Research on Pricing Strategy of Dual-Channel Supply Chain Based on Customer Value and Value-Added Service

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Abstract: Considering customer value and value-added services provided by the online retail platform, this paper studies the differential pricing of a dual-channel supply chain consisting of one manufacturer and one online retail platform. Taking customer value into account in the dual-channel supply chain, this paper constructs separate and unified pricing of the direct sales channel and online retail platform’s distribution channel, and discusses each pricing model under a decentralized decision scenario and centralized decision scenario respectively. The results show that the total profit of a supply chain under the centralized decision scenario is better than the decentralized decision scenario in different ways, and the customer value of the two channels is also higher. Compared with the unified pricing of the two channels, the profit of the manufacturer is larger while the profit of the online retail platform is smaller under the separate pricing of the two channels. Moreover, the benefit of value-added services remains important to maximize the profit of the online retail platform and the customer value at the same time. Whether it is under separate pricing or unified pricing of the two channels, the antinomies effect always exists between the customer value and the profit per unit product. In order to further improve each party’s profit in the dual-channel supply chain under the decentralized decision scenario, it is necessary to improve the customer perception of profit as much as possible, and reduce the customer perception of loss as much as possible.

Keywords: customer value; value-added services; dual-channel supply chain; online retail platform; differential pricing

1. Introduction

With the increasingly mature online retail market and the vigorous development of the internet economy, e-commerce, online shopping, and consumption have gradually become the first choice of contemporary consumers. Especially since the outbreak of the COVID-19 pandemic this year, people cannot go out often in the face of the epidemic, and can only “stay” at home. Therefore, people’s online shopping habits have been further strengthened. Suning.com data shows that, during the epidemic, in addition to the rapid growth in demand for medical and disinfection supplies, the sales of instant fast food, fresh fruits, women’s cosmetics, casual snacks, digital products, children’s toys, fitness equipment, furniture, and home appliances all increased. At the same time, with customers’ growing preferences for online consumption, online retail platforms have played an increasingly important role in online shopping.

In order to cater to consumers’ online consumption needs and increase their own product market share, more and more manufacturers choose to march into and earn a place in large-scale online retail platforms to carry out online direct sales. At the same time, based on the huge advantages of online retail platforms (such as targeted advertising, higher advertising efficiency, etc.), more and more manufacturers are also actively constructing distribution channels for online retail platforms, relying on its edges for product sales. The employed “manufacturer direct sales plus online retail platform distribution” model can further expand sales channels and increase sales of its own products.
In addition, the prosperity of the e-commerce economy has brought huge dividends to many online retail platforms, while it has also led to more cut-throat competition among online retail platforms. At the same time, the continuous development of economy has seen higher level of consumption of customers and more diversified demands. Consumers not only focus on the quality and price of the product itself, but also pay attention to the experience of the consumption process, especially the service level. In order to maximize the acquisition of potential consumers, more and more online retail platforms choose to provide customers with value-added services. The value-added services refer to providing unconventional and personalized services while ensuring basic services. For example, Tmall Mall offers four types of after-sales value-added services, including “remote service”, “national warranty”, “electrical insurance package”, and “extended warranty” for customers who purchase electronic products. In addition to the above four value-added services, JD.com also provides door-to-door services with its own characteristics.

As the development momentum of the modern supply chain has gradually shifted from producer-driven to consumer-driven, and the development direction is shifted from commodity-oriented to service-oriented, more and more online retail platforms provide customers with diversified value-added services to meet the needs of different customers, with an aim to enhance customer value and attract potential consumers. Therefore, in a customer value-oriented market environment, addressing an issue that needs to be solved urgently, while maximizing the profits of both parties, manufacturers and online retail platforms should choose a pricing method and how to adjust their own value-added services to maximize customer value.

The theoretical significance of this paper is that since few studies integrate value-added services into customer value and closely link the two to discuss the pricing decisions of manufacturers and online retail platforms, this paper investigates in-depth the differential pricing and unified pricing strategies of dual-channel supply chains in consideration of customer value and value-added services of online retail platforms. Therefore, this paper enriches the content of the dual-channel supply chain decision-making research. The practical significance of this paper is that based on the service-oriented and customer-oriented market environment, that online retail platforms provide high-quality value-added services to increase customer value and attract potential customers has become an important means for enhancing market competitiveness. In this context, this paper has launched a research on the different pricing methods of the supply chain composed of manufacturers and online retail platforms from the perspective of value-added services and customer value, and the conclusions of the research can provide manufacturers, online retail platforms and supply chains consultants with some useful suggestions to choose suitable pricing methods and make pricing decisions.

Based on the above background and research purpose, this paper studies the pricing methods of manufacturers and online retail platforms considering customer value and online retail platforms’ value-added services. We are mainly committed to solving the following issues:

Considering the customer value and online retail platforms’ value-added services, what are the optimal pricing decisions of the manufacturer and the online retail platform under separate pricing and unified pricing these two different pricing methods? What is the difference between the optimal decisions under centralized and decentralized decision scenarios under separate pricing and unified pricing methods? How does online retail platforms’ value-added service affect the profits of supply chain members and the customer value?

How does online retail platforms’ value-added service affect the pricing strategies, the profits of supply chain members, and the customer value? What are the differences under different decision scenarios?

How do the customer perception of profit and the customer perception of loss affect the pricing strategies, the profits of supply chain members? What are the differences under different decision scenarios?
The main contributions of this paper are as follows.

Firstly, this paper discusses the optimal pricing decisions of manufacturers and online retail platforms comprehensively considering of the customer value and value-added services of online retail platforms. At present, few studies integrate value-added services into customer value and closely link the two to discuss the pricing decisions of manufacturers and online retail platforms in the dual-channel supply chain.

Secondly, this paper solves the optimal pricing decisions of manufacturers and online retail platforms under four decision scenarios of the separate pricing and the unified pricing methods. The conclusions reveal different pricing methods, different decision scenarios, the value-added services, the perception of customer gains and losses on both parties’ optimal pricing strategies, different channel demand and customer value, the profits of both parties, and the overall profit of the supply chain.

Finally, based on the research hypothesis, combined with the actual situation and reference to the previous related literature, this paper conducts the simulation analysis, which clearly shows the impacts of value-added services value, customer benefit perception, and customer loss perception on equilibrium results.

The rest of this paper is organized as follows. In Section 2, we summarize the related literature. In Section 3, we present the description of the model. In Section 4, we analyze centralized decision-making model and decentralized decision-making model based on separate and unified pricing the two channels. In Section 5, we compare models in different situations. In Section 6, we do a simulation analysis. In Section 7, we summarize and put forward some suggestions for dual-channel supply chain.

