Research on Pricing Strategy of Three-echelon Dual-channel Supply Chain under Market Equilibrium

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Abstract. The healthy and sustainable development of supply chain must be based on the consideration of both enterprise profit and consumer benefit and only the market behavior under perfect competition environment might maximize the social total welfare. The market equilibrium in perfect competition market is the premise of maximizing the sum of consumer and producer surplus. Taking the pricing strategies of supplier, manufacturer and retailer as research objects, market demand and supply functions considering the effect of different channel prices is built, and a three-echelon dual-channel supply chain model is constructed. Then, the optimal pricing strategies of decentralized and integrated three-echelon dual-channel supply chain are developed by applying two-stage stackelberg game theory and overall revenue maximization principle. Furthermore, the conditions of optimal equilibrium prices existing with the restriction of market equilibrium are discussed, and the expressions of the optimal equilibrium prices about different supply chain structures are analyzed. Eventually, we use method of numerical analysis to explain the pricing strategy we analyze.

1. Introduction
With the rapid advance of information techniques and electronic equipment, the Internet is making changes to human way of study and work extensively and deeply, and its influence on our daily life becomes more and more obvious. The great convenience and efficiency brought by Internet attract more and more people to use it. As of January 2019, the permeability of global active Internet users reached 57\% of the total population and this number grew by 9.13\% compared to one year ago. According to the China Internet Network Information Center [1], China’s Internet users exceeded 904 million as of March 2020, occupying over 64\% of the total population.

The Internet has brought many benefits to consumers and enterprises. Firstly, consumers can no longer be affected by time, space, weather and other factors, and can search and find a large amount of commodity information online without leaving home. Secondly, because online sales shorten the length of supply chain and reduce the number of intermediate links, the product prices are greatly reduced, which will undoubtedly benefit customers and further promote the market sales of enterprises effectively. Thirdly, through online direct sales, enterprises can get closer to consumers, so as to better understand customer needs and make production and operation management more efficient. By the end of 2019, 51.6\% of Chinese companies sold their products through online channel, and an increasing number of manufacturers upgraded the enterprise operation modes from single to dual-channel.

The dual-channel supply chain system includes both online and offline channels. Its fundamental
goal is to meet the needs of consumers while making profits for suppliers, manufacturers, retailers and other enterprises. Therefore, if this system would like to develop healthily and sustainably, it must take into account both the interests of consumers and enterprises. The social welfare is selected as key indicator to measure the total revenue of consumers and enterprises in economics and it can be maximized only in the perfectly competitive market environment. On the premise of maximizing social welfare, this paper constructs a three-echelon dual-channel supply chain model considering market equilibrium, and formulates the pricing strategies for supply chain members with different supply chain structures.

The remainder of this paper is described as follows: we sort out the related literature in Section 2. Section 3 mainly prepares for the construction of our model, and explains the theoretical basis of it. In Sections 4-5, the market equilibrium prices of decentralized and integrated three-echelon dual-channel supply chain system are discussed respectively, and the influencing factors of pricing are also analyzed. In Section 6, we use numerical analysis to explain the pricing strategies we analyze. Finally, a summary and prospect of this paper are given in Section 7.

2. Literature Review

The homogeneous commodities are sold through both online and offline channels simultaneously in dual-channel supply chain, this character has intensified the conflicts among supply chain members. This situation has attracted more and more scholars and entrepreneurs’ attention, they have done a lot of contributions to coordinate the supply chain system effectively. Product prices is not only the source of corporate profits, but also the main method of competition, hence, price competition, pricing strategies and equilibrium of different channels have become the focus of this field.

