Research on Hybrid Contract Design of Dynamic Coordination of Fresh Supply Chain

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Abstract

In this study, we assumed that the consumer's needs are not only directly affected by freshness, but also by the indirect influence of freshness and promotion efforts through goodwill, and constructed a dynamic game model of two-level fresh food supply chain under the influence of freshness-keeping efforts and promotion efforts. And on this basis, a compound contract, which combines revenue sharing, cost sharing and price locking mechanisms, is designed to coordinate the fresh food supply chain. The results show that, the compound contract perfectly coordinate the promotion, freshness-keeping and price between the upstream and downstream enterprises in fresh food supply chain, and improve their benefits. The coordination effect is consistent with the effect under centralized decision-making, and is significantly better than the result under decentralized decision-making. Finally, numerical simulations verify the effectiveness of the contract.

Keywords

E-commerce of fresh agricultural product; Freshness-keeping effort; Promotion effort; Compound contract; Supply chain coordination.

1. Introduction

In recent years, with the rapid growth of people's demand for high-quality fresh food, fresh e-commerce has ushered in a rapid development opportunity, and famous fresh e-commerce companies such as “Box Horse Fresh Life”, JD 7FRESH, Suning Tesco “Su Xian-sheng” have emerged. Two reasons have prompted the rapid growth of fresh e-commerce. First, online prices are cheaper than offline supermarkets. Second, high freshness and fast delivery. In order to promote low-priced promotions, many fresh e-commerce companies are engaged in fresh festivals, such as the Autumn Fresh Food Festival of Ali’s “Box Horse Fresh Life” and the 618 Live Fresh Festival of JD Fresh. In order to maintain freshness, large-scale fresh e-commerce companies have invested in the whole process of cold chain technology, such as JD Fresh, Fresh and Fresh. Although the fresh e-commerce platform has achieved rapid growth due to low-cost and fresh-keeping facilities investment, these growths have been exchanged for large losses. According to Xinhuanet, more than 4,000 fresh e-commerce companies nationwide are only 1% profitable, 88% loss, and 7% huge losses. The reason for the loss seems to be low prices, but the more important reason is that the perishable characteristics of fresh products have caused huge losses. According to statistics, the circulation loss rate of fresh produce such as fruits and vegetables in China is as high as 20% to 30%, while that in developed countries is only 1.7% to 5%. It can be seen that only an efficient coordination mechanism is established between the upstream and downstream to reduce the loss and ensure that the end consumers get fresh, high quality and affordable fresh products. In view of the needs of the development of the industry,

this paper explores the coordination of price, preservation and quality control between fresh upstream and downstream enterprises, with a view to contributing to the development of the emerging fresh e-commerce industry.

2. Literature Review

Retailer's promotional investment is an important means of increasing the value of the supply chain. Edelman et al. used the promotion effort perception as a mediator variable to construct two promotion mechanisms to study the impact of promotion efforts on consumers' online purchase behavior[1]. The results show that online promotion efforts have positive effects on consumers' online purchase motivation. Promotions cannot be simple discount sales. Experimental studies by Campbell et al. show that price promotions can undermine consumer perception of product quality[2] . Wang Xinyi and other researches show that the promotion method affects consumers' product quality perception[3]. An experimental study conducted by Konuk found that consumers' perceptions of product quality are influenced by their own promotional preferences[4]. Therefore, fresh retailers need to invest more in promotion and innovation efforts to help consumers improve their awareness of product attributes, enhance customer perception of product value, and satisfy consumers' value appetite for products, thereby enhancing consumer purchases. Willingness to promote purchases. However, if the promotion cost is only borne by the retailer, it will only invest in the promotion resources in the way of maximizing its own interests, and the promotion effort will not be able to reach the optimal level of the entire supply chain. Therefore, it is necessary to study the joint promotion coordination mechanism, so that upstream and downstream enterprises in the supply chain can jointly undertake the promotion cost and optimize the level of promotion efforts.