2. Literature Review

Since the 1980s, customer value theory has been a hot topic for many scholars. Measuring customer value from the different connotations of customer value is essential to the development of customer value. Lapierre [1] puts forward the measurement of customer value. The customer benefits mainly include product value factors and service value factors, while customer losses only include price factors, time and effort factors, and mismatch factors. However, in different industries, these value influencing factors have subtle differences. This view has been recognized by many scholars who study customer value, such as Bai and Liao [2], Zeithaml [3], and Kotler [4]. According to Porter’s value chain theory, customer value, as a part of the supply chain value chain, should explore the impact of customer value on the supply chain from the perspective of supply chain management. Chun and Xiu [5] analyzed the mechanism of customer value creation under supply chain management. Starting from the theory of customer value innovation, Zhou [6] analyzed the cost control of embedded partnerships and the cross-organizational cost control of information sharing. Zhou and Zhou [7] discussed the impact of changes in innovation investment coefficients brought about by information technology on customer value. Luo and Chen [8] studied the influence of customer value and power structure on supply chain product selection and pricing decisions. Mishra et al. [9] studied the customer value creation of a closed-loop supply chain led by circular economy. Wang and Song [10] studied the impact of money-back guarantee and customer value on the dual-channel supply chain.

With the increasingly fierce market competition, more and more online retail platforms expand product channel demand by providing value-added services to attract potential customers, enhance channel competitiveness. At present, many scholars have studied the value-added services strategies of the supply chain, such as Liu and Yang [11], Dou [12], Zhang et al. [13], Tang [14], Simple and Liang [15], Pan et al. [16], etc. While considering value-added services, the issue of pricing is studied. Luo et al. [17] studied the impact of the manufacturer’s product value-added services on the manufacturer’s dual-channel supply chain pricing strategy. Lin and Chen [18] studied the game model between a manufacturer providing value-added services and two competing suppliers. Li and Li [19] discussed the coordination of the manufacturer’s dual-channel supply chain in the context of retailers’
fairness concerns and the provision of value-added services. Wang et al. [20] studied the
game model of duopoly enterprises providing value-added services. For the situation that
both channels provide value-added services, Shang guan et al. [21] studied the impact
of online channel value-added services on the member companies of the supply chain.
Dan et al. [22] studied the dual-channel supply chain game model of free value-added
services. Gamchi and Torabi [23] discussed the impact of customer risk attitudes and value-
added services on the decision-making of dual-channel supply chain members. Yan and
Li [24] studied the impact of personalized value-added services on cross-channel services.
Hong et al. [25] discussed the impact of value-added services in the remanufacturing supply
chain on the profit and optimal decision-making of supply chain members. Liu et al. [26]
analyzed the impact of preservation efforts and value-added services on the optimal
decision of all parties in the supply chain.

The issue of pricing decision-making in dual-channel supply chains has always been
a hot topic of research. In previous studies, scholars mainly studied and analyzed the
separate pricing of dual-channel supply chain. For example, Kong et al. [27] studied
the impact of BOPS effect on different pricing strategies in a dual-channel supply chain.
Qin et al. [28] studied how a trade credit policy influences different pricing strategies for
dual-channel supply chain. Although there are relatively fewer studies on the issue of
dual-channel unified pricing, they have gradually received attention from scholars in recent
years. For example, Liu et al. [29] studied the impact of manufacturers’ unified pricing and
channel selection based on retail price markup strategies on dual-channel supply chains.
Wang and Yang [30] discussed the impact of retailers’ unified pricing on all parties in the
supply chain under the background of competition between two chains. Niu et al. [31]
studied the impact of retailers’ online and offline price strategy on the profit of each node
in the supply chain under fair preference. Ji et al. [32] found that under the unified pricing
and differential pricing strategies, the repurchase contract does not affect the optimal
pricing and return strategy. Liu et al. [33] studied the promotion and coordination strategy
of dual-channel supply chain under the unified pricing of manufacturers. Based on the
assumption that uniform pricing increases customer demand and reduces operating costs,
Cai et al. [34] analyzed the impact of uniform pricing on the profits of all parties in the
supply chain.

Through combing and summarizing the above literature, it can be found that many
scholars agree that customer value is a trade-off between customer gains and customer
losses, and some studies integrate customer value into a dual-channel supply chain game
model. Based on previous studies, some scholars have integrated customer value into
the supply chain model, but no scholars have yet integrated value-added services of
online retail platform into customer value. Some scholars have studied value-added
services provided by retailers and compared separate pricing and uniform pricing methods
of two channels, but they did not consider the customer value. Therefore, from the
perspective of customer value, this paper considers the impact of value-added services on
customer value. When manufacturers open direct sales channels, online retail platforms
provide value-added services, and the two channels compete based on customer value,
in this context, do manufacturers adopt unified pricing or separate pricing methods to
ease price competition between two channels? In view of this, this paper discusses the
optimal pricing decisions of manufacturers and online retail platforms in the four decision-
making scenarios of the separate pricing of the two channels under decentralized decision-
making and centralized decision-making, the unified pricing of the two channels under
decentralized decision-making and centralized decision-making, revealing different pricing
methods. Under different decision-making situations, the value-added services of the
online retail platform, the perception of customer gains and losses on both parties’ optimal
pricing strategies, different channel demand and customer value, the profits of both parties
and the overall profit of the supply chain, are expected to be effective in the e-commerce
economic environment. Manufacturers and online retail platforms choose appropriate
pricing methods to increase channel customer value, expand the demand for channel products, and provide a useful reference for increasing the profits of both parties.

3. Problem Description and Assumptions

This paper considers a two-level supply chain system composed of a manufacturer and an online retail platform. The specific structure is shown in Figure 1.

![Figure 1. Value-added service model of online retail platform in the dual-channel supply chain.](image)

The manufacturer sells products to customers through an online direct sales channel and an online distribution channel of the online retail platform. Customers can freely choose any channel to purchase products, and their decision is based on the value gained through the channel, that is, the higher the value customers obtain in the channel, the more customers are willing to buy products in that channel. To facilitate the following study, some assumptions are made below:

1. When the two channels are priced separately, the customer value of the direct sales channel is $CV_d = CB_d - CS_d$, the customer perceived gain is $CB_d = f_b v$, the customer perceived loss is $CS_d = f_b p_d$, the customer value of the online distribution channel of the online retail platform is $CV_e = CB_e - CS_e$, the customer perceived gain is $CB_e = f_b (v + v_e)$, the customer perceived loss is $CS_e = f_b p_e$, $v$ indicates the value of value-added services provided by the online retail platform, $v_e$ indicates product value, $f_b > 0$ indicates customer benefit perception, $f_b > 0$ indicates customer loss perception, $p_d$ indicates the sales price for the manufacturer’s online direct sales channel, $p_e$ indicates the sales price for the online distribution channel of the online retail platform, in particular, when the two channels have unified pricing, there is $p_e = p_d = p$.

2. Suppose the product market demand function is a linear function, and the product market demand is affected by customer value, so the product demand function of the manufacturer’s direct sales channel can be obtained as $Q_d = a_d + \lambda_1 CV_d - \lambda_2 CV_e$, the product demand function of the online distribution channel is $Q_e = a_e + \lambda_1 CV_e - \lambda_2 CV_d$, $\lambda_1 > 0$ is the channel customer value elasticity coefficient, $\lambda_2 > 0$ is the elastic coefficient of cross-channel customer value, apparently, there is $\lambda_1 > \lambda_2$, $a_d > 0$, $a_e > 0$ are the basic market demand for products of the manufacturer’s direct sales channel and online retail platform distribution channel.

3. The online retail platform will provide value-added services to customers, refer to the research Dan (2017) [22], suppose the input cost of unit product value-added services is $k_1 v_e^2$, $k_1 > 0$ is the input cost coefficient for value-added services of online retail platform, the manufacturer’s unit production cost is $c$, to simplify the model, without loss of generality, it is assumed that $c = 0$.