Most of scholars believe that the key to attracting customers and coordinating the dual-channel supply chain is to formulate optimal pricing strategies, such as Reference [2-5]. Furthermore, Dan et al. [6] specified the optimal retail service and price of the dual-channel supply chain, including centralized and de-centralized. On the basis of considering the pricing policy in the dual-channel supply chain, Chen et al. [7] obtained two conclusions: first, improving the brand loyalty is beneficial to manufacturers and retailers at the same time, and second, increasing service value can not only ease the threat of online channels to retailers, but also improve the profits of manufacturers. Similarly, Ren et al. [8] also discussed the optimal strategies in the case of concentration and decentralization. They considered the factors such as consumer returns policies, price and service competition among different channels, built a dual-channel supply chain model and determined a contract to coordinate the supply chain. Unlike the research of the above scholars, Panda et al. [9] investigated how to reduce the unit cost pricing of products and how to formulate optimal production policies in a short life cycle. In the dual-channel supply chain model of Li et al. [10], suppliers and retailers were set to be risk-neutral and risk-averse respectively, and equilibrium solutions under de-centralized and centralized conditions were gained. Liu et al. [11] considered the impact of interruption risk on the two channels under the risk-aversion attitude. Subsequently, Liu et al. [12] proposed a loss-averse consumer behavior model in the purchase decision-making process and the decisions behind loss-averse consumers were explored and the optimal price strategies were obtained. Considering the impact of return policies on dual-channel supply chain, Li et al. [13] showed that when the customers' return rate was relatively low, manufacturers tended to prefer full-refund policy regardless of online or offline channels, and retailers can benefit more from this policy in the indirect channel. Also, in the research of pricing strategies, Li et al. [14] believed that the showrooing effect would make enterprises benefit the most from the ex-post service efforts. Wu et al. [15] showed that when only the third-party recyclers (TPRs) had concerns about fairness, the profit of the recycling center and the transfer price of the offline channel would decline, TPR's profits, however, were the opposite. Using Stackelberg game, Qin et al. [16] explored the optimal pricing strategies of each supply chain partners, and discussed the influence of trade credit policies on easing conflicts for a dual-channel supply chain system of a manufacturer and a value-added retailer. In order to determine the location, product transfer and pricing strategies, Rahmani et al. [17] constructed a green supply chain model based on a
dual-channel system.

According to the existing literature on dual-channel supply chain pricing strategies, adopting appropriate pricing strategies can alleviate channel conflicts and double marginalization effectively, regardless of whether there is product competition between channels (Kumar and Ruan [18]). But all of the research mentioned before discussed pricing strategy on the premise of that there is only one manufacturer in the market, so it means that the market environment of dual-channel supply chain is monopolistic. Furthermore, there are few researches on the three-echelon dual-channel supply chain. Consequently, the authors select three-echelon dual-channel supply chain under free competition market environment as study object to discuss price strategies of different industries rather than different individual enterprises.

3. Model Formulation
In economics, social welfare as the key indicator reflects the total revenue of consumers’ and enterprises’ market behavior, and total social surplus is selected as index estimating social total welfare due to the resource investment. The total social surplus includes consumer and producer surplus. The consumer surplus reflects the benefits that consumers obtain by purchasing commodities, while the producer surplus reflects the profits that producers obtain by selling commodities. The social total surplus is equal to the sum of these two. In order to maximize the social welfare, it is necessary to ensure the maximum sum. Increasing consumer or producer surplus unilaterally is not conducive to the increase of total social welfare. The market equilibrium caused by free competition is not only the guarantee of healthy development of market economy but also the prerequisite of maximizing total social welfare. In other words, the maximum of social welfare can be realized only in the perfectly competitive market environment and any other type of market environment must lead to deadweight loss.

If and only if market demand is equal to market supply, market equilibrium appears. At the intersection point of demand and supply curve, the loss of consumer surplus caused by short supply and producer surplus caused by scarce demand are eliminated simultaneously. Market equilibrium overcomes the disadvantages of both sellers and buyers markets and makes consumers and enterprises achieve their respective maximum satisfaction at the same time. Our model discusses equilibrium price of supply chain members based on market equilibrium.

3.1. Assumptions and Parameters Settings
In this paper, a distribution system composed of the industries of supplier, manufacturer and retailer is considered. In which there are enough enterprises in every industry to make market environment perfectly competitive. In this three-echelon supply chain, only one product is produced and sold. Every manufacturer buys raw materials for production at the same price from suppliers (or manufacturers will purchase from the suppliers charging lower price) and sell product to retailers at the unified price (or retailers will buy from the manufacturers offering lower price). Retailers sell products by offline channel, while manufacturers sell the same product through their wholly owned online channel. Consumers can buy products through online or offline channels. Because of the free competition market environment, each retailer’s prices of offline channel are identical, so is the online channel price. But the prices of offline and online channel may be different due to the difference of channel characteristics and consumer preference.