The fresh supply chain not only needs joint promotion, but also needs to coordinate the preservation investment. Dye et al. constructed a model of deteriorating fresh stocks with time, and studied the impact of fresh-keeping technology investment on sellers' stocks and profits[5]. Hsu et al. constructed the retailer's optimal fresh-keeping investment and inventory decision-making model, showing that the optimal inventory will increase with the increase of fresh-keeping investment[6]. Research by Huang et al. shows that retailers' fresh-keeping investment is not only beneficial to wholesalers but also to producers. This also means that the retailer's fresh-keeping investment based solely on its own profit maximization is usually lower than the overall optimal preservation input of the supply chain[7]. Cao Yu et al. have expanded this and studied the impact of two types of fresh-keeping cost-sharing contracts on the fresh-keeping efforts of fresh suppliers and retailers, indicating that the bilateral cost-sharing mechanism is more motivating the level of preservation efforts of suppliers and retailers[8]. Song et al. proposed a combination contract for preservation cost sharing and revenue sharing to improve the level of fresh-keeping efforts of supply chain members[9]. Wu et al. found that two tariff contracts could help retailers improve their preservation efforts[10]. Gu et al. proposed to realize the preservation and price optimal decision of fresh supply chain through two-way revenue sharing contract[11]. In general, many researchers have carried out research on the field of preservation and put forward some coordination strategies. However, the fresh supply chain also needs to consider the coordination of preservation and promotion investment. At present, there is still a lack of research that considers the coordination of both.

In order to achieve effective coordination of the supply chain, researchers consider a variety of hybrid coordination mechanisms. Su et al. considered the deterioration loss and logistics cost of the fresh agricultural product supply chain in the circulation process, and designed the joint coordination contract model of the fresh supply chain[12]. Wang Daoping considered the two-stage pricing of the fresh supply chain and introduced a contractual mechanism for joint price subsidies and revenue sharing[13]. Yan and others based on the quality problems of product supply, constructed a repurchase contract and revenue sharing coordination contract

mechanism to meet the product supply chain environment[14]. Based on the complex needs of fresh supply chain coordination, including preservation efforts, promotion and price, this study combines the level of preservation efforts, promotion efforts and pricing decisions into the dynamic analysis framework of the fresh supply chain, and studies the mixed coordination strategy for these three. The impact of important factors.

According to the review, although the scholars have studied the coordination of the fresh supply chain in terms of promotion, preservation and pricing, the fresh-keeping supply chain's preservation, promotion and pricing coordination requirements exist simultaneously, and few literature attempts to solve this problem at the same time. several questions. Based on this, this paper constructs a two-level fresh supply chain differential game model, analyzes the optimal fresh-keeping efforts, optimal promotion efforts and pricing decisions under the dynamic game framework, and proposes the three factors that simultaneously realize the fresh e-commerce supply chain. Excellent coordination of the hybrid contract mechanism.

3. Problem Description and Assumptions

3.1. Problem Description

Consider a two-stage fresh supply chain consisting of a fresh supplier and a fresh e-commerce platform. Fresh suppliers will carry out preservation activities by introducing new technologies and upgrading production equipment to reduce the production and sale of fresh products. The quantity loss and quality loss in the process, such as the introduction of fresh-keeping vehicles in the four seasons of Beijing, to shorten the logistics delivery time, research and development of fresh insulation “green flow box” to reduce product quality loss. The fresh e-commerce platform accelerates sales by providing value-added promotions, price promotions, and service promotions for fresh products, and improves the freshness level of products sold. The operation mode of the fresh e-commerce supply chain studied in this paper is shown in Figure 1. The supplier and the fresh e-commerce platform can jointly determine the optimal effort level of the supply chain as a whole, and can also decentralize the optimal effort level of each decision, depending on the coordination contract between the two. Therefore, the work of this paper is to propose a hybrid contract that simultaneously achieves the optimal coordination of the three factors of the fresh electricity supplier supply chain.