4. The manufacturer and the online retail platform are both rational decision makers, both of them have complete information and make decisions with the goal of maximizing their own interests. The manufacturer is the leader of the game and the online retail platform is the follower.

4. Model Construction and Solution

Based on the problem description and related assumptions in the previous section, this section will construct decentralized decision-making and centralized decision-making
under separate pricing of the two channels and unified pricing of the two channels, and give solutions. For ease of presentation, the superscripts “S1” and “S2” are used to denote the decentralized and centralized decision-making scenarios under separate pricing of the two channels, and “U1” and “U2” are used to denote the decentralized and centralized decision-making scenarios under unified pricing of the two channels.

4.1. Game Analysis of Separate Pricing of Two Channels
4.1.1. Decentralized Decision-Making Model

At this time, the manufacturer’s direct sales channel and distribution channel of the online retail platform implement separate pricing method, and the decision objective functions of the manufacturer and the online retail platform are as follows:

\[
\begin{align*}
\text{Max } & \pi_1^\text{S1} = w^\text{S1}Q^\text{S1}_e + p^\text{S1}_dQ^\text{S1}_d, \\
\text{Max } & \pi_2^\text{S1} = (p^\text{S1}_e - w^\text{S1} - c(v_e))Q^\text{S1}_e.
\end{align*}
\]

(1)

Proposition 1. Under decentralized decision-making, the optimal product wholesale price \(w^\text{S1*}\), the sales price of the direct sales channel \(p^\text{S1*}_d\), the optimal sales price of the distribution channel \(p^\text{S1*}_e\) are presented as follows:

\[
\begin{align*}
w^\text{S1*} &= \frac{\lambda_1A + \lambda_2B + (\lambda_1^2 - \lambda_2^2)(f_d - k_1v_2)}{2(\lambda_1^2 - \lambda_2^2)f_d}, \\
p^\text{S1*}_d &= \frac{\lambda_1B + \lambda_2A}{2(\lambda_1^2 - \lambda_2^2)f_d}, \\
p^\text{S1*}_e &= \frac{(3\lambda_1^2 - \lambda_2^2)A + 2\lambda_1B + \lambda_2(\lambda_1^2 - \lambda_2^2)(3f_d - k_1v_2)}{4\lambda_1f_1(\lambda_1^2 - \lambda_2^2)}.
\end{align*}
\]

(2)

The market demand for the online retail platform distribution channel \(Q^\text{S1*}_e\), the market demand for the manufacturer’s direct sales channel \(Q^\text{S1*}_d\), the unit product profit of distribution sales channel \(F^\text{S1*}\), the unit product profit of direct sales channel \(Z^\text{S1*}\), the manufacturer’s profit \(\pi^\text{S1*}_m\), and the profit of the online retail platform \(\pi^\text{S1*}_e\) are presented as follows:

\[
\begin{align*}
Q^\text{S1*}_d &= \frac{A + \lambda_1(f_d - k_1v_2)}{4}, \\
Q^\text{S1*}_d &= \frac{A + \lambda_1(f_d - k_1v_2)}{4}, \\
F^\text{S1*} &= \frac{\lambda_1A + \lambda_2B + (\lambda_1^2 - \lambda_2^2)(f_d - k_1v_2)}{2(\lambda_1^2 - \lambda_2^2)f_d}, \\
Z^\text{S1*} &= \frac{\lambda_1A + \lambda_2B + (\lambda_1^2 - \lambda_2^2)(f_d - k_1v_2)}{2(\lambda_1^2 - \lambda_2^2)f_d}, \\
\pi^\text{S1*}_m &= F^\text{S1*}Q^\text{S1*}_e + Z^\text{S1*}Q^\text{S1*}_d, \\
\pi^\text{S1*}_e &= \frac{A + \lambda_1(f_d - k_1v_2)}{4}\pi^\text{S1*}_m.
\end{align*}
\]

(3)

where \(A = a_e + (\lambda_1 - \lambda_2)f_d v, B = a_d + (\lambda_1 - \lambda_2)f_d v\).

4.1.2. Centralized Decision-Making Model

At this time, both the manufacturer and the online retail platform make centralized decisions as a whole, and their decision goals are to maximize the overall profit of the supply chain. At this point, the overall decision objective function of the supply chain is:

\[
\text{Max } \pi^\text{S2} = (p^\text{S2}_e - c(v_e))Q^\text{S2}_e + p^\text{S2}_dQ^\text{S2}_d.
\]

(4)
Proposition 2. Under centralized decision-making, the optimal sales price of the direct sales channel \( p_{d}^{S2} \), the optimal sales price of the distribution channel \( p_{d}^{S2} \) are presented as follows:

\[
\begin{align*}
\left\{ \begin{array}{c}
p_{d}^{S2+} = \frac{\lambda_1 A + \lambda_2 B + (\lambda_1 - \lambda_2) f_2 b_k v^2}{2(\lambda_1 - \lambda_2)f_s}, \\
p_{d}^{S2-} = \frac{\lambda_1 A + \lambda_2 B}{2(\lambda_1 - \lambda_2)f_s}.
\end{array} \right.
\]

The market demand for the online retail platform distribution sales channel \( Q_{d}^{S2+} \), the market demand for the manufacturer’s direct sales channel \( Q_{d}^{S2-} \), the unit product profit of distribution channel \( F^{S2+} \), the unit product profit of direct sales channel \( Z^{S2+} \), and the total profit of supply chain \( \pi^{S2+} \) are presented as follows:

\[
\begin{align*}
Q_{d}^{S2+} &= \frac{A + \lambda_1 f_2 b_k v - (\lambda_1 - \lambda_2) f_2 k_1 v^2}{2}, \\
Q_{d}^{S2-} &= \frac{B - \lambda_2 f_2 b_k v + \lambda_2 f_1 k_1 v^2}{2}, \\
F^{S2+} &= \frac{\lambda_1 A + \lambda_2 B + (\lambda_1 - \lambda_2) f_2 b_k v - (\lambda_1 - \lambda_2) f_2 k_1 v^2}{2(\lambda_1 - \lambda_2)f_s}, \\
Z^{S2+} &= \frac{\lambda_1 A + \lambda_2 B + (\lambda_1 - \lambda_2) f_2 b_k v - (\lambda_1 - \lambda_2) f_2 k_1 v^2}{2(\lambda_1 - \lambda_2)f_s}, \\
\pi^{S2+} &= F^{S2+} \times Q_{d}^{S2+} + Z^{S2+} \times Q_{d}^{S2-}.
\end{align*}
\]

where \( A = a_d + (\lambda_1 - \lambda_2)f_2v, B = a_d + (\lambda_1 - \lambda_2)_2f_2v. \)

4.2. Game Analysis of Unified Pricing of Two Channels

4.2.1. Decentralized Decision-Making Model

At this time, in order to reduce the conflict between the direct sales channel and distribution channel, the manufacturer and online retail platform cooperate to implement the unified pricing strategy for direct sales channel and distribution channel, and the unified sales price is determined by the online retail platform. The decision objective functions of the manufacturer and the online retail platform are as follows:

\[
\begin{align*}
\max \pi_{d}^{U1} &= w^{U1} Q_{d}^{U1} + p^{U1} Q_{d}^{U1}, \\
\max \pi_{e}^{U1} &= (p^{U1} - w^{U1} - c(v_e)) Q_{d}^{U1}. \\
\end{align*}
\]