Let $D$ denote the market demand and $S$ denote the market supply. The parameter $p$ represents the channel price, $\omega$ represents the wholesale price of the product, $c$ represents the cost of per unit product, $\pi$ represents the corporate profits, $\rho$ represents the market share of offline channel $(0<\rho<1)$, $\alpha>0$ represents the commodity price influence coefficient on market demand, $\beta>0$ represents the product price influence coefficient on market supply. We use subscript $s$, $m$, $r$ to mark the parameters of suppliers, manufacturers, and brick-and-mortar retailers, use subscript 1 and 2 to mark the parameters of traditional and direct channel. This model can be shown in figure 1.
3.2. Model Construction

In free competitive market environment, market demand and supply both are affected by commodity price. For reflecting the relationship between market demand and commodity channel prices, based on the linear demand function of economics and using the demand model in (Huang et al. [19]) for reference, the consumer demand formula of the dual-channel supply chain can be expressed as below:

\[ D = a - \alpha_1 p_1 - \alpha_2 p_2 \]  

(1)

where \( a > 0 \) is the potential market demand. Equation (1) reflects the negative correlation between two channel prices and market demand and expresses the commodity quantity that consumers are willing and able to purchase under various possible combinations of channel prices.

Considering the market supply, manufacturer industry meets customer demand through network channel and online channel price affects their profits directly, so the higher channel price will lead to the more industry supply. For traditional offline channel, however, retailers make profit by reselling product which is bought from manufacturers to customers, no matter how high the traditional channel price is, manufacturers can only benefit from wholesale price of product. Hence, the factor encouraging manufacturers to provide product to the market is not the traditional retail channel price but the wholesale price they can charge retailers. According to the above analysis, the market supply expression of the dual-channel supply chain under the conditions of completely competitive market is as follows:

\[ S = -b + \beta_1 \omega_m + \beta_2 p_2 \]  

(2)

where \( b > 0 \) shows manufacturers start to produce only when wholesale and online channel price reach a certain degree. Equation (2) reflects the positive correlation between wholesale price and online channel price and market supply and expresses the product quantity that manufacturers are willing and able to provide under various possible combinations of price level.

The profit expressions of supplier, manufacturer and retailer industries are respectively as follows:

\[ \pi_s = (p_1 - \omega_m) \rho D \]  

(3)

\[ \pi_m = (\omega_m - \omega_s - c_m) \rho D + (p_2 - \omega_s - c_m)(1 - \rho) D \]  

(4)

\[ \pi_s = (\omega_s - c_s) D \]  

(5)

4. Model Analysis in Decentralized Dual-channel Supply Chain

In a decentralized dual-channel supply chain, the suppliers, manufacturers and retailers all take
maximizing their own interests as the decision-making goals. But because of the difference of product characteristic, industry scale, external environment and so on, the market position and power of these three industries are different significantly. This paper assumes that the industries located upstream in supply chain are in the advantage position. It means that suppliers are dominant compared with manufacturers and manufacturers are dominant compared with retailers. There is a two-stage Stackelberg game in this three-echelon dual-channel supply chain. Firstly, suppliers determine raw material wholesale price \( \omega_s \), then manufacturers determine product wholesale price \( \omega_m \) and online channel price \( p_2 \) according to \( \omega_s \); Secondly, retailers determine offline channel price \( p_1 \) according to \( \omega_m \) and \( p_2 \).

Two-stage backward induction can be used to solve our two-stage Stackelberg game model. In the first stage, the optimal pricing strategies of the manufacturer industry can refer to the retailer’s reaction for manufacturer’s wholesale price and direct channel price. In the second stage, we can determine suppliers’ optimal wholesale price according to manufacturers’ pricing strategy. When the market is cleared, market demand equals supply. Based on equation (1) and (2)

\[
a - \alpha, p'_1 - \alpha_2 p'_2 = -b + \beta_1 \omega'_m + \beta_2 p'_2
\]  
(6)

The superscript “’” indicates the parameters of decentralized dual-channel supply chain. From Formula (6), the following expression can be obtained:

\[
p'_2 = \frac{a + b - \beta_1 \omega'_m - \alpha_1 p'_1}{\alpha_2 + \beta_2}
\]  
(7)

Substituting (7) into (1) and (2), get the market demand and supply under market equilibrium:

\[
D' = S' = \frac{a \beta_2 - b \alpha_2 + \alpha_2 \beta_2 \omega'_m - \alpha_1 \beta_2 p'_1}{\alpha_2 + \beta_2}
\]  
(8)

