while increasing the profits of relevant members of the supply chain.

However, existing studies rarely consider the government's support and guidance for suppliers' brand building of agricultural products, as well as the significance of e-commerce platforms fulfilling social responsibilities as important subjects in agricultural products trading.As the fulfillment of social responsibility by e-commerce platforms plays an important role in the long-term development of agricultural products trading, and the government plays an important role in encouraging and leading the

future development of rural e-commerce industry, this paper is based on three different government subsidy models, dominated by e-commerce platforms. The decision-making behavior and profit changes of suppliers in brand building of agricultural products and social responsibility fulfillment of e-commerce platforms, as well as the optimal subsidy strategy and optimal subsidy rate of the government were discussed respectively.

2 PROBLEM DESCRIPTION AND MODEL ASSUMPTIONS

2.1 Problem Description

This paper studies a two-level agricultural product e-commerce supply chain composed of suppliers and e-commerce platforms. The supplier determines the brand building level β of agricultural products and the wholesale price w of agricultural products. The e-commerce platform determines its own level of social responsibility and sells agricultural products to consumers at the retail price p. Both e-commerce platforms and suppliers make decisions with the goal of maximizing their own profits. The government subsidizes the cost of the supplier's agricultural product brand building investment and the e-commerce platform's social responsibility. Subscript f represents the value of the supplier, subscript q represents the value of the e-commerce platform, and subscript sc represents the value of the agricultural product e-commerce supply chain.

2.2 Model Assumptions

In order to be more suitable for real life, this paper assumes the following:

Hypothesis 1: The social responsibility level of e-commerce platform and the brand building level of agricultural products of suppliers are positively correlated with market demand, and the market demand function is $d=a-\gamma p+\epsilon h+e\beta$, Where, a is the potential market size of agricultural products, γ is the sensitivity coefficient of consumers to the price of agricultural products $0<\gamma<1$,ϵ is the sensitivity coefficient of consumers to the social responsibility of e-commerce platforms $0<\epsilon<1$, e is the sensitivity coefficient of consumers to the level of agricultural product brand building of suppliers $0<e<1$.

Hypothesis 2: The platform improves its level of social responsibility by supervising suppliers and the authenticity of their agricultural product information, and the cost it needs to pay is $\frac{\varphi h^2}{2}$, φ is the cost coefficient of social responsibility level $0<\varphi<1$, h is the social responsibility level of e-commerce platform.

Hypothesis 3: Referring to the research of scholars such as Zhou[9], due to the marginal diminishing return effect of brand building investment, assume that brand building cost is a one-time investment and construction cost is $\frac{s\beta^2}{2}$, s is the cost coefficient of brand building level $0<s<1$.

Hypothesis 4: The cost of the supplier's agricultural product brand building investment and the e-commerce platform's social responsibility is subsidized, and the government subsidy coefficient is calculated $t \in 0,1$.

Hypothesis 5: In this paper, social welfare is defined as the sum of government expenditure, total profit of agricultural e-commerce supply chain and consumer surplus, where CS= $\frac{d^2}{2\gamma}$ [10][10].

3 MODEL SOLVING

3.1 Supply Chain Model of Agricultural Products E-commerce Without Government Subsidies (N)

At this time, the game order of the supply chain is:first, the e-commerce platform decides the retail price of agricultural products (p^N) and the social responsibility level (hN), and then the supplier decides the brand building level (β^N) and the wholesale price (w^N). As the decision-making leader, the e-commerce platform, in order to ensure profitability, set (m^N) as the profit earned by the unit of agricultural products, and the retail price $p^N = m^N + w^N$, c is the production cost per unit of agricultural products.. The total profit of suppliers, e-commerce platform, e-commerce supply chain and total social welfare function are respectively

$$II_f^N = (w^N - c)d - \frac{1}{2}s(\beta^N)^2 \tag{1}$$

$$II_q^N = m^N d - \frac{1}{2}\varphi(h^N)^2 \tag{2}$$

$$II_{sc}^N = II_f^N + II_q^N \tag{3}$$

$$SW^N = II_{sc}^N + CS \tag{4}$$

Theorem 1 The equilibrium solution of e-commerce supply chain is as follows:

$$m^{N*} = \frac{\varphi(a - c\gamma)(2s\gamma - e^2)}{\gamma(4s\gamma\varphi - s\epsilon^2 - 2\varphi e^2)}$$

$$h^{N*} = \frac{s\epsilon(a - c\gamma)}{4s\gamma\varphi - s\epsilon^2 - 2\varphi e^2}$$

$$w^{N*} = \frac{-cs\epsilon^2 - 2c\varphi e^2 + as\varphi + 3cs\gamma\varphi}{4s\gamma\varphi - s\epsilon^2 - 2\varphi e^2}$$

$$\beta^{N*} = \frac{e\varphi(a - c\gamma)}{4s\gamma\varphi - s\epsilon^2 - 2\varphi e^2}$$

$$p^{N*} = \frac{sc\gamma\epsilon^2 - sc\gamma^2\varphi + c\gamma\varphi e^2 - 3as\gamma\varphi + a\varphi e^2}{\gamma(2\varphi e^2 + s\epsilon^2 - 4s\gamma\varphi)}$$

Proof: The equilibrium conditions are: $2\varphi(2s\gamma - e^2) - s\epsilon^2 > 0$,$a > c\gamma$,Will β^{N*},w^{N*},m^{N*},h^{N*} and p^{N*} into the profit function gives the following result

$$\mathrm{II}_{\mathrm{f}}^{\mathrm{N}*} = \frac{\mathrm{s}\varphi^2(a - c\gamma)^2(2s\gamma - \mathrm{e}^2)}{2(2\mathrm{e}^2\varphi + \mathrm{s}\epsilon^2 - 4s\gamma\varphi)^2}$$

$$\mathrm{II}_{\mathrm{q}}^{\mathrm{N}*} = \frac{\mathrm{s}\varphi(a - c\gamma)^2}{2(4s\gamma\varphi - 2\mathrm{e}^2\varphi - \mathrm{s}\epsilon^2)}$$

$$\mathrm{II}_{\mathrm{sc}}^{\mathrm{N}*} = \frac{\mathrm{s}\varphi(a - c\gamma)^2(6s\gamma\varphi - s\epsilon^2 - 3\mathrm{e}^2\varphi)}{2(2\mathrm{e}^2\varphi + \mathrm{s}\epsilon^2 - 4s\gamma\varphi)^2}$$

$$SW^{N*} = \frac{\mathrm{s}\varphi(a - c\gamma)^2(7s\gamma\varphi - s\epsilon^2 - 3\mathrm{e}^2\varphi)}{2(2\mathrm{e}^2\varphi + \mathrm{s}\epsilon^2 - 4s\gamma\varphi)^2}$$

3.2 Supply Chain Model of Agricultural E-commerce when the Government only Provides Subsidies to Suppliers (F)

At this time, the game order of the supply chain is: first, the government decides the subsidy rate t, then the e-commerce platform decides the retail price of agricultural products (p^F) and the level of social responsibility (h^F), and finally, the supplier decides the brand building level (β^F) and the wholesale price(w^F). The total profit of suppliers, e-commerce platform, e-commerce supply chain and total social welfare function are respectively

$$II_f^F = (w^F - c)d - \frac{1}{2}s(\beta^F)^2(1 - t) \tag{5}$$

$$II_q^F = m^F d - \frac{1}{2}\varphi(h^F)^2 \tag{6}$$

$$II_{sc}^F = II_f^F + II_q^F \tag{7}$$

$$SW^F = II_{sc}^F + CS - \frac{1}{2}st(\beta^F)^2 \tag{8}$$

Theorem 2 The equilibrium solution of e-commerce supply chain is as follows:

$$m^{F*} = \frac{(a - c\gamma)[e^2 + 2s\gamma(t - 1)]\varphi}{\gamma[s(1 - t)(\epsilon^2 - 4\gamma\varphi) + 2e^2\varphi]}$$

$$h^{F*} = \frac{s\epsilon(t - 1)(a - c\gamma)}{s(1 - t)(\epsilon^2 - 4\gamma\varphi) + 2e^2\varphi}$$

$$w^{F*} = \frac{s(t - 1)(\epsilon^2 c - \varphi a - 3\gamma\varphi c) + 2ce^2\varphi}{s(1 - t)(\epsilon^2 - 4\gamma\varphi) + 2e^2\varphi}$$

$$\beta^{F*} = \frac{e\varphi(c\gamma - a)}{s(1 - t)(\epsilon^2 - 4\gamma\varphi) + 2e^2\varphi}$$

$$p^{F*} = \frac{e^2\varphi(a + c\gamma) + \gamma s(t-1)(3a\varphi + \gamma c\varphi - \epsilon^2 c)}{\gamma[s(1-t)(\epsilon^2 - 4\gamma\varphi) + 2e^2\varphi]}$$

Proof: The equilibrium conditions are: $2s\gamma(1-t) - e^2 > 0$,$a > c\gamma$, $2e^2\varphi + s(1-t)(\epsilon^2 - 4\gamma\varphi) < 0$.Will $m^{F*}, h^{F*}, p^{F*}, w^{F*}$, and β^{F*} into the profit function gives the following result

$$\mathrm{II}_{\mathrm{f}}^{\mathrm{F}*} = \frac{\mathrm{s}\varphi^2(t-1)(a-c\gamma)^2[\mathrm{e}^2 + 2s\gamma(t-1)]}{2[2\mathrm{e}^2\varphi + \mathrm{s}(t-1)(\epsilon^2 - 4\gamma\varphi)]^2}$$

$$\mathrm{II}_{\mathrm{q}}^{\mathrm{F}*} = \frac{\mathrm{s}\varphi^2(t-1)(a-c\gamma)^2}{2[2\mathrm{e}^2\varphi + \mathrm{s}(t-1)(\epsilon^2 - 4\gamma\varphi)]}$$

$$\mathrm{II}_{\mathrm{sc}}^{\mathrm{F}*} = \frac{\mathrm{s}\varphi^2(t-1)(a-c\gamma)^2[\mathrm{e}^2 + 2s\gamma(t-1)]}{[2\mathrm{e}^2\varphi + \mathrm{s}(t-1)(\epsilon^2 - 4\gamma\varphi)]^2}$$

$$SW^{F*} = \frac{\mathrm{s}\varphi(a-c\gamma)^2[\mathrm{e}^2(2t-3)\varphi - s(t-1)^2(\epsilon^2 - 7\gamma\varphi)]}{2[2\mathrm{e}^2\varphi + \mathrm{s}(t-1)(\epsilon^2 - 4\gamma\varphi)]^2}$$

3.3 Supply Chain Model of Agricultural Products E-commerce when the Government only Subsidizes the E-commerce Platform (Q)

At this time, the game order of the supply chain is: first, the government decides the subsidy rate t, then the e-commerce platform decides the retail price of agricultural products (p^Q) and the level of social responsibility (h^Q), and finally the supplier decides the brand building level (β^Q) and the wholesale price (w^Q). The supplier, e-commerce platform, total profit of e-commerce supply chain and total social welfare function are respectively

$$II_f^Q = (w^Q - c)d - \frac{1}{2}s(\beta^Q)^2 \tag{9}$$

$$II_q^Q = m^Q d - \frac{1}{2}\varphi(h^Q)^2(1-t) \tag{10}$$

$$II_{sc}^Q = II_f^Q + II_q^Q \tag{11}$$

$$SW^Q = II_{sc}^Q + CS - \frac{1}{2}\varphi t(h^Q)^2 \tag{12}$$

Theorem 3 The equilibrium solution of e-commerce supply chain is as follows:

$$m^{\mathrm{Q}*} = \frac{(t-1)(a-c\gamma)(2s\gamma - e^2)\varphi}{\gamma[2\varphi(1-t)(e^2 - 2s\gamma) + \epsilon^2 s]}$$

$$h^{\mathrm{Q}*} = \frac{s\epsilon(c\gamma - a)}{2\varphi(1-t)(e^2 - 2s\gamma) + \epsilon^2 s}$$

$$w^{Q*} = \frac{\varphi(1-t)(2\varphi e^2 - 3c\gamma - as)(1-t_2) + sc\epsilon^2}{2\varphi(1-t)(e^2 - 2s\gamma) + \epsilon^2 s}$$

$$\beta^{Q*} = \frac{e\varphi(t-1)(a-c\gamma)}{2\varphi(1-t)(e^2 - 2s\gamma) + \epsilon^2 s}$$

$$p^{Q*} = \frac{\varphi(1-t)(ae^2 - 3s\gamma a - cs\gamma^2 + \gamma ce^2) + sc\gamma\epsilon^2}{\gamma[2\varphi(1-t)(e^2 - 2s\gamma) + \epsilon^2 s]}$$

Proof: The equilibrium conditions are: $a>c\gamma$,$2s\gamma-e^2>0$, $2\varphi(1-t)(e^2 - 2\gamma s)+s\epsilon^2<0$.Will $m^{Q*}, h^{Q*}, p^{Q*}, w^{Q*}$ and β^{Q*} generation into the profit function results are as follows

$$II_f^{Q*} = \frac{s\varphi^2(t-1)^2(a-c\gamma)^2(2s\gamma - e^2)}{2[2\varphi(1-t)(e^2 - 2s\gamma) + s\epsilon^2]^2}$$

$$II_q^{Q*} = \frac{s\varphi(t-1)(a-c\gamma)^2}{2[2\varphi(1-t)(e^2 - 2s\gamma) + s\epsilon^2]}$$

$$II_{sc}^{Q*} = \frac{s\varphi(t-1)(a-c\gamma)^2[3\varphi(1-t)(e^2 - 2s\gamma) + s\epsilon^2]}{2[2\varphi(1-t)(e^2 - 2s\gamma) + s\epsilon^2]^2}$$

$$SW^{Q*} = \frac{s\varphi(a-c\gamma)^2[\varphi(7s\gamma - 3e^2)(t-1)^2 - s\epsilon^2]}{2[2\varphi(1-t)(e^2 - 2s\gamma) + s\epsilon^2]^2}$$

4 COMPARISON AND ANALYSIS

Inference 1

$m^{F*} - m^{N*} > 0$; $h^{F*} - h^{N*} > 0$; $w^{F*} - w^{N*} > 0$; $\beta^{F*} - \beta^{N*} > 0$; $\mathrm{II}_f^{F*} - \mathrm{II}_f^{N*} > 0$; $\mathrm{II}_q^{F*} - \mathrm{II}_q^{N*} > 0$

Corollary 1 shows that when the government only provides subsidies to suppliers, the marginal profit of the platform, the retail price of the product, the level of brand building of agricultural products, the level of social responsibility of the level station, the profit of the supplier and the profit of the platform will increase compared with when the government does not provide subsidies. The reasons are as follows: When the government only provides subsidies to suppliers, it is equivalent to reducing the input cost of brand building of agricultural products, and the suppliers will gain more profits. The increase in profits of suppliers enables them to improve the level of brand building, provide more high-quality agricultural products to the platform, attract consumers to buy, and increase the total market demand for products. Due to the expansion of market demand, the platform will wholesale more agricultural products and increase product prices to obtain higher profits, and the corresponding suppliers will also increase wholesale prices. The platform occupies a dominant advantage in the supply chain, leading to further increase of marginal profits of agricultural products.

The expansion of profit margin enables the e-commerce platform to actively fulfill more social responsibilities. It is conducive to enhancing consumer brand loyalty of agricultural products and expanding product market demand, and the situation is repeated to the equilibrium of both sides.