Proposition 3. Under decentralized decision-making, the optimal product wholesale price \( w^{U1+} \), the optimal sales price of the distribution channel \( p^{U1+} \) are presented as follows:

\[
\begin{align*}
w^{U1+} &= \frac{B - \lambda_2 f_2 b_k v - 2(\lambda_1 - \lambda_2) f_2 k_1 v^2}{2(\lambda_1 - \lambda_2)f_s}, \\
p^{U1+} &= \frac{3A + B + (3\lambda_1 - \lambda_2) f_2 b_k v + (\lambda_1 - \lambda_2) f_2 k_1 v^2}{6(\lambda_1 - \lambda_2)f_s}.
\end{align*}
\]

The market demand for the online retail platform distribution channel \( Q_{d}^{U1+} \), the market demand for the manufacturer’s direct sales channel \( Q_{d}^{U1+} \), the unit product profit of distribution channel \( F^{U1+} \), the unit product profit of direct sales channel \( Z^{U1+} \), the manufacturer’s profit \( \pi_{m}^{U1+} \), and the profit of the online retail platform \( \pi_{e}^{U1+} \) are presented as follows:

\[
\begin{align*}
Q_{d}^{U1+} &= \frac{3A + B + (3\lambda_1 + \lambda_2) f_2 b_k v - (\lambda_1 - \lambda_2) f_2 k_1 v^2}{6(\lambda_1 - \lambda_2)f_s}, \\
Q_{d}^{U1-} &= \frac{5B - 3A - (3\lambda_1 + 3\lambda_2) f_2 b_k v - (\lambda_1 - \lambda_2) f_2 k_1 v^2}{6(\lambda_1 - \lambda_2)f_s}, \\
F^{U1+} &= \frac{B - \lambda_2 f_2 b_k v - 2(\lambda_1 - \lambda_2) f_2 k_1 v^2}{2(\lambda_1 - \lambda_2)f_s}, \\
Z^{U1+} &= \frac{3A + B + (3\lambda_1 - \lambda_2) f_2 b_k v + (\lambda_1 - \lambda_2) f_2 k_1 v^2}{6(\lambda_1 - \lambda_2)f_s}, \\
\pi_{m}^{U1+} &= F^{U1+} Q_{d}^{U1+} + Z^{U1+} Q_{d}^{U1+}, \\
\pi_{e}^{U1+} &= \frac{3A + B + (3\lambda_1 - \lambda_2) f_2 b_k v - (\lambda_1 - \lambda_2) f_2 k_1 v^2}{6(\lambda_1 - \lambda_2)f_s} = \frac{(Q_{d}^{U1+})^2}{(\lambda_1 - \lambda_2)f_s}. \\
\end{align*}
\]
where \( A = a_e + (\lambda_1 - \lambda_2)f_s\nu, \ B = a_d + (\lambda_1 - \lambda_2)f_s\nu. \)

### 4.2.2. Centralized Decision-Making Model

At this time, both the manufacturer and the online retail platform make centralized decisions as a whole, and their decision goals are to maximize the overall profit of the supply chain. At this point, the overall decision objective function of the supply chain is:

\[
\text{Max} \pi^{U2} = (p^{U2} - c(v_e))Q^{U2} + p^{U2}Q_d^{U2}. \quad (10)
\]

**Proposition 4.** Under centralized decision-making, the unified sales price \( p^{U2*} \) set by the online retail platform is as follows:

\[
p^{U2*} = \frac{A + B + (\lambda_1 - \lambda_2)f_s\nu_e + (\lambda_1 - \lambda_2)f_s k_1\nu_e^2}{4(\lambda_1 - \lambda_2)f_s}. \quad (11)
\]

The market demand for the online retail platform distribution channel \( Q_d^{U2*} \), the market demand for the manufacturer’s direct sales channel \( Q_d^{U2*} \), the unit product profit of distribution channel \( F^{U2*} \), the unit product profit of direct sales channel \( Z^{U2*} \), and the total profit of supply chain \( \pi^{U2*} \) are presented as follows:

\[
\begin{align*}
Q_d^{U2*} &= \frac{3A - B + (3\lambda_1 + \lambda_2)f_s\nu_e - (\lambda_1 - \lambda_2)f_s k_1\nu_e^2}{4}, \\
Q_d^{U2*} &= \frac{3B - A - (3\lambda_1 + \lambda_2)f_s\nu_e - (\lambda_1 - \lambda_2)f_s k_1\nu_e^2}{4}, \\
F^{U2*} &= \frac{A + B + (\lambda_1 - \lambda_2)f_s\nu_e + (3\lambda_1 - \lambda_2)f_s k_1\nu_e^2}{4(\lambda_1 - \lambda_2)f_s}, \\
Z^{U2*} &= \frac{A + B + (\lambda_1 - \lambda_2)f_s\nu_e + (3\lambda_1 - \lambda_2)f_s k_1\nu_e^2}{4(\lambda_1 - \lambda_2)f_s}, \\
\pi^{U2*} &= F^{U2*}Q_d^{U2*} + Z^{U2*}Q_d^{U2*}.
\end{align*}
\]

where \( A = a_e + (\lambda_1 - \lambda_2)f_s\nu, \ B = a_d + (\lambda_1 - \lambda_2)f_s\nu. \)

### 5. Comparison and Analysis

**Corollary 1.** In the case of separate pricing of the two channels under the decentralized decision-making, there are \( \frac{\partial Q_d^{S1*}}{\partial \nu_e} > 0, \ \frac{\partial P_d^{S1*}}{\partial \nu_e} = 0, \ \frac{\partial Q_d^{S1*}}{\partial \nu_e} = \frac{\lambda_2 - 2f_s k_1\nu_e}{4\lambda_1}, \ \frac{\partial Q_d^{S1*}}{\partial \nu_e} = \frac{\lambda_2 f_s - 2f_s k_1\nu_e}{4}. \)

Corollary 1 shows that in the case of separate pricing of the two channels under the decentralized decision-making, with the increase of the online retail platform’s value-added services value \( \nu_e \), the online retail platform’s sales price of distribution channel \( p_e^{S1*} \) will increase continuously, the manufacturer’s direct sales channel price \( p_d^{S1*} \) will remain unchanged, and the manufacturer’s wholesale price \( w^{S1*} \) will increase first and then decrease. With the increase of the online retail platform’s value-added services value \( \nu_e \), the market demand of the online retail platform \( Q_d^{S1*} \) will first increase and then decrease, and the market demand of the manufacturer’s direct sales channel \( Q_d^{S1*} \) will first decrease and then increase.