Hence, the profit of retailer industry is

\[
\pi' = \rho(p'_1 - \omega'_m) \frac{a \beta_2 - b \alpha_2 + \alpha_2 \beta_2 \omega'_m - \alpha_1 \beta_2 p'_1}{\alpha_2 + \beta_2}
\]  
(9)

In order to generate the most revenue of theirs, retailers will determine \( p'_1 \) to maximize \( \pi' \). Solve the equation \( \frac{\partial \pi'}{\partial p'_1} = 0 \) to get \( p'_1 \).

\[
\frac{\partial \pi'}{\partial p'_1} = \frac{\rho}{\alpha_2 + \beta_2} \left[ a \beta_2 - b \alpha_2 + (\alpha_1 \beta_2 + \alpha_2 \beta_2) \omega'_m - 2 \alpha_1 \beta_2 p'_1 \right] = 0
\]  
(10)

For \( \frac{\partial^2 \pi'}{\partial p'_1^2} = -2 \rho \alpha \beta_2 < 0 \), there is \( p'_1 \) maximizes \( \pi' \). We can get optimal reaction function of retailers about manufacturers’ wholesale price from (10):

\[
p'_1 = \frac{a \beta_2 - b \alpha_2 + (\alpha_1 \beta_2 + \alpha_2 \beta_2) \omega'_m}{2 \alpha \beta_2}
\]  
(11)

Substituting (11) into (7) and (8), get the manufacturers’ online channel price and market demand under the condition of market equilibrium.

\[
p'_2 = \frac{a \beta_2 + 2 b \beta_2 + b \alpha_2 - (\alpha_1 \beta_2 + \alpha_2 \beta_2 + 2 \beta_1 \beta_2) \omega'_m}{2 \beta_2 (\alpha_2 + \beta_2)}
\]  
(12)
To get the profit function of manufacturer industry, we substitute (12) and (13) into (4). Similar to retailers, manufacturers will determine \( \omega'_m \) to maximize \( \pi'_m \). Take the derivative of \( \pi'_m \) for \( \omega'_m \):

\[
\frac{\partial \pi'_m}{\partial \omega'_m} = \frac{(\alpha_2\beta_1 - \alpha_1\beta_2)(\alpha + \beta_1)(\omega'_m + c_m)}{2(\alpha_2 + \beta_2)^2} - \frac{2\rho\beta_2(\alpha_2 + \beta_2)(1 - \rho)(\alpha_2\beta_1 + \alpha_2\beta_1 + 2\beta_1\beta_2)}{2(\alpha_2 + \beta_2)^2} \]

(14)

and if

\[
\frac{\partial^2 \pi'_m}{\partial \omega'^2_m} = \frac{(\alpha_2\beta_1 - \alpha_1\beta_2)[2\rho\beta_2(\alpha_2 + \beta_2) - (1 - \rho)(\alpha_2\beta_1 + \alpha_2\beta_1 + 2\beta_1\beta_2)]}{2(\alpha_2 + \beta_2)^2} < 0
\]

(15)

there is \( \omega'_m \) can maximize \( \pi'_m \). So when

\[
(\alpha_2\beta_1 - \alpha_1\beta_2)[2\rho\beta_2(\alpha_2 + \beta_2) - (1 - \rho)(\alpha_2\beta_1 + \alpha_2\beta_1 + 2\beta_1\beta_2)] < 0
\]

(16)

the optimal reaction function of manufacturers about suppliers’ wholesale price is

\[
\omega'_m = \frac{\beta_2}{2\rho\beta_2(\alpha_2 + \beta_2) - (1 - \rho)(\alpha_2\beta_1 + \alpha_2\beta_1 + 2\beta_1\beta_2)}
\]

(17)

The profit function of supplier industry can be gotten by substituting (17) into (13) then into (5).

The optimal wholesale price of supplier industry can be expressed as:

\[
\omega''_s = \frac{\rho(a_2\beta_2 - b\alpha_s)(1 - \rho)(a_2\beta_1 - b\alpha_s)}{2(a_2\beta_2 - a_2\beta_1)} \]

(19)

Formula (19) demonstrates a negative correlation between suppliers’ optimal wholesale price and the difference between the production cost of manufacturers and suppliers. Substituting (19) into (17), then into (12) and (11), the optimal pricing strategies of manufacturer and retailer industry can be obtained respectively.

5. Model Analysis in Integrated Dual-channel Supply Chain

In an integrated dual-channel supply chain, suppliers, manufacturers and retailers make business strategies based on the overall profit maximization of the three industries.