Inference 2

$m^{Q*} - m^{N*} > 0$; $h^{Q*} - h^{N*} > 0$; $w^{Q*} - w^{N*} > 0$; $\beta^{Q*} - \beta^{N*} > 0$; $\mathrm{II}_f^{Q*} - \mathrm{II}_f^{N*} > 0$; $\mathrm{II}_q^{Q*} - \mathrm{II}_q^{N*} > 0$

Inference 2 shows that when the government does not subsidize the platform, product profit, product retail price, supplier brand building level, platform social responsibility level, and supply chain member profit all increase. The reason is that when the government only subsidizes the e-commerce platform, it is equivalent to reducing the cost expenditure of the platform to fulfill its social responsibility, which can improve the profit margin of the platform, encourage the platform to take the initiative to improve its social responsibility level, establish a good corporate image, and thus increase the market demand for products. Due to the rising market demand for products, the platform will increase the retail price of products and strengthen the supply capacity of the platform in order to obtain more profits, and suppliers will increase the wholesale price of agricultural products in order to obtain higher profits. When the profit of the supplier increases, it will actively build the brand of agricultural products, thereby winning the trust of the consumer brand and increasing the demand of the product market. This situation develops into a virtuous circle to find a balance among members.

Inference 3

Under different subsidy conditions, the relationship between the total profit of the e-commerce supply chain is as follows: $\mathrm{II}_{\mathrm{sc}}^{F*} \geq \mathrm{II}_{\mathrm{sc}}^{Q*} \geq \mathrm{II}_{\mathrm{sc}}^{N*}$

Corollary 3: The overall return of the supply chain of e-commerce in the case of government subsidies to suppliers is higher than that in the case of government subsidies, and higher than that in the case of no subsidies. When the government provides subsidies to suppliers for brand building of agricultural products, the overall benefit of the e-commerce supply chain is the largest, so when the government provides relevant subsidies to suppliers, the entire supply chain can achieve the optimal.

Inference 4

The relationship between the size of social welfare in three different situations can be obtained as follows: When t is less than $\frac{2(3s\gamma - e^2)(4s\gamma\varphi - s\epsilon^2 - 2\varphi e^2)}{3e^2 s\epsilon^2 - 7s^2\gamma\epsilon^2 + 8\varphi e^4 - 36e^2 s\gamma\varphi + 40s^2\gamma^2\varphi}$, there is $SW^{F*} > SW^{Q*} > SW^{N*}$.

It can be seen that when certain conditions are met, the social welfare when the government subsidizes the supplier is greater than the government welfare when the government subsidizes the platform, and greater than the social welfare when the government does not provide any subsidies. It can also be seen from Corollary 4 that government behavior always aims at maximizing social welfare. In summary, the government will adopt subsidy policies for suppliers.

Inference 5

Optimal government subsidy rate:

$$t^* = \frac{6s\gamma\varphi - \varphi e^2}{10s\gamma\varphi - s\epsilon^2}$$

As can be seen from the above, when the government provides subsidies for the investment in brand building of agricultural products, social welfare can be maximized. Therefore, by finding the maximum value of t in SW^{F*}, we can find the optimal subsidy rate. According to the calculation, in the case that the subsidy supplier is the optimal strategy, although the supply chain members and the related profits of the system will increase with the subsidy ratio, the government will control the ratio within a limited range to make the total social welfare optimal.

5 EXAMPLE VERIFICATION

In order to directly analyze the three different situations when the government does not provide subsidies, only provides subsidies to suppliers or only provides subsidies to platforms, and solve the optimal subsidy strategy and optimal subsidy rate. Assuming: a=200,s=16,γ=12,ϵ=10,e=10,φ=16,c=8. When $t \in 0,0.7$, three kinds of function expression equilibrium solutions exist. The calculation results are shown in Figure 1-5 below.

