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The pricing decision strategy of value-added services in two-stage supply chain with e-commerce platform

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Abstract: The homogenization of products has caused e-commerce platform merchants to provide differentiated services to consumers through value-added services, in order to enhance the competitiveness of the market. Introduce the value-added service level factor in the e-commerce environment, consider the impact of e-commerce platform merchants providing value-added services on supply chain pricing, construct a secondary supply chain for manufacturers and e-commerce platform merchants, and compare and analyze centralized decision-making supply chains and dispersion decision-making supply chain pricing decisions. The simulation analysis shows that the increase of the value-added service level coefficient in a certain range has a positive stimulation effect on the product pricing of the e-commerce platform. Centralized decision-making supply chain and decentralized decision-making supply chain have a critical value for product pricing, and centralized decision-making supply chain is more sensitive to value-added services.The impact of the value-added service level on the overall profit of the centralized decision-making supply chain is less than the overall profit of the decentralized decision-making supply chain.

Keywords: Pricing decisions, Value-added services, Centralized decision making, Decentralized decision making

1. INTRODUCTION

With the increasingly fierce market competition and the shortened product life cycle [1], the sales model of enterprises has undergone major changes, and more and more enterprises tend to sell products through e-commerce platforms. Merchants of the e-commerce platform realized that in addition to the quality and price of the product itself, by providing differentiated value-added services, the utility of the consumer can be improved, thereby winning greater profits [2]. The homogenization of various similar products is becoming more and more serious. Merchants increase market competitiveness through value-added services. More and more enterprises mean the importance of value-added services. For example, Jingdong Mall announced the launch of the “211” time-limited service in 2010. In the same year, Jingdong’s sales exceeded 10 billion, an increase of 150% from 2009.

2. LITERATURE REVIEW

Many businesses are aware of the importance of value-added services, but they don't know much about how value-added services affect consumers' choices and incentives. A large number of scholars study its impact on product pricing from the perspective of consumer behavior, sales channels, product performance. Cohen and Whang [3] constructed a product lifecycle model that examined the competition decision-making issues between manufacturers and independent service providers regarding after-sales service quality and price; Based on strategic consumer behavior between Nairp [4] and Levin [5], The dynamic pricing problem of retailers' products is studied from the perspectives of monopoly and competition. Du et al.[6]considering the strategic consumer risk

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appetite and decreasing willingness to pay, studied and analyzed the price compensation strategy that can alleviate the consumer behavior of the strategy and the applicable conditions of this strategy. Liu et al. [7] and Prasad et al. [8] studied the dynamic pricing of differentiated products in the presence of strategic consumers. The former studies the multi-stage dynamic price competition of strategic consumers from the perspective of product vertical differentiation. The latter assumes that both strategic consumers and short-sighted consumers exist simultaneously. Based on two-stage dynamic pricing, two different pricing methods are studied. Manufacturers opening network direct sales channels will inevitably affect the profits of related retailers, resulting in channel conflicts and affecting retailers' order enthusiasm. Zhao Lianxia and Cheng Mingbao studied the pricing strategy of manufacturers not opening up direct marketing and open network direct sales channels when making profit sharing[9]. Liu Xinmin [10] and others proceeded from consumer satisfaction, considering consumers' heterogeneous preferences for green products, and constructing a three-way dynamic game model involving manufacturers, retailers and consumers. Analyze the impact of consumer sensitivity on price and greenness on consumer satisfaction and vendor pricing decisions.

At present, most scholars are priced to influence the pricing decisions of products, and it is easy to ignore the influence of intangible factors on product pricing decisions. This paper introduces the value-added service level factor in the e-commerce environment, and considers the impact of e-commerce platform merchants providing value-added services on supply chain pricing. In summary, in the e-commerce environment, this paper constructs a secondary supply chain consisting of manufacturers and e-commerce platform merchants, and builds a demand function for the value-added service level of e-commerce platform merchants. Contrasting and analyzing the strategies of optimal pricing and value-added service levels of each entity under centralized decision-making and decentralized decision-making.