**Corollary 2.** In the case of separate pricing of the two channels, there are \( \Delta \pi = \pi^{S1*} - (\pi^{S1*} \pi^{S1*} \pi^{S1*} \pi^{S1*}) > 0, \ \Delta P_e = p_e^{S2*} - p_e^{S1*} < 0, \ \Delta A = a^{S2*} - a^{S1*} = 0, \ CV^{S2*} > CV^{S1*}, \ CV^{S2*} = CV^{S1*}, \ F^{S2*} = F^{S1*}, \ Z^{S2*} = Z^{S1*}, \ \Delta Q_e = Q_e^{S2*} - Q_e^{S1*} < 0, \ \Delta Q_d = Q_d^{S2*} - Q_d^{S1*} < 0. \)

Corollary 2 shows that, with separate pricing of the two channels, compared with the decentralized decision-making, under the centralized decision-making, the manufacturer’s direct sales channel sales price remains unchanged, the online retail platform’s distribution
channel sales prices will fall, the online retail platform’s market demand will increase, market demand of the manufacturer’s direct sales channels will reduce, and the supply chain’s total profits will rise. This is because, in the decentralized decision-making case, the manufacturer and online retail platform stand on the point of view of their own profit maximization to make decisions, and ultimately led to the rise in the price of the product, corporate profits decline, resulting in the “double marginalized effect”.

**Corollary 3.** In the case of unified pricing of the two channels under the decentralized decision-making, there are $\frac{\partial \pi^{U1^*}}{\partial v_e} > 0, \frac{\partial \pi^{U2^*}}{\partial v_e} < 0, \frac{\partial Q^{U1^*}}{\partial v_e} = \frac{(3\lambda_1+\lambda_2)\delta-2(\lambda_1-\lambda_2)\delta_1v_e}{\delta}, \frac{\partial Q^{U2^*}}{\partial v_e} < 0$.

Corollary 3 shows that, in the case of unified pricing of the two channels under the decentralized decision-making scenario, with the increase of the online retail platform’s value-added services value $v_e$, unified sales prices of the two channels $p^{U1^*}$ will continue to increase, the manufacturer’s wholesale price $w^{U1^*}$ will continue to reduce, the online retail platform’s market demand $Q^{U1^*}$ will decrease first and then increase, and the manufacturer’s market demand of direct sales channels $Q^{U2^*}$ will continue to reduce.

**Corollary 4.** In the case of unified pricing of the two channels, there are $\Delta \pi = \pi^{U2^*} - (\pi^{U1^*} + \pi^m) > 0, \Delta p = p^{U2^*} - p^{U1^*} < 0, CV_{e}^{U2} > CV_{e}^{U1^*}, CV_{d}^{U2} > CV_{d}^{U1^*}, F^{U2^*} > F^{U1^*} > 0, Z^{U2^*} > Z^{U1^*} < 0, \Delta Q_e = Q_e^{U2^*} - Q_e^{U1^*} > 0, \Delta Q_d = Q_d^{U2^*} - Q_d^{U1^*} > 0$.

Corollary 4 shows that, in the case of unified pricing of the two channels, compared with decentralized decision-making, the unified sales price of the two channels under centralized decision-making $p^{U2^*}$ is lower, the online retail platform’s market demand of distribution channels and the manufacturer’s market demand of direct sales channels is greater, and the supply chain’s total profit is also greater.

**Corollary 5.** (1) In the case of separate and unified pricing of the two channels under the decentralized decision-making, there are $p_d^{S1^*} < p_{U1^*} < p_{U2^*} < F^{U1^*} < F^{U2^*} > S^{U1^*} > S^{U2^*}$, $CV_{d}^{U1^*} < CV_{d}^{S1^*}$, $CV_{e}^{U1^*} > CV_{e}^{S1^*}$, $Q_{d}^{U1^*} < Q_{d}^{S1^*}$, $Q_{e}^{U1^*} > Q_{e}^{S1^*}$; (2) In the case of separate and unified pricing of the two channels under the centralized decision-making, there are $p_d^{S2^*} < p_{U1^*} < p_{U2^*} < F^{U2^*} < F^{U1^*} > S^{U2^*} > S^{U1^*}$, $CV_{d}^{U1^*} < CV_{d}^{S2^*}$, $CV_{e}^{U1^*} > CV_{e}^{S2^*}$, $Q_{d}^{U1^*} > Q_{d}^{S2^*}$, $Q_{e}^{U1^*} < Q_{e}^{S2^*}$.

Corollary 5 shows that, when the product sales price is lower, the customer value is greater, and thus the market demand is greater. At the same time, the lower the product sales price, the lower the unit product profit. This is obviously in line with the antinomy effect. In order to overcome this problem, for a dual-channel supply chain, it is far from enough to increase customer value simply by improving value-added services. It is also necessary to increase unit product profits, e.g., by reducing product costs and reducing value-added service costs, etc.

**Corollary 6.** $\pi^{S2^*} > \pi^{U2^*}, \pi_{e}^{U1^*} > \pi_{e}^{S1^*}$.

Proof (See Appendix A).

Corollary 6 shows that when both parties make centralized decisions, the total profit of supply chain under separate pricing of the two channels $\pi^{S2^*}$ is greater than that under unified pricing of the two channels $\pi^{U2^*}$. When two parties make decentralized decisions, separate pricing of the two channels is beneficial to the manufacturer, while unified pricing of the two channels is beneficial to the online retail platform.

Corollary 6 shows that when the two parties make decentralized decisions, the supply chain’s total profit under separate pricing of the two channels $\pi^{S2^*}$ is greater than the supply chain’s total profit under the unified pricing of the two channels $\pi^{U2^*}$, when the two parties make decentralized decisions, the separate pricing of the two channels is
more beneficial to the manufacturer, while the unified pricing of the two channels is more beneficial to the online retail platform.

**Corollary 7.** (1) In the case of separate pricing of the two channels under decentralized decision-making, when the online retail platform’s optimal value-added services value is \( v_r^{S1*} = \frac{k}{2\lambda_1 - \lambda_2} \), the customer value of the online retail platform distribution channel \( CV_r^{S1*} \), the customer value of the manufacturer’s direct sales channel \( CV_m^{S1*} \), and the profit of the online retail platform are all can reach the maximum; (2) In the case of unified pricing of the two channels under the decentralized decision-making, when the optimal value-added services value of the online retail platform is \( v_r^{U1*} = \frac{(\lambda_1 + \lambda_2)/k}{2\lambda_1 - \lambda_2} \), the online retail platform itself can achieve the maximum profit, but the customer value of the online retail platform \( CV_r^{U1*} \) and the customer value of the manufacturer’s direct sales channel \( CV_m^{U1*} \) cannot reach the maximum value.

Corollary 7 shows that, under the different pricing methods of the dual-channel supply chain, the online retail platform needs to consider slightly different factors to provide value-added services, because the two parties in the supply chain are more closely connected under the unified pricing of the two channels, and the dual-channel sales prices directly affect customer value, which in turn affects the market demand, and finally affects the profit of each node of the supply chain. At this time, the optimal value-added services value needs to consider the customer value influence coefficients \( \lambda_1 \) and \( \lambda_2 \) between the two channels. For the online retail platform, increasing the value of the best value-added services can increase the online retail platform’s profit. Therefore, in the face of different pricing methods, the online retail platform needs to consider different factors. Under the separate pricing of the two channels: customer benefit perception, customer loss perception and the cost of value-added services; under the unified pricing of the two channels: customer benefit perception, customer loss perception, value-added services cost, channel customer value elasticity coefficient and channel cross customer value elasticity coefficient.