It can be seen from Figure 1 and 2 that the decision variable value when the government subsidizes the supplier and the platform respectively is greater than the decision variable value when the government does not subsidize. The wholesale price of agricultural products, brand building level, retail price of agricultural products and platform social responsibility level increase with the increase of government subsidy rate. Consistent with corollary 1. Similarly, Corollary 2 describes that the profits of supply chain members when the government subsidize suppliers or platforms are greater than the profits of suppliers and platforms when the government does not subsidize them. As can be seen from the figure below, when the government subsidiizes suppliers, the wholesale price of agricultural products, the level of brand building and the profits of supply chain members of the e-commerce supply chain are higher than the wholesale price of agricultural products, the level of brand building and the profits of each member when the government subsidiizes the platform.

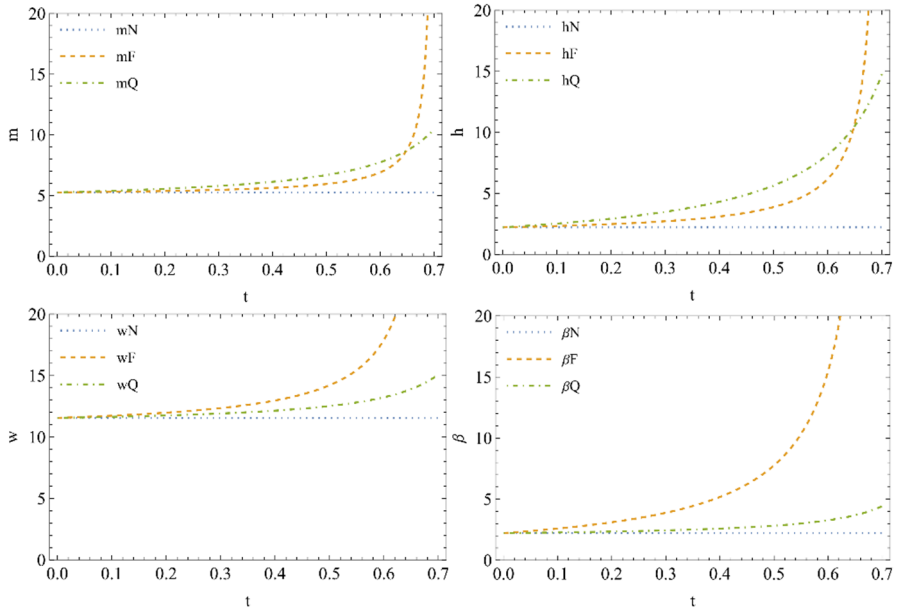

Fig. 1. Comparison of decision variables under the three models

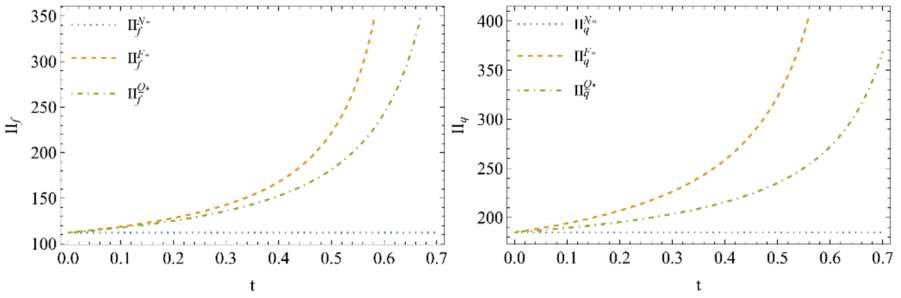

Fig. 2. Profit comparison diagram of each entity under the three models

As can be seen from Figure 3, when the government provides subsidies, increasing the subsidy ratio will lead to an increase in the overall revenue of the e-commerce supply chain, indicating a positive correlation between the two. Moreover, when the government only provides subsidies to suppliers, the total profit of the supply chain system is always higher than that of the e-commerce supply chain when the government provides subsidies to the platform, which is consistent with the description of Inference 3.