3. PROBLEM DESCRIPTION AND PARAMETER ASSUMPTION

Two-stage supply chain based on a manufacturer(M) and an e-commerce platform merchant(R). Typically, manufacturers provide goods to e-commerce platform merchants, while e-commerce platform merchants provide consumers goods with value-added services through e-commerce platforms. Merchants stimulate market demand by providing value-added services, which brings the cost of value-added services $C(S)=\frac{1}{2}\eta s^2$ [11].The product demand function [12,13,14] with value-added services can be represented by $Q=D-\alpha P+\beta s$, and the product demand function without value-added services can be represented by $Q=D-\alpha P$. Since the product pricing issue is considered in the text, there is no shortage of goods. Assuming information is Shared in the supply chain, e-commerce platform merchants and manufacturers are ideal individuals whose risk appetite is neutral [15].Because each individual in the supply chain is for profit, the unit cost per manufacturer for producing a commodity is c , and the e-commerce platform purchases the product at the wholesale price ω and then sells it to the consumer at the price p . So there is $p>\omega>c$. The relevant parameter symbols are shown in Table 1.

Table 1. Parameter description

symbol	meaning	symbol	meaning
D	Basic consumer demand for products on e-commerce platforms	S_1	Product value-added service level under centralized decision supply chain
α	Consumer sensitivity to price	S_2	Product value-added service level under decentralized decision-making supply chain

β	Consumer sensitivity to value-added services	π_{11}	The overall profit of the supply chain under the centralized decision of value-added services
η	E-commerce platform to increase the cost coefficient of value-added services	π_{12}	The overall profit of a centralized decision-making supply chain without value-added services
p_{11}	Product pricing under a centralized decision-making supply chain with value-added services	π_{21}	The overall profit of a decentralized decision-making supply chain with value-added services
p_{12}	Centralized decision-making supply chain product pricing without value-added services	π_{22}	The overall profit of a decentralized decision-making supply chain without value-added services
p_{21}	Decentralized decision-making supply chain product pricing with value-added services	π_{2M_1}	Profits of decentralized decision-making supply chain manufacturers with value-added services
p_{22}	There is no value-added service decentralized decision-making supply chain product pricing	π_{2M_2}	Decentralized decision-making supply chain manufacturer's profit without value-added services
ω_1	Wholesale price of products under centralized decision supply chain	π_{2R_1}	Profits of e-commerce platforms in providing value-added services under decentralized decision-making
ω_2	Wholesale price of products under decentralized decision supply chain	π_{2R_2}	Profits of e-commerce platforms without value-added services under decentralized decision-making

4. CENTRALIZED DECISION-MAKING SUPPLY CHAIN E-COMMERCE PLATFORM MERCHANT PRICING STRATEGY

In the centralized decision-making supply chain, manufacturers and e-commerce platform merchant are seen as a whole, and strive to maximize the profit of the supply chain. At this time, the biggest profit of the supply chain is to seek the maximum profit of the supply chain as a whole [16].

4.1 Centralized decision-making supply chain pricing strategy with value-added services

When e-commerce platform merchants provide value-added services, the overall profit function of the supply chain is $\pi_{11}=(p_{11}-c)Q-c(s_1)=(p_{11}-c)(D-\alpha P_{11}+\beta s_1)-\frac{1}{2}\eta {s_1}^2$.

According to the backstepping method,the optimal pricing of the e-commerce platform merchants in the centralized decision-making supply chain is $p_{11}^*=\frac{\eta D+c(\alpha\eta-\beta^2)}{2\alpha\eta-\beta^2}$, and the optimal value-added service level is $s_1^*=\frac{\beta(D-\alpha c)}{2\alpha\eta-\beta^2}$.

Substituting $p_{11}^*=\frac{\eta D+c(\alpha\eta-\beta^2)}{2\alpha\eta-\beta^2}$ and $s_1^*=\frac{\beta(D-\alpha c)}{2\alpha\eta-\beta^2}$ into π_{11} yields the optimal profit under the centralized decision-making supply chain:

$$\pi_1=\frac{\eta(D-\alpha c)^2}{2(2\alpha\eta-\beta^2)} \quad (1)$$

4.2 Centralized decision-making supply chain pricing strategy without value-added services

When the e-commerce platform merchant does not provide value-added services, the overall profit function

of the supply chain is $\pi_{12}=(p_{12}-c)Q=(p_{12}-c)(D-\alpha P_{12})$.