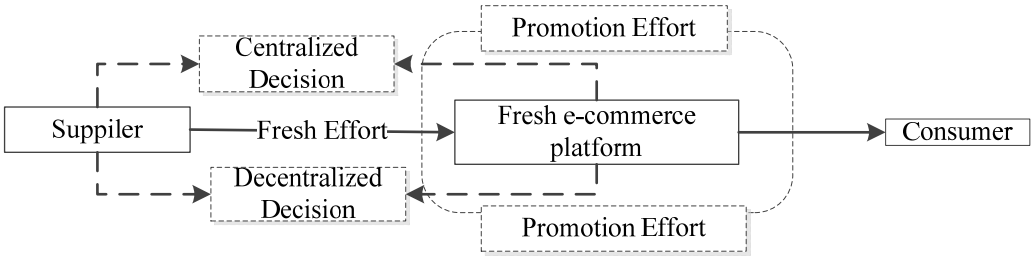

Fig 1. Operation mode of the fresh e-commerce supply chain

3.2. Model Hypothesis

In order to simplify the model and ensure that the research content is close to the actual situation, combined with the existing research literature, the following conditions are assumed.

Hypothesis 1 Referring to the study of the marginal time variation function of freshness by EI Ouardighi et al[15]. This paper sets the product freshness differential model with time decay as:

$$\theta^*(t) = \varepsilon M(t) - \varphi\theta(t)$$

Hypothesis 2 Brand goodwill of fresh products is also positively affected by product freshness and promotion efforts of fresh e-commerce platform. Reference scholars EI and Kogan and other literature, and draw on the deformation of the Ner-love classic goodwill model to represent the marginal function of goodwill[15]. This paper uses the following differential equation to describe the changes in the reputation of fresh e-commerce brands over time[16]:

$$B^{*}(\mathrm{t}) = \lambda E(t) + \mu\theta(\mathrm{t}) - \sigma B(t)$$

Hypothesis 3 By referring to the description of the demand function, it is assumed that the consumer's purchasing behavior is affected by the freshness of fresh products, brand reputation and price. The market demand function of fresh produce is as follows[17-18]:

$$D(t) = (\beta\theta(t) + \kappa B(t))(a - bp(t))$$

Hypothesis 4 Suppose that the supplier's fresh-keeping effort cost and the fresh-selling e-commerce platform's promotion effort cost are the convex functions of the fresh-keeping effort level and the promotion effort level respectively[18-19]. Referring to the practice of most literatures, the supplier's fresh-keeping efforts cost and the promotional effort cost of the fresh e-commerce platform is set to:

$$C_m(t) = \frac{1}{2}\eta_m M(t)^2 \quad , \quad C_r(t) = \frac{1}{2}\eta_r E(t)^2$$

Hypothesis 5 assumes that suppliers and fresh e-commerce platforms make rational decisions based on complete information without time-bound constraints. Assuming that the supplier and the fresh e-commerce platform have the same discount factor $\rho > 0$, the profits of the supplier, the fresh e-commerce platform and the entire supply chain system are respectively π_m, π_r, π_s.

$$\pi_m = \int_0^\infty e^{-\rho t}\left[w(t)D(t) - C_m(t)\right]dt$$

$$\pi_r = \int_0^\infty e^{-\rho t}\left[(p(t) - w(t))D(t) - C_r(t)\right]dt$$

$$\pi_s = \int_0^\infty e^{-\rho t}\left[p(t)D(t) - C_m(t) - C_r(t)\right]dt$$

4. Hybrid Contract Design for Fresh Supply Chain Coordination

References Coordinating the fresh supply chain means that suppliers and e-commerce platforms can achieve optimal preservation efforts, promotion efforts, and pricing, maximizing the total profit of both parties. When the supplier and the e-commerce platform belong to one interest group—that is, the decision is made by a profit maximization subject (centralized decision), the profit maximization decision can always be realized, the optimal coordination is surely achieved. However, if two stakeholders take their own decisions from their own interests, the supply chain will have problems such as double margins and cannot achieve optimal coordination. Based on the model in the previous section, this section first proposes a hybrid

contract, and calculates the results of the respective decisions of the two main bodies in the supply chain under the hybrid contract, and then compares them with the results of centralized decision-making and decentralized decision-making to analyze this Whether the hybrid contract can support the optimal coordination among the enterprises in their respective fresh supply chains.