In perfectly competitive market environment, the market demand of the integrated dual-channel supply chain will also be dually influenced by the online and offline channel retail prices, so the demand function
does not change in the form. But for the supply function, although the price of direct channel can still affect market supply, the wholesale price of manufacturers will no longer have effect on supply because of the integration of supply chain. When supply chain members make decision uniformly, the selling price between them does not affect the overall revenue of the whole supply chain, nor does it promote the supply of the industry. Conversely, the offline channel retail price could benefit supply chain alliances directly and it will replace the manufacturers' wholesale price to influence market supply. In an integrated dual-channel supply chain, any retail price increase in any channel will benefit the supply chain and stimulate the alliance to increase supply. As a result, the market demand and supply functions of integrated dual-channel supply chain are:

\[ D_c = a - \alpha_1 p_1 - \alpha_2 p_2 \]  
\[ S_c = -b + \beta_1 p_1 + \beta_2 p_2 \]

where the subscript \( c \) marks the parameters of integrated dual-channel supply chain.

When the market reaches equilibrium, market demand and supply achieve a balance. Let equation (20) - (21), we can use the price of one channel to denote the other, for example

\[ p_1 = \frac{a + b - (\alpha_1 + \beta_1) p_2}{\alpha_1 + \beta_1} \]  
(22)

Substituting (22) into (20) and (21), we get the consumer demand and industry supply under market equilibrium:

\[ D_c = S_c = \frac{a \beta_1 - b \alpha_1 + (\alpha_1 \beta_2 - \alpha_2 \beta_1) p_2}{\alpha_1 + \beta_1} \]  
(23)

Based on equation (3), (4) and (5), the overall revenue of the integrated dual-channel supply chain can be expressed as

\[ \Pi_c = p_1 \rho D_c + p_2 (1 - \rho) D_c - (c_s + c_m) D_c \]  
(24)

In order to maximize the overall profits, substitute (22) and (23) into (24), then take the derivative of \( \Pi_c \) for \( p_2 \):

\[ \frac{\partial \Pi_c}{\partial p_2} = \frac{2(\alpha_1 \beta_2 - \alpha_2 \beta_1)(1 - \rho)(\alpha_1 + \beta_1)(\alpha_2 + \beta_2) - (\alpha_1 \beta_2 - \alpha_2 \beta_1)(\alpha_1 + \beta_1)(1 - \rho)(\alpha_2 + \beta_2)}{(\alpha_1 + \beta_1)^2} \]  
(25)

And

\[ \frac{\partial^2 \Pi_c}{\partial p_2^2} = \frac{2(\alpha_1 \beta_2 - \alpha_2 \beta_1)(1 - \rho)(\alpha_1 + \beta_1)(\alpha_2 + \beta_2)}{(\alpha_1 + \beta_1)^2} \]  
(26)

If there is \( p_2 \) maximizing \( \Pi_c \), need

\[ (\alpha_1 \beta_2 - \alpha_2 \beta_1)(1 - \rho)(\alpha_1 + \beta_1) - \rho(\alpha_2 + \beta_2) \leq 0 \]  
(27)

when (27) is true, the optimal direct channel price is

\[ p_2^* = \frac{-(\alpha_1 \beta_2 - \alpha_2 \beta_1)(\alpha_1 + \beta_1)(c_s + c_m)}{2(\alpha_1 \beta_2 - \alpha_2 \beta_1)(1 - \rho)(\alpha_1 + \beta_1) - \rho(\alpha_2 + \beta_2)} \]  
(28)
Furthermore, substitute (28) into (22), we get the optimal traditional channel price is

$$p_1^* = \frac{(1 - \rho)\left[(a + b)(\alpha_2 - \alpha_1 \beta_2) - (a_1 + \beta_1)(a_2 - b \alpha_1)\right] + \rho(\alpha_2 + \beta_2)(a_2 - b \alpha_1)}{2(\alpha_2 - \alpha_1 \beta_2)\left[(1 - \rho)(\alpha_1 + \beta_1) - \rho(\alpha_2 + \beta_2)\right]}$$

Under the constraints of equation (27), the denominators of equation (28) - (29) are both more than zero. There is a reverse change in the optimal prices of the two channels due to $\alpha > 0$ and $\beta > 0$. When the production cost of the supply chain becomes higher, the degree change in opposite direction of two channels prices will be greater.