According to the backstepping method,The optimal pricing of products for e-commerce platform merchants in a centralized decision-making supply chain without value-added services is $p_{12}^{*}=\frac{\alpha c+D}{2\alpha}$.

At this point, bring $p_{12}^{*}=\frac{\alpha c+D}{2\alpha}$ into π_{12}, and get the optimal profit of the electronic platform merchant when there is no value-added service.

$$\pi_{12}^{*}=\frac{(D-\alpha c)^{2}}{4\alpha} \quad (2)$$

5. DECENTRALIZED DECISION-MAKING SUPPLY CHAIN E-COMMERCE PLATFORM MERCHANT PRICING STRATEGY

In the decentralized decision-making supply chain, manufacturers and e-commerce platform merchants are independent individuals, with the goal of maximizing their respective interests. In this case, manufacturers sell products to e-commerce platforms at wholesale prices ω_2 based on production costs, expected market demand and expected returns. At this point, e-commerce platform merchants conduct price analysis based on expected revenue and market demand and value-added service cost to determine whether the price is reasonable. If accepted, the agreement is reached; otherwise, the manufacturer re-quotes until the parties reach an agreement.

5.1 Decentralized decision-making supply chain pricing strategy with value-added services

When an e-commerce platform merchant provides value-added services, the profit function of the e-commerce platform merchant is:

$$\pi_{2R_1}=(p_{21}-\omega_2)Q-c(s_2)=(p_{21}-\omega_2)(D-\alpha P_{21}+\beta s_2)-\frac{1}{2}\eta {s_2}^{2} \quad (4)$$

According to the backstepping method, in decentralized decision-making supply chain, when the wholesale price is ω_2, the optimal pricing for the product is $p_{21}^{*}=\frac{\eta D+\omega_2(\alpha\eta-\beta^2)}{2\alpha\eta-\beta^2}$, and the optimal value-added service level is $s_2^{*}=\frac{\beta(D-\alpha\omega_2)}{2\alpha\eta-\beta^2}$.

From this we can get $\pi_{2R_1}=\frac{\eta(D-\alpha\omega_2)^2}{2(2\alpha\eta-\beta^2)}$.

According to the agreement reached between the manufacturer and the e-commerce platform merchants under the decentralized decision-making supply chain, the profit function of the manufacturer can be obtained when the e-commerce platform merchant provides value-added services:

$$\pi_{2M_1}=(\omega_2-c)Q=(\omega_2-c)(D-\alpha P_{21}+\beta s_2) \quad (5)$$

Substituting p_{21}^{*} and s_2^{*} into equation (4) gives the manufacturer the maximum profit:

$$\pi_{2M_1}=\frac{\alpha\eta(\omega_2\text{-}c)(D-\alpha\omega_2)}{2\alpha\eta-\beta^2} \quad (6)$$

The optimal profit of the supply chain under decentralized decision is:

$$\pi_{21}=\pi_{2R_1}+\pi_{2M_1}=\frac{\eta\left(D-\alpha\omega_2\right)^2}{2\left(2\alpha\eta-\beta^2\right)}+\frac{\alpha\omega_2\left(\eta-c\right)\left(D-\alpha\omega_2\right)}{2\alpha\eta-\beta^2}=\frac{\left(D-\alpha\omega_2\right)\left(\eta D+\alpha\omega_2\eta-2\alpha\omega_2 c\right)}{2\left(2\alpha\eta-\beta^2\right)} \tag{7}$$

5.2 Decentralized decision-making supply chain pricing strategy without value-added services

When the e-commerce platform merchant does not provide value-added services, the profit function of the e-commerce platform merchant is: $\pi_{2R_2}=\left(p_{22}-\omega_2\right)Q=\left(p_{22}-\omega_2\right)\left(D-\alpha P_{22}\right)$

According to the backstepping method, In decentralized decision-making supply chain, e-commerce platform merchants do not provide value-added services. When the wholesale price is ω_2, the optimal pricing of the e-commerce platform merchant for the product is $p_{22}^*=\frac{D+\omega_2\alpha}{2\alpha}$.