It has been proved that the supply chain is fully coordinated through joint pricing, revenue sharing and cost sharing, or a combination of the two, but the contract design that combines the three has not been considered. In order to realize the complete coordination of promotion and preservation efforts in the dynamic pricing process of fresh products, this paper designs a contract for the simultaneous implementation of wholesale and retail price fixed ratio, promotion cost sharing and revenue sharing. First, the supplier cooperates with the fresh e-commerce platform to establish a wholesale price discount mechanism, so that the wholesale price is equal to the fixed ratio of the retail price. That is $w = \psi p$, ψ $(0 < \psi < 1)$ is the price discount factor. Secondly, in order to encourage the e-commerce platform to actively promote, the supplier chooses to actively share the promotion cost, and the apportionment ratio is s $(0 < s < 1)$. Finally, the fresh e-commerce platform shares the retail revenue share with the supplier and sets a sharing ratio factor of ϕ $(0 < \phi < 1)$. Under the Coordination Contract (ψ, ϕ, s) , the superscript D is used to represent the three-funded contract mechanism, and the income function of the fresh product supplier and the fresh e-commerce platform is:

$$\begin{cases} \pi_{r\ p,E}^{D} = \int_0^{\infty} e^{-\rho t}\left[(1-\psi+\phi\psi)\,p(\beta\theta+\kappa B)(a-bp)-\frac{1}{2}(1-s)\eta_r E^2\right]dt \\ \pi_{m\ s,M}^{D} = \int_0^{\infty} e^{-\rho t}\left[(1-\phi)\psi\, p(\beta\theta+\kappa B)(a-bp)-\frac{1}{2}\eta_m M^2-\frac{1}{2}s\eta_r E^2\right]dt \end{cases}$$

In order to obtain the equilibrium solution of the differential game, the optimal control solution is used, and the inverse induction method is used to solve the optimal control problem of the fresh e-commerce platform. The optimal value function of the long-term profit of the e-commerce platform after t is $\pi_r^{D^*}(p,E) = e^{-\rho t}V_r^D(\theta,B)$, and $V_r^D(\theta,B)$ satisfies the HJB equation for any $\theta \geq 0$ and $B \geq 0$.

$$\rho V_r^D(\theta,B) = \underset{p,E}{Max}\left[(1-\psi+\phi\psi)\,p(\beta\theta+\kappa B)(a-bp)-\frac{1}{2}(1-s)\eta_r E^2+V_{r\theta}^{D'}(\varepsilon M-\varphi\theta)+V_{rB}^{D'}(\lambda E+\mu\theta-\sigma B)\right]$$

For the right side of the formula $\rho V_r^D(\theta,B)$, the fresh e-commerce platform seeks partial biases for p and E , so that it is equal to zero, and obtains the first-order condition of retail price p and promotion effort level E , which can be solved:

$$p = \frac{a}{2b},\quad E = \frac{\lambda V_{rB}^{D'}}{(1-s)\eta_r}$$

Similarly, the optimal value function of the supplier's profit is $\pi_m^{D^*}(M) = e^{-\rho t}V_m^D(\theta,B)$, and the HJB equation is satisfied for any $\theta \geq 0$ and $B \geq 0$.

$$\rho V_m^D(\theta,B)=\underset{M}{Max}\left[(1-\phi)\psi\, p(\beta\theta+\kappa B)(a-bp)-\frac{1}{2}\eta_m M^2-\frac{1}{2}s\eta_r E^2+V_{m\theta}^{D'}(\varepsilon M-\varphi\theta)+V_{mB}^{D'}(\lambda E+\mu\theta-\sigma B)\right]$$

Find the partial derivative on the right side of equation $\rho V_m^D(\theta,B)$ and make it equal to zero. Obtain the first-order condition about the preservation effort M and solve the problem.

$$M=\frac{\varepsilon V_{m\theta}^{D'}}{\eta_m},\quad s=\frac{2V_{mB}^{D'}-V_{rB}^{D'}}{2V_{mB}^{D'}+V_{rB}^{D'}}$$

Combining equations p/E and M/s, substituting equations $\rho V_r^D(\theta,B)$ and $\rho V_m^D(\theta,B)$.