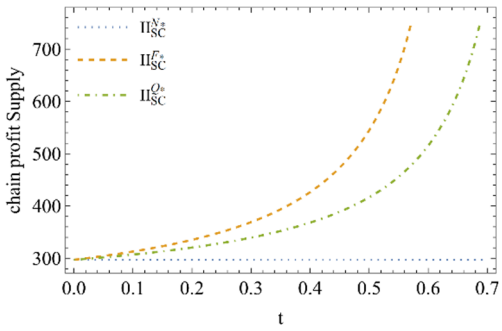

Fig. 3. Changes of supply chain profit with t subsidy rate

Figure 4 shows that under different subsidy conditions, social welfare increases first and then decreases with the change trend of subsidy rate, with a maximum value. When the government subsidizes the supplier, the social welfare reaches the maximum value when t is 0.523077, and when the government subsidizes the platform, the social welfare reaches the maximum value when t is 0.455939. When the government provides subsidies to suppliers, the social welfare can reach the maximum, so it can be concluded that the optimal strategy of the government is to provide subsidies only to suppliers. Same description as Corollary 4.

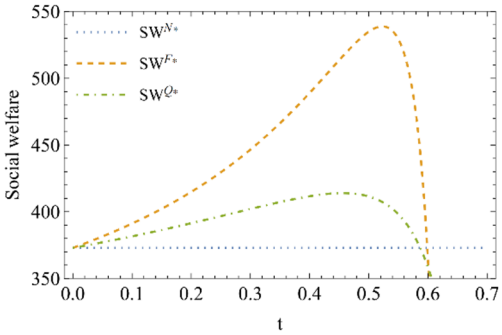

Fig. 4. Changes of social welfare with t

As can be seen from Figure 5, the optimal social welfare can be obtained when the government subsidizes the supplier. When t<0.523077, the social welfare is positively correlated with the subsidy ratio of the government. When t>0.523077, the social welfare is negatively correlated with the subsidy ratio of the government. When t=0.523077, the maximum social welfare is 538.835, which is consistent with the description in inference 5.

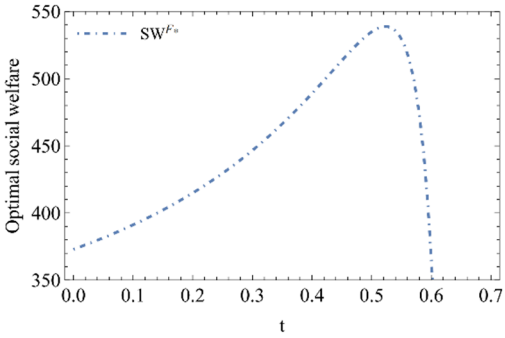

Fig. 5. Changes with t under the optimal subsidy strategy

6 CONCLUSIONS

This paper mainly draws the following conclusions:

(1) When the government only gives subsidies to suppliers, platform marginal profit, product retail price, agricultural product brand building level, level of social responsibility, supplier profit and platform profit increase. The investment in brand building of suppliers is positively correlated with the rate of government subsidies, and government subsidies are conducive to guiding suppliers to strengthen the level of brand building of agricultural products.

(2) Compared with the situation where the government does not subsidize the platform, the government only subsidizes the platform, which increases the product profit, product retail price, supplier brand building level, platform social responsibility level, and supply chain member profit. The social responsibility level of the platform is positively correlated with the government subsidy rate, and the government subsidy encourages the platform to actively undertake more social responsibilities.

(3) The overall benefits of the e-commerce supply chain can be greatest when the government only subsidizes suppliers.

(4) When the government subsidizes, the social welfare increases first and then decreases with the change of the subsidy rate, and there is a unique maximum value that maximizes the social welfare.

(5) The optimal subsidy strategy is that the government only subsidizes the supplier to strengthen the brand building of agricultural products, and the optimal subsidy rate is $t^* = \frac{6s\gamma\varphi - \varphi e^2}{10s\gamma\varphi - s\epsilon^2}$.

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