From this we can get $\pi_{2R_2}^*=\frac{\left(D-\alpha\omega_2\right)^2}{4\alpha}$.

According to the agreement reached between the manufacturer and the e-commerce platform merchants under the decentralized decision-making supply chain, the profit function of the manufacturer when the e-commerce platform merchant does not provide value-added services is:

$$\pi_{2M_2}=\left(\omega_2-c\right)Q=\left(\omega_2-c\right)\left(D-\alpha p_{22}\right) \tag{8}$$

Substituting p_{22}^* into π_{2R_2} gives the manufacturer the maximum profit:

$$\pi_{2M_2}=\frac{\left(\omega_2-c\right)\left(D-\alpha\omega_2\right)}{2} \tag{9}$$

The optimal profit of the supply chain under decentralized decision-making is:

$$\pi_{22}=\pi_{2R_2}+\pi_{2M_2}=\frac{\left(D-\alpha\omega_2\right)\left(D+\alpha\omega_2-2\alpha c\right)}{4\alpha} \tag{10}$$

6. CENTRALIZED DECISION-MAKING AND DECENTRALIZED DECISION-MAKING SUPPLY CHAIN SIMULATION ANALYSIS

Assume that the basic market demand $D=200$ of a certain commodity of an e-commerce platform, the sensitivity coefficient of the sales price and the value-added service level are $\alpha=10,\beta=5$, The value-added service cost coefficient of e-commerce platform merchants is $\eta=10$. The manufacturer's unit cost of the product $c=5$, the wholesale price ω_1=8, ω_2=9. This is the case $2\alpha\eta$-β^2=175f 0, and Table 2 can be derived from this.

Table 2. Centralized decision-making supply chain and decentralized decision-making supply chain numerical calculation results

mode	p	s	Q	π
Value-added service centralized decision-making supply chain	13.6	4.3	85.5	642.9
Value-added service decentralized decision-making supply chain	15.2	3.1	63.5	628.6
no value-added service centralized decision-making supply chain	12.5	——	75	562.5
no value-added service decentralized decision-making supply chain	14.5	——	55	522.5

6.1 Analysis on the influence of value-added service level coefficient β

There is a critical value $\beta=\sqrt{\alpha\eta}$ between the centralized decision-making supply chain and the decentralized decision-making supply chain for the pricing of e-commerce platform merchants. When $\beta > \sqrt{\alpha\eta}$, the optimal pricing of the e-commerce platform merchants in the decentralized decision-making supply chain is higher than the centralized decision-making supply chain; when $\beta < \sqrt{\alpha\eta}$, the e-commerce platform in the centralized decision-making supply chain is optimally priced for the product is higher than the decentralized decision-making supply chain, as shown in Figure 1. The increase of the value-added service level coefficient has a certain positive stimulation effect on the value-added service level of e-commerce platform products, and the centralized decision-making supply chain is more sensitive to the increase of the value-added service level coefficient, as shown in Figure 2.