6. Numerical Analysis

In order to analyze the pricing strategies in Sections 4 and 5, we adopt some numerical experiments to support our conclusions in this section and explore the differences between the decentralized and integrated three-echelon dual-channel supply chain. To facilitate the comparison, the parameters we choose must ensure that both supply chain structures have optimal pricing strategies. We choose $a=15$, $b=9$, $a_1=0.55$, $a_2=0.45$, $\beta_1=0.35$, $\beta_2=0.4$, $\rho=0.7$, $c_s=1$, $c_m=3$, the above parameters can make the equation (16) and (27) true simultaneously. On the basis of equation (19) and (17), it can be known that the optimal wholesale price for suppliers and manufacturers in the distributed supply chain are $\omega_s^* = 9.2$ and $\omega_m^* = 21.2$. As shown in table 1 and figure 2-3 are the results of numerical experiments.

![Figure 2. Industry profits in decentralized supply chain.](image-url)

The following conclusions can be drawn from figure 2. In a decentralized three-echelon dual-channel supply chain, when suppliers change their wholesale price each industry profit also changes with it, but there is optimal wholesale price maximizing supplier industry profit.
Table 1 shows that the change of suppliers’ wholesale price affects members’ pricing in decentralized supply chain only and has no effect for integrated supply chain. Table 1 also proves the pricing strategy based on maximizing suppliers’ profits can’t make the whole supply chain profits maximization and integrated supply chain can gain more overall profits than decentralized supply chain.

| $\omega_s'$ | $\omega_m'$ | $p_1'$ | $p_2'$ | $p_1^*$ | $p_2^*$ | $\Pi'$ | $\Pi_c$ |
|------------|------------|--------|--------|--------|--------|-------|-------|
| 6          | 17.30      | 19.27  | 8.64   | 9.75   | 17.91  | 6.177 | 12.931|
| 7          | 18.51      | 20.32  | 7.47   | 9.75   | 17.91  | 5.812 | 12.931|
| 8          | 19.73      | 21.36  | 6.29   | 9.75   | 17.91  | 5.412 | 12.931|
| 9          | 20.95      | 22.41  | 5.11   | 9.75   | 17.91  | 4.979 | 12.931|
| 9.2        | 21.20      | 22.62  | 4.87   | 9.75   | 17.91  | 4.889 | 12.931|
| 10         | 22.17      | 23.46  | 3.93   | 9.75   | 17.91  | 4.512 | 12.931|
| 11         | 23.39      | 24.50  | 2.75   | 9.75   | 17.91  | 4.011 | 12.931|
| 12         | 24.61      | 25.55  | 1.57   | 9.75   | 17.91  | 3.476 | 12.931|
| 13         | 25.83      | 26.60  | 0.39   | 9.75   | 17.91  | 2.907 | 12.931|

Figure 3 shows that in integrated three-echelon dual-channel supply chain, if unit product cost ($c_s+c_m$) changes, the optimal prices of online and offline channel change in opposite directions. The reasons for this are obvious: when one channel price rises, consumer surplus produced by purchasing through this channel will reduce. In order to maintain the maximization of social welfare, the other channel price must fall to increase consumer surplus.

7. Conclusions
The healthy and sustainable development of supply chain must be based on the consideration of both enterprise profit and consumer benefit. In economics, social total surplus (the sum of producer surplus and consumer surplus) is used to describe total benefits of producers and consumers obtained from the
market behavior. The total social surplus can be maximized if and only if under the perfect competition market environment. Aiming at maximizing the social welfare, we study the pricing strategies of the three-echelon dual-channel supply chain.

This paper first establishes the market supply and demand functions that consider the influences of traditional and direct channel prices. Then, the optimal pricing strategies of decentralized and integrated three-echelon dual-channel supply chain are discussed respectively. In decentralized supply chain, the conditions for the existence of the optimal equilibrium price are determined by using the two-stage Stackelberg rule, and the optimal wholesale price of supplier and manufacturer industry and the optimal retail price of online and offline channels under market equilibrium are calculated. In integrated supply chain, the condition of profit maximization of supply chain is analyzed and the optimal channel retail prices are given. At last, numerical experiments are used to explain the pricing strategies we analyze.

There may also be some limitations to our analysis. This paper proposes an assumption that the demand and supply of the market are static. However, the dynamic market demand and supply are much more common. Therefore, analysis on pricing strategy under dynamic environment can be a direction of further research.

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