Combining Corollary 6 and Corollary 7, it can be seen that under the separate pricing of the two channels, the manufacturer’s profit will increase and the online retail platform’s profit will decrease, but the online retail platform can maximize its own profit and customer value through value-added services; while under unified pricing of the two channels, the manufacturer’s profit will decrease, and the online retail platform’s profit will also decrease, but the online retail platform cannot maximize its own profit and customer value through value-added services.

**Corollary 8.** (1) In the case of separate pricing of the two channels under the decentralized decision-making: \( \frac{\partial v_r^{S1*}}{\partial f_b} > 0, \frac{\partial v_m^{S1*}}{\partial f_b} < 0, \frac{\partial CV_r^{S1*}}{\partial f_b} > 0, \frac{\partial CV_m^{S1*}}{\partial f_b} < 0 \); (2) In the case of unified pricing of the two channels under the decentralized decision-making: \( \frac{\partial v_r^{U1*}}{\partial f_b} > 0, \frac{\partial v_m^{U1*}}{\partial f_b} < 0, \frac{\partial CV_r^{U1*}}{\partial f_b} > 0, \frac{\partial CV_m^{U1*}}{\partial f_b} < 0 \).

Proof (See Appendix A).

Corollary 8 shows that customer benefit perception \( f_b \) has a positive effect on the profits of both parties under the decentralized decision-making, while customer loss perception \( f_s \) has a negative effect on the profits of both parties under decentralized decision-making.

6. Simulation Analysis

In order to further verify the conclusions obtained in the previous paper, and analyze the impact of key parameters on the equilibrium strategy obtained under different pricing methods and different decision-making situations, this section will conduct simulation analysis of calculation examples. Reference related documents (Xu [35], Lin and Chen [18]), assign the relevant parameters to \( v = 800, \lambda_1 = 10, \lambda_2 = 1, a_c = 1500, a_d = 1000, k_1 = 0.01, f_b = 1, f_s = 1 \). Since decentralized decision-making and centralized decision-making are the two main decision-making scenarios studied in this paper, we will compare the equilibrium
solutions about separate pricing of the two channels and unified pricing of the two channels under decentralized decision-making and centralized decision-making. In addition, since customer value is the key to a company winning the market, and customer benefit perception and customer loss perception are the most important parameters, the sensitivity analysis of customer benefit perception and customer loss perception will be done next.

6.1. Sensitivity Analysis of Equilibrium Results under Decentralized Decision-Making

In the case of decentralized decision-making, the simulation analysis of price, customer value, unit product profit, market demand, profits of all parties in the supply chain and total profit under the separate and unified pricing of the two channels is carried out successively, as shown in Figure 2.

As can be seen from Figure 2a, no matter how the value of value-added services value changes, it will always exist $p_{d1}^{S1} < p_{d1}^{U1} < p_{c}^{S1} > w_{d1}^{S1} > w_{d1}^{U1}$. With the increase of value-added services value $v_c$, the wholesale price under separate pricing of the two channels $w_{d1}^{S1}$ will increase first and then decrease, this is because the online retail platform improve the value of value-added services $v_c$, market demand will increase, the manufacturer will improve the wholesale price. However, with the increase of value-added services value $v_c$, value-added services cost will increase, customer value will decrease, the online retail platform’s market demand of distribution channel will decline, so the manufacturer’s
wholesale price will decrease. As the online retail platform’s value-added services value \( v_e \) will increase, the direct channel price \( p^*_d \) will remain unchanged under the separate pricing of the two channels, while the sales price of distribution channel \( p^*_e \) will increase, while the wholesale price \( w^*_d \) will first increase and then decrease. Under the unified pricing of the two channels, the unified price of the two channels \( p^*_U \) will increase and the wholesale price \( w^*_U \) will decrease.

It can be seen from Figure 2b that, no matter how the value of value-added service changes, it will always exist \( CV^*_d < CV^*_U < CV^*_d \). Under the separate pricing of the two channels, with the increase of the online retail platform’s value-added services value \( v_e \), the customer value of direct sales channel \( CV^*_d \) will remain unchanged, while the customer value of distribution channel \( CV^*_d \) will continue to decrease. Under unified pricing of the two channels, the customer value of direct sales channel \( CV^*_d \) will increase continuously while that of distribution channel \( CV^*_d \) will decrease continuously.

It can be seen from Figure 2c that no matter how the value of value-added service changes, it will always exist \( F^*_d > F^*_U \), \( Z^*_d < Z^*_U \). Under the separate pricing of the two channels, as the online retail platform’s value-added services value \( v_e \) increases, the unit product profit of direct sales channel \( Z^*_d \) will remain unchanged, while the unit product profit of distribution channel \( F^*_d \) will increase first and then decrease. Under the unified pricing of the two channels, the unit product profit of direct sales channel \( Z^*_d \) will increase continuously while the unit product profit of distribution channel \( F^*_U \) will decrease continuously.

It can be seen from Figure 2d that no matter how the value-added services value changes, there will always exist \( q^*_d > q^*_U \), \( q^*_e < q^*_U \). Under the separate pricing of the two channels, with the increase of value-added services value of the online retail platform \( v_e \), the market demand of direct sales channel \( q^*_d \) will remain unchanged, while the market demand of distribution channel \( q^*_e \) will first increase and then decrease. Under unified pricing of the two channels, the market demand of direct channel \( q^*_d \) will continue to decrease while the market demand of distribution channel \( q^*_e \) will continue to increase.

It can be seen from Figure 2e that no matter how the value-added services value changes, it will always exist \( \pi^*_d > \pi^*_U \), \( \pi^*_e < \pi^*_U \). As can be seen from Figure 2f, no matter how the value of value-added services changes, they will still exist \( \pi^*_d > \pi^*_U \). As the value-added services value of the online retail platform \( v_e \) increases, the total profit of supply chain under the separate pricing of the two channels \( \pi^*_d \) will increase first and then decrease, while the total profit of supply chain under the unified pricing of the two channels \( \pi^*_U \) will decrease continuously.

6.2. Sensitivity Analysis of Equilibrium Results under Centralized Decision-Making

In the case of centralized decision-making, the price, customer value, unit product profit, market demand, profits of all parties in the supply chain, and total profit of the supply chain under separate and unified pricing of the two channels are simulated and analyzed successively, as shown in Figure 3.
Figure 3. The impact of value-added services value on equilibrium results under centralized decision-making. (a) The impact of $v_e$ on sales price. (b) The impact of $v_e$ on customer value. (c) The impact of $v_e$ on unit product profit. (d) The impact of $v_e$ on market demand. (e) The impact of $v_e$ on total profit of supply chain.

It can be seen from Figure 3a that, no matter how the value of value-added services changes, it will always exist $p_d^{S2x} < p_d^{U2x} < p_e^{S2x}$. Under the separate pricing of the two channels, as the value-added services value of the online retail platform $v_e$ increases, the direct channel sales price $p_d^{S2x}$ will remain unchanged, while sales price of the distribution channel $p_d^{S2x}$ will increase, and under the unified pricing of the two channels, sales price of the two channels $p_d^{U2x}$ will increase.