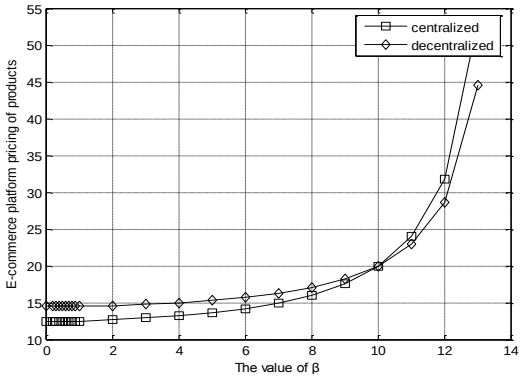

Figure 1. The impact of β on the pricing of e-commerce platforms

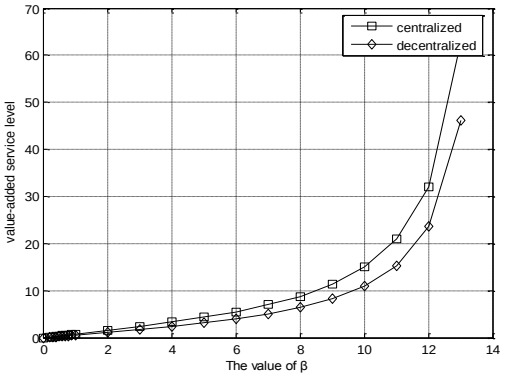

Figure 2. The impact of β on the value of value-added services

6.2 Influence of β on the overall profit of supply chain

When $\beta > 2\sqrt{\alpha\eta}$, with the increase of the value-added service level coefficient, the overall profit of the supply chain is also increasing. This shows that when the consumer's shopping demand is significantly affected by the value-added service level of the e-commerce platform products, improving the value-added service level can improve the overall profit of supply chain, but the increase in value-added service levels means that products that require e-commerce platforms will bring greater value-added service costs, which will lead to a decline in the profit of the supply chain, and even a state of loss, as shown in Figure 3.For the decentralized supply chain overall profit level difference, within a certain interval, as the value of β increases, the difference gradually increases, but when $\beta < 2\sqrt{\alpha\eta}$, the overall profit level of the supply chain will have a negative value. For the overall profit of the centralized decision-making supply chain, the presence or absence of value-added services is not much different from the overall profit of the supply chain, as shown in Figure 4.

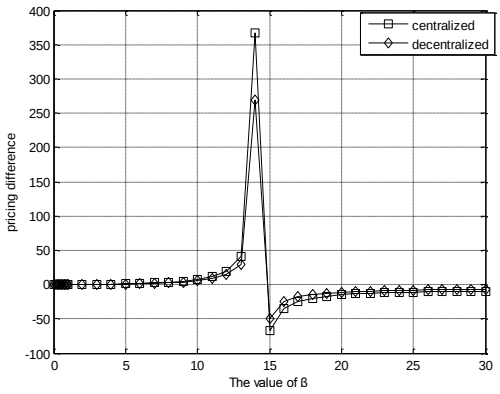

Figure 3. The impact of β on the overall profit of the supply chain

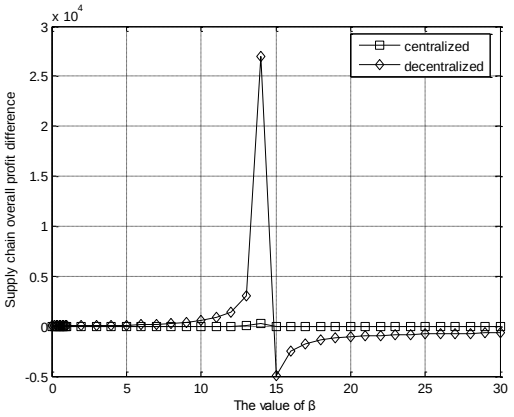

Figure 4. Effect of the presence or absence of β on the overall profit margin of the supply chain

7.SUMMARY

Providing value-added services to products is an important means for enterprises to achieve differentiated competition. In the increasingly fierce market competition, differentiated value-added services play an increasingly important role in the product sales process. By studying the pricing strategies of centralized decision-making supply chain and decentralized decision-making supply chain, the relevant conclusions are as follows:(1) There is a critical value for the centralized decision-making supply chain and the decentralized decision-making supply chain optimal pricing decision. When $\beta > \sqrt{\alpha\eta}$, At this time, the centralized decision-making supply chain pricing strategy is better; when $\beta < \sqrt{\alpha\eta}$, At this time, the decentralized decision-making supply chain pricing strategy is better.(2)The existence of value-added service level, the overall pricing difference of the centralized decision-making supply chain influence is less than the overall pricing difference of the decentralized decision-making supply chain.(3) When $\beta > 2\sqrt{\alpha\eta}$, the overall profit of the centralized decision-making supply chain and the decentralized decision-making supply chain is on the rise. When $\beta < 2\sqrt{\alpha\eta}$, the overall profit of the centralized decision-making supply chain and the decentralized decision-making supply chain will plummet. There are even cases of negative values. In the establishment of the consumer demand function, this paper assumes that there is a clear linear relationship between demand and price and value-added service level. However, in real life, there are many uncertainties, so in the next research, we will consider supplying in an uncertain environment chain synergy.

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