$$\begin{cases}\rho V_r^D(\theta,B)=(\dfrac{\beta a^2(1-\psi+\psi\phi)}{4b}-\varphi V_{r\theta}^{D'}+\mu V_{rB}^{D'})\theta+(\dfrac{\kappa a^2(1-\psi+\psi\phi)}{4b}-\sigma V_{rB}^{D'})B+\dfrac{\lambda^2 V_{rB}^{D'}(2V_{mB}^{D'}+V_{rB}^{D'})}{4\eta_r}+\dfrac{\varepsilon^2(V_{r\theta}^{D'}V_{m\theta}^{D'})}{\eta_m}\\ \rho V_m^D(\theta,B)=(\dfrac{\beta a^2(1-\phi)\psi}{4b}-\varphi V_{m\theta}^{D'}+\mu V_{mB}^{D'})\theta+(\dfrac{\kappa a^2(1-\phi)\psi}{4b}-\sigma V_{mB}^{D'})B+\dfrac{\varepsilon^2(V_{m\theta}^{D'})^2}{2\eta_m}+\dfrac{\lambda^2(2V_{mB}^{D'}+V_{rB}^{D'})^2}{8\eta_r}\end{cases}$$

According to the structure of formula $\rho V_r^D(\theta,B)$ and $\rho V_m^D(\theta,B)$, the optimal value function of the fresh e-commerce platform and the supplier is based on the linear analytical expressions of product freshness and brand goodwill: $V_r^D(\theta,B)=h_1\theta+h_2B+h_3$, $V_m^D(\theta,B)=k_1\theta+k_2B+k_3$, of which h_1, h_2, h_3 and k_1, k_2, k_3 are undetermined coefficients. Equations $V_r^D(\theta,B)$, $V_m^D(\theta,B)$ and their partial derivatives of freshness θ and brand goodwill B are substituted into equations $\rho V_r^D(\theta,B)$ and $\rho V_m^D(\theta,B)$, respectively, to obtain h_1^*, h_2^*, h_3^* and k_1^*, k_2^*, k_3^*.

Substituting (h_1^*,h_2^*,h_3^*) and (k_1^*,k_2^*,k_3^*) into equations p/E and M/s, respectively, can solve the price under the coordination contract mechanism, the optimal fresh-keeping effort level, and the cost-sharing ratio.

$$p^{D*}=\frac{a}{2b},\quad E^{D*}=\frac{\lambda\kappa a^2(1+\psi-\phi\psi)}{8\eta_r b(\rho+\sigma)}$$

$$M^{D*}=\frac{\varepsilon a^2(1-\phi)\psi}{4\eta_m b(\rho+\varphi)}(\beta+\frac{\kappa\mu}{\rho+\sigma}),\quad s^*=\frac{3\psi-3\phi\psi-1}{1+\psi-\phi\psi}$$

Under this coordination contract, the overall long-term equilibrium and maximum profit of the e-commerce platform, suppliers and supply chain are respectively.

$$\pi_r^{D*}=\frac{(1-\psi+\psi\phi)\theta a^2}{4b(\rho+\varphi)}(\beta+\frac{\kappa\mu}{\rho+\sigma})+\frac{(1-\psi+\psi\phi)B\kappa a^2}{4b(\rho+\sigma)}+\frac{\lambda^2\kappa^2a^4(1-\psi+\psi\phi)(1+\psi-\psi\phi)}{64\rho b^2\eta_r(\rho+\sigma)^2}+\frac{\varepsilon^2a^4(1-\psi+\psi\phi)(1-\phi)\psi}{16\rho b^2\eta_m(\rho+\varphi)^2}(\beta+\frac{\kappa\mu}{\rho+\sigma})^2$$

$$\pi_m^{D*}=\frac{(1-\phi)\psi\theta a^2}{4b(\rho+\varphi)}(\beta+\frac{\kappa\mu}{\rho+\sigma})+\frac{(1-\phi)\psi B\kappa a^2}{4b(\rho+\sigma)}+\frac{\varepsilon^2a^4(1-\phi)^2\psi^2}{32\rho b^2\eta_m(\rho+\varphi)^2}(\beta+\frac{\kappa\mu}{\rho+\sigma})^2+\frac{\lambda^2\kappa^2a^4(1-\psi-\psi\phi)^2}{128\rho b^2\eta_r(\rho+\sigma)^2}$$

$$\pi_s^{D*}=\frac{\theta a^2}{4b(\rho+\varphi)}(\beta+\frac{\kappa\mu}{\rho+\sigma})+\frac{B\kappa a^2}{4b(\rho+\sigma)}+\frac{\varepsilon^2a^4(1-\phi)\psi(2-\psi+\psi\phi)}{32\rho b^2\eta_m(\rho+\varphi)^2}(\beta+\frac{\kappa\mu}{\rho+\sigma})^2+\frac{\lambda^2\kappa^2a^4(3-\psi+\psi\phi)(1-\psi+\psi\phi)}{128\rho b^2\eta_r(\rho+\sigma)^2}$$