It can be seen from Figure 3b that no matter how the value of value-added services changes, it will still exist $CV_d^{S2x} < CV_d^{U2x}, CV_d^{S2x} < CV_d^{U2x}$. Under the separate pricing of the two channels, as the value-added services value of the online retail platform $v_e$ increases, the customer value of the distribution channel $CV_d^{S2x}$ will first increase and then decrease. Under the unified pricing of the two channels, the customer value of the direct channel $CV_d^{U2x}$ will remain unchanged, the customer value of the distribution channel $CV_d^{U2x}$ will increase, while the customer value of the direct channel $CV_d^{U2x}$ will decrease.

It can be seen from Figure 3c that, no matter how the value of added services changes, it will always exist $F^{S2x} > F^{U2x}, Z^{S2x} < Z^{U2x}$. Under the separate pricing of the two channels, as the value-added services value of the online retail platform $v_e$ increases, the unit product profit of direct sales channel $Z^{S2x}$ will remain unchanged, while the unit product profit of distribution channel $F^{S2x}$ will increase first and then decrease. Under the unified pricing of the two channels, the unit product profit of direct sales channel $Z^{U2x}$ will increase continuously, while the unit product profit of distribution channel $F^{U2x}$ will increase first and then decrease.
It can be seen from Figure 3d that no matter how the value of value-added services changes, it will always exist \( q_{e}^{S2*} < q_{e}^{U2*}, q_{d}^{S2*} > q_{d}^{U2*} \). Under separate pricing of the two channels, with the increase of value-added services value of the online retail platform \( v_e \), the market demand of direct channel \( q_{e}^{S2*} \) will remain unchanged, while the market demand of distribution channel \( q_{d}^{S2*} \) will first increase and then decrease. Under unified pricing of the two channels, the market demand of direct sales channel \( q_{d}^{U2*} \) will decrease and the market demand of distribution channel \( q_{d}^{U2*} \) will increase.

It can be seen from Figure 3e that no matter how the value-added services value changes, it will still exist \( \pi^{S2*} > \pi^{U2*} \). Under the decentralized decision-making, as the value-added services value of the online retail platform \( v_e \) increases, the total profit of supply chain under the separate pricing of the two channels \( \pi^{S2*} \) will increase first and then decrease, and the total profit of supply chain under the unified pricing of the two channels \( \pi^{U2*} \) will also increase first and then decrease.

6.3. Sensitivity Analysis of Equilibrium Results under Decentralized Decision-Making

Due to customer benefit perception \((f_b)\) and customer loss perception \((f_s)\) are the most important parameters affecting customer value, so this section will separately analyze how customer benefit perception \((f_b)\) and customer loss perception \((f_s)\) affect the price and profits of all parties in supply chain under the decentralized decision-making, to reveal its effects, the key parameter is set to \( v = 800, \lambda_1 = 10, \lambda_2 = 1, a_e = 1500, a_d = 1000, k_1 = 0.01, v_e = 50 \).

1. The impact of customer benefit perception \(f_b\)

In order to study the impact of customer benefit perception \(f_b\) on supply chain pricing and profit, the customer loss perception \(f_s\) is fixed at 1.0. Customer benefit perception \(f_b\) reflects the value perception provided by customers to the enterprise. The value perceived by customers may be the value that the enterprise exceeds the value provided by the enterprise. It may also be lower than the value provided by the company. If the value range is too large or too small, it may not be in line with the actual situation, so it is assumed \( f_b \in [0.5, 2] \) here.

It can be seen from Figure 4 that, with the increase of customer benefit perception \(f_b\), the sales price under the decentralized decision-making will rise (As shown in Figure 4a), the sales price under the centralized decision-making will rise (as shown in Figure 4b), and the profits of all parties in the supply chain under the decentralized decision-making will rise (as shown in Figure 4c). The increase of customer benefit perception \(f_b\) means that the higher the value brought by the manufacturer and online retail platform to customers, the greater the market demand will be, and the greater the profits of the manufacturer and online retail platform will be. Meanwhile, in order to obtain more profits, the manufacturer and online retail platform will increase the sales price of products.

2. The impact of customer loss perception \(f_s\)

In order to study the impact of customer loss perception \(f_s\) on supply chain pricing and profit, customer benefit perception \(f_b\) is fixed at 1.0. Customer loss perception \(f_s\) reflects customer perception of cost. Customer perception loss may be that the enterprise exceeds the cost or it may be below the cost, and if the value range is too large or too small, this may not be in line with the reality, so it is assumed \( f_s \in [0.5, 2] \) here.

It can be seen from Figure 5 that with the increase of customer loss perception \(f_s\), the sales price under the decentralized decision-making will decrease (As shown in Figure 5a), the sales price under the centralized decision-making will decrease (as shown in Figure 5b), and the profit of all parties of supply chain under the decentralized decision-making will decrease (as shown in Figure 5c). The increase of customer loss perception \(f_s\) means that the higher the cost brought by the manufacturer and online retail platform to customers, the lower the market demand will be, and the lower the profits of the manufacturer and online retail platform will be. Meanwhile, in order to obtain more profits, the manufacturer and online retail platform will reduce the sales price of products.
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**Figure 4.** The impact of customer benefit perception $f_b$ on equilibrium results. (a) The impact of $f_b$ on sales price under the decentralized decision-making. (b) The impact of $f_b$ on sales price under the centralized decision-making. (c) The impact of $f_b$ on profits of two parties under the decentralized decision-making.

**Figure 5.** The impact of customer loss perception $f_s$ on equilibrium results. (a) The impact of $f_s$ on sales price under the decentralized decision-making. (b) The impact of $f_s$ on sales price under the centralized decision-making. (c) The impact of $f_s$ on profits of two parties under the decentralized decision-making.
7. Conclusions

This paper comprehensively considers the customer value and the value-added services provided by the online retail platform, and studies the pricing strategy of the manufacturer and the online retail platform in the dual-channel supply chain. The specific content is to first solve the equilibrium strategies of the manufacturer and the online retail platform in the four decision-making scenarios: the separate pricing of the two channels under the decentralized decision-making and centralized decision-making, the unified pricing of the two channels under the decentralized and centralized decision-making, and then the equilibrium results are carried out. Through in-depth comparison and analysis, relevant important conclusions have been obtained. Finally, the research conclusions are further verified through calculation examples. The main conclusions are as follows:

Under the separate pricing of the two channels, there is a certain value for the value of value-added services, which can maximize the profit of the online retail platform while maximizing customer value; and under unified pricing of the two channels, there is also a certain value for value-added services. Although it can maximize the profit of the online retail platform, it cannot maximize the customer value. The different pricing methods of the manufacturer and online retail platform not only affect their own profits, but also affect customer value.

The customer benefit perception has a positive effect on the price under the decentralized decision-making and centralized decision-making, and the profits of all parties in the supply chain under the decentralized decision-making, while the customer loss perception has a negative effect. Whether it is separate pricing or unified pricing of the two channels, customer value and unit product profit have antithetical effects.

Under the separate and unified pricing of the two channels, the centralized decision-making model is better than the decentralized decision-making model. For centralized decision-making, the total profit of the supply chain under the separate pricing of the two channels is greater than that under the unified pricing of the two channels. For decentralized decision-making, the profit of the manufacturer under the separate pricing of the two channels is greater than that under the unified pricing of the two channels, while the profit of the online retail platform is the opposite.