5. Study Simulation

The original data of the simulation in this paper is derived from a well-known e-commerce enterprise internship by team members. Since the data involves the confidentiality requirements of the company, the original data is properly processed under the premise of ensuring the validity of the simulation results. Then the adjusted data is used in the simulation of the model study, and then the optimal trajectory and stability value of the product state variables under different decisions are analyzed. The incentive effect of the contract mechanism on the level of fresh-keeping efforts and promotion efforts and the coordination effect of the fresh supply chain are analyzed. Data drawing with software MATLAB R2015a, the model benchmark parameters are as follows: $a=5$; $b=1$; $\varepsilon=0.8$; $\varphi=0.2$; $\lambda=1$; $\mu=0.5$; $\sigma=0.3$; $\beta=0.5$; $\kappa=0.5$; $\eta_m=1$; $\eta_r=1$; $\rho=0.4$; $\theta_0=10$; $B_0=50$. According to assignment of the benchmark parameters, the contract parameter change results under the coordination contract model can be obtained, as shown in Table 1.

Table 1. Optimal returns of EC platforms under the coordination of different contract parameters

Contract parameter			Coordination1		Coordination2		Pareto	
ψ	s	ϕ	π_m^{N*}	π_r^{N*}	π_m^{D*}	π_r^{D*}	$\Delta\pi_m^*$	$\Delta\pi_r^*$
0.95	0.62	0.28	277.2	139.3	378.3	178.2	101.2	38.9
0.90	0.53	0.31	277.2	139.3	343.2	213.3	66.1	74.0
0.85	0.44	0.34	277.2	139.3	309.9	246.5	32.7	107.2
0.80	0.35	0.36	277.2	139.3	282.7	273.5	5.5	134.2

Combined with the conditions of the coordination contract, the total return of the fresh supply chain under the coordination mechanism is 5.562 million yuan, which achieves the overall optimal return of the fresh supply chain when the decision-making situation is concentrated. It is not difficult to find from Table 1. The optimal returns of product suppliers and fresh e-commerce platforms have been improved by Pareto under the contract mechanism, thus achieving the maximization goal of the overall profit of the fresh supply chain.

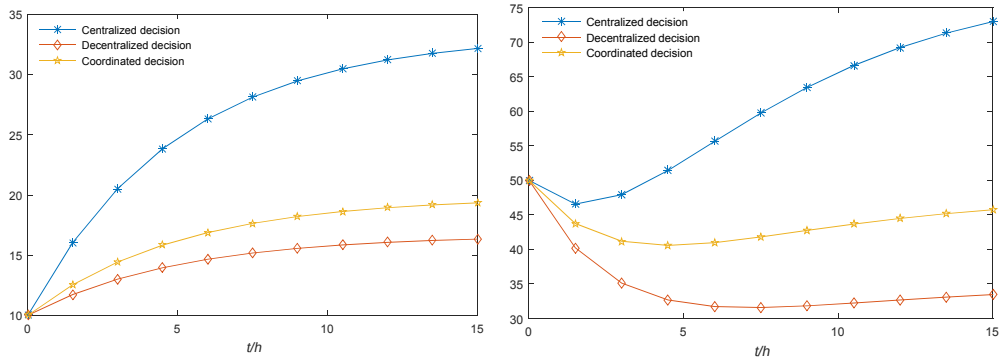

Fig 2. Optimal trajectory of fresh product freshness/fresh brand goodwill

It can be seen from Figure 2 that under different decision-making situations, product freshness and brand goodwill have a stable trend of time, and will gradually approach the stable value with the passage of time. This means that the freshness or fresh brand goodwill deviates from the steady state even if it is disturbed by external factors such as consumer forgetting or technical error, but it can still return to stability over time. In addition, the optimal trajectory of product freshness has a monotonous increase, that is, the consumer's recognition of the e-

commerce platform's fresh-keeping efforts makes it possible to accept the rising price of fresh food within the appropriate range. However, the trend of fresh brand goodwill is to decrease first and then increase, because the brand goodwill is affected by both the fresh-keeping efforts and the promotion efforts. The level of effort invested in different market stages is different, resulting in diversity in its direction of change.

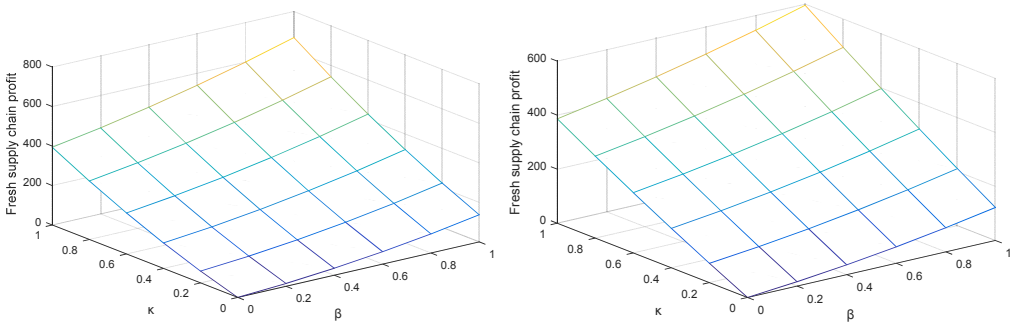

Fig 3. The impact of preference coefficient on the profit of e-commerce platform

It can be seen from Figure 3 that with the increase of consumer brand preference and freshness preference coefficient, the profit of fresh e-commerce platform is increasing, because the level of efforts of fresh e-commerce platform and suppliers is to improve the freshness and quotient of products. The reputational stability value played a positive role. It can be seen from Figure 6 that the freshness of fresh products and the improvement of brand goodwill can increase the profits of both parties, thus stimulating both parties to improve the level of fresh-keeping efforts and promotion efforts. As consumers increase their income and become more mature, their demand for freshness quality will continue to increase. This means that the hybrid contract mechanism will be strengthened as consumers become more mature, and promote more quality inputs such as preservation. Consumers continue to mature and form a benign interaction.

6. Conclusion

The fresh preservation and promotion cooperation between the fresh e-commerce platform and its suppliers is not an important reason for the huge loss of the fresh circulation in China. Based on the purpose of coordinating the fresh-keeping efforts, promotion and price of upstream and downstream enterprises, this paper constructs a two-level fresh supply chain differential game model that directly affects demand and freshness and promotion efforts indirectly affecting consumer demand through goodwill. Based on the model, a hybrid contract including wholesale price linkage with retail price, revenue sharing and promotion cost sharing is proposed. On the basis of model solving, the paper analyzes the optimal level and profit of supply chain under centralized decision, decentralized decision and hybrid contract, and depicts the dynamic trajectory of product freshness and goodwill change with time.

The main conclusions of this study are as follows: (1) The hybrid contract including revenue sharing, promotion cost sharing and fixed price-to-zero ratio can coordinate the upstream and downstream enterprises in the fresh supply chain, and the coordination effect is similar to centralized decision-making; Consumers' sensitivity to freshness and goodwill rises, mixed contracts are more likely to promote preservation and promotion investment, and corporate profits are also more significant; (3) With the improvement of fresh-keeping capacity of upstream and downstream enterprises, the level of profit and profit of enterprises It will also rise. As the consumer's economic income has increased and the demand for fresh-keeping has been further improved, it is recommended that fresh-supply chain companies adopt a hybrid

cooperation contract to further enhance coordination in the preservation of fresh-keeping investment and promotion efforts, and improve the business results of the company.

In this paper, the research on the coordination problem of fresh supply chain is still relatively preliminary. The impact of freshness on the demand function itself, the interaction between promotion and freshness, and the discussion of multiple suppliers and e-commerce platforms have not been specifically considered. The issue of cooperative competition can be used as a follow-up research question.

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