Our contributions can be summarized as follows: Firstly, when the online retail platform provides value-added services, the manufacturer should adopt separate pricing of the two channels, while unified pricing of the two channels will reduce the customer value of the direct channel and its own profit. Secondly, the online retail platform can maximize customer value and its own profit by adjusting the value of value-added services under the separate pricing of the two channels. Thirdly, the lower the cost of value-added services, the greater the value of value-added services provided by online retail platforms, whether the two channels are priced separately or uniformly. Finally, improving the customer benefit perception and reducing the customer loss perception are both conducive to the profits of all parties in the dual-channel supply chain. Based on the above conclusions, the following management enlightenment can be obtained:

In order to overcome the antithetical effect of customer value and unit product profit, supply chain enterprises need to provide value-added services to improve customer value on the one hand. On the other hand, it is necessary to reduce product costs and value-added service costs.

In the dual-channel supply chain, the value-added services provided by the online retail platform will inevitably increase price competition between channels. If the manufacturer unifies the pricing with the online retail platform in order to ease the competition between channels, the result will damage the profit of the manufacturer. Therefore, in the face of the online retail platform providing value-added services, what the manufacturer needs to do is to adopt separate pricing of the two channels and to ease competition between channels through coordination contracts, while maximizing the profits of all parties in the supply chain.
Under the separate pricing of the two channels, the value-added services provided by the online retail platform can increase the revenue of the supply chain, and there is the best value-added services value. How to improve the value of the best value-added services mainly involves reducing the cost of value-added services through innovation and a series of marketing measures (trial, new media push, platform live broadcast) to improve customer benefit perception, and the customer loss perception is mainly the consumer’s valuation of costs, which is affected by the market currency value. Under the unified pricing of the two channels, there is also the optimal value-added services value of the online retail platform, which is not only affected by the customer benefit perception, value-added service cost coefficient, and customer loss perception, but also by the channel customer value elasticity coefficient and channel cross customer value elasticity coefficient influences.

The present study has the following limitations which can be explored in future. In this paper, the demand function is considered deterministic, but demand might be uncertain in reality. The value-added service of online retail platform is too abstract and has not been implemented into the concrete service. In the future, we hope to refine value-added services on the online retail platform, such as extended warranty service, and integrate them into the customer value model to discuss the impact of value-added service on pricing strategies of all parties in the dual-channel supply chain. In addition, we also hope to integrate return service into customer value, to consider the relationship between return service and customer value, and analyze its impact on all parties in the dual-channel supply chain.

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Appendix A

Proof of Corollary 6.

(1) Let \[ \frac{\pi^{(1)}_{U^2} - \pi^{(2)}_{Q^2}}{2} = A - B + (\lambda_1 + \lambda_2) (f_1 u_1 + f_1 k_1^2) = M, \quad Q^{(1)}_{S^2} - Q^{(2)}_{S^2} = \frac{A - B}{2} + \frac{M}{\lambda_1 + \lambda_2}, \]
then \[ \pi^{(1)}_{U^2} = F^{(1)}_{Q^2} + Z^{(1)}_{U^2} Q^{(2)}_{U^2} = (f_{Q^2} - \frac{M}{\lambda_1 + \lambda_2}) Q^{(2)}_{S^2} + M + (Z_{S^2} + \frac{M}{\lambda_1 + \lambda_2}) Q^{(2)}_{d^2} - M). \]
As a result of \[ \frac{\pi^{(2)}_{S^2} - \pi^{(2)}_{d^2}}{2} = N, \quad F^{(2)}_{S^2} - Z^{(2)}_{S^2} = \frac{N}{\lambda_1 + \lambda_2}, \] then \[ \pi^{(2)}_{U^2} = \pi^{(2)}_{S^2} + M (F^{(2)}_{S^2} - Z^{(2)}_{S^2}) - \frac{2 M^2}{\lambda_1 + \lambda_2}, \]
so \[ \pi^{(1)}_{U^2} = \pi^{(2)}_{U^2} - \frac{2 M^2}{\lambda_1 + \lambda_2} f \geq 0, \]
\[ \pi^{(1)}_{U^2} - \pi^{(2)}_{U^2} = (\Delta \pi^{(1)}_{U^2} - \Delta \pi^{(2)}_{U^2}) - (\pi^{(1)}_{S^2} - \pi^{(2)}_{S^2}) + \frac{2 M^2}{\lambda_1 + \lambda_2}/f \]
where \[ E = A + \lambda_1 (f_1 u_1 - f_1 k_1^2) > 0, \]
\[ Y = 3 A - B + (3 \lambda_1 + \lambda_2) f_1 u_1 - (\lambda_1 - \lambda_2) f_1 k_1^2, \]
as result of \[ Y - 4 E = 4 M, \]
so \[ \pi^{(1)}_{S^2} - \pi^{(2)}_{S^2} = \frac{(2E+4M)^2}{24(\lambda_1 + \lambda_2)^2} - \frac{E^2}{8(\lambda_1 + \lambda_2)^2} - \frac{3(\lambda_1 - \lambda_2)^2}{24(\lambda_1 + \lambda_2)^2}. \]

(2) \[ \pi^{(1)}_{U^2} - \pi^{(2)}_{U^2} = \frac{16 A (\lambda_1 - \lambda_2)^2}{144 M (\lambda_1 + \lambda_2)^2}/f = \frac{(7 \lambda_1 + 9 \lambda_2)^2 + 64 \lambda_1 + 64 \lambda_2 + 64 \lambda_1 + 64 \lambda_2)^2}{144 M (\lambda_1 + \lambda_2)^2}/f > 0. \] Corollary 6 is proved. □
Proof of Corollary 8. Separate pricing of the two channels: 
\[
\frac{\partial \pi^{s_1}_1}{\partial f} > 0, \quad \frac{\partial \pi^{s_1}_2}{\partial f} < 0, \quad \frac{\partial \pi^{s_2}_1}{\partial f} < 0, \quad \frac{\partial \pi^{s_2}_2}{\partial f} > 0,
\]
\[
\frac{\partial s^{s_1}_1}{\partial f} < 0, \quad \frac{\partial s^{s_1}_2}{\partial f} > 0, \quad \frac{\partial s^{s_2}_1}{\partial f} > 0, \quad \frac{\partial s^{s_2}_2}{\partial f} < 0.
\]
\[
\sigma^{s_1}_e = \left(\frac{Q^{s_1}_e}{\lambda_1 f_1}\right)^2 \text{ Unified pricing of the two channels:}
\]
\[
\frac{\partial \mu^{l_1}}{\partial f} > 0, \quad \frac{\partial \mu^{l_2}}{\partial f} < 0, \quad \frac{\partial \lambda^{l_1}}{\partial f} > 0, \quad \frac{\partial \lambda^{l_2}}{\partial f} < 0,
\]
\[
\pi^{s_1}_e = F^{s_1}_e + Q^{s_1}_e + Z^{s_1}_e + Q^{s_2}_e, \quad \pi^{l_1}_e = \left(\frac{Q^{s_1}_e}{\lambda_1 f_1}\right)^2.
\]
Corollary 8 is proved. □

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