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# Research on Dual Channel Supply Chain Decision Making of New Retailing Enterprises Considering Service Behavior in the Era of Big Data

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## ABSTRACT

Drawing from extant retailing and supply chain research, this paper studies the dual channel supply chain decision making of member channel, and obtains the optimal price strategy, maximum demand, and maximum total revenue of the supply chain of network channel and retailing channel under the centralized decision making and decentralized decision making respectively. The contributions of this study are that investing in big data within a certain threshold can improve the channel service level, reduce the channel price, and improve the income of the supply chain. Supply chain members improve the channel service level and increase the corresponding channel price. The supply chain can get the most advantages when manufacturers and retailers make centralized decisions. This paper provides a starting point for new retailing academic and practical research in a domain that is deficient in empirical research and provides the theoretical framework to new retailing enterprises and decision-making model for their sustainable competitive advantage.

## KEYWORDS

Big Data, Centralized Decision-Making, Decentralized Decision-Making, Dual Channel, New Retailing, Service Behavior, Smart Retailing, Supply Chain Management

## INTRODUCTION

The world of retailing is changing rapidly due to the changes of computer technology and network technology. The breakthrough of information technology, the acquisition of big data resources and the development of artificial intelligence are all continuing to promote the rapid development of the new retail economy. The traditional retailing industry has been strongly impacted by the online retailing. Even before COVID-19, retailing industry had undergone tremendous changes under the impetus of new technology (Grewal, Roggeveen, and Nordfält 2017). The world has already witnessed a large number of brave retailing entrepreneurs and a large number of "death lists" in recent most active year for retailing. The higher opening and operating costs, the increasing cost of equipment repairing by unmanned shelves and unmanned convenience stores and the cost of technology maintenance

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are all directly impact on the development of retailing. Nowadays big data has gradually become the core competitive resource all over the world. In the past two years, the development of big data has swept the world. With the strong support and promotion of the Internet and big data, the supply chain of traditional retailing industry has actively reformed and innovated, promoted the upgrading of retail enterprise infrastructure and business model, the new retailing era has come. Under these new environment and background, where is the way for development of new retailing supply chain? How to reduce operating costs while improving utilization efficiency? How to continue to improve the profits and find the new exploration and model innovation of supply chain? Actually, new retailing has transformed to "service", "digital" and "integration" and has become a new engine and initiative of national economic development. And the supply chain innovation of new retail has attracted extensive attention. Accordingly, all these changes and concerns are worthy of our further excavation and exploration.

In today's multi-channel environment, consumers can get a variety of choices by integrating technology into their daily life. Some shoppers prefer to use mobile apps to buy products, but also prefer to buy products in physical stores. Others use digital channels for search process, but go to physical stores to make actual purchases (Nakano and Kondo, 2018; Liu et al., 2021). Therefore, one of the most important challenges facing retailers is how to integrate digital and mobile technologies and services into online and offline dual-channel operations (Taher et al., 2019; Yu et al., 2021; Roggeveen, Nordfält & Grewal, 2016). With the vigorous development of Internet and e-commerce, there are more and more conflicts in the supply chain, and the competition between enterprises for customer resources is becoming more and more intense. The emergence of dual channel supply chain is a change in the structure of supply chain (Saha, 2018; Feng, Liu & Feng, 2021; Lv & Wu, 2021). Due to the characteristics of dual channel supply chain selling products online and offline at the same time, more and more manufacturers have established online direct sales channels. The development of online and offline channels makes the channel service behavior of supply chain members widely concerned. The high-quality channel service behavior shortens the distance between enterprises and consumers, and promotes the stable development of sales relations. Based on the analysis above, this paper specifies two following issues. Discussed whether retailing enterprises' supply chain investing big data can improve supply chain efficiency, and made the comparison between centralized decision-making and decentralized decision-making to get the optimal decision when considering service behavior when investing big data. The contribution of this paper lies in the following points. The existing literature focuses more on the conceptual elaboration of new retailing and also rarely studying the dual channel supply chain from the perspective of big data information. This paper enriches the theoretical research on big data and channel service behavior in dual channel supply chain management and also increases the empirical research of new retailing. Meanwhile, big data has widely used in all industry, and it is very important to introduce big data into the dual channel supply chain in the bid data era. This paper also provides theoretical support for manufacturers and retailers to invest in big data, and helps enterprises make reasonable decisions in supply chain activities, promotes the integration of big data information, supply chain members' channel service behavior and dual channel supply chain, and provides a strong basis and direction for the operation of new retailing dual channel supply chain.

## BACKGROUND

### New Retailing

The new retailing integrates the whole retail link scientifically and improves the overall operation efficiency from raw material production, rational transport, optimize distribution to final sale and after-sale service. Based on the evolution process of retail model, Kärkkäinen T (2015) proposed that innovation is an important competitive advantage in the process of new value points. Gino

(2016) explored cases of several Italian food companies and analyzed how to set logistics variables and logistics model in omni-channel management strategy. The method of enterprises to set various logistics variables from four strategic areas, and channel integration and multi configuration coexistence are the main driving force of omni channel operation. Murfield (2017) found that the timeliness of logistics is an important factor to maintain consumer satisfaction and loyalty through the investigation of logistics service quality in the omni-channel retail environment, retailers need to invest a lot of resources to meet the requirements of timely delivery. Based on the case of glasses retailer-Direct Optic, Karine (2018) explored the process and challenges of the store towards the omni-channel strategy, and finally gave proposal from the aspects of organizational change to operation evolution.

## Big Data Supply Chain

Today big data is an important strategic asset and has rich analysis value. Compared with traditional data analysis, big data has greater advantages for objective and comprehensive analysis. Big data analysis technology can improve enterprise evaluation mechanism, and at the time realize enterprise visual operation (Zheng, Han & Yang, 2021; Kusi-Sarpong et al., 2021). Waller Matthew (2013) proposed the definition of supply chain big data analysis, investigated qualitative method for conceptual analysis, and then used quantitative method with data support to evaluate the current situation of big data technology application in enterprises. With the continuous improvement of research theory, the application of big data is becoming more and more important for supply chain. Although big data plays significant role in the effective operation of supply chain, there are few studies on the dynamics of supply chain and how to use these collected data in these systems to improve its performance (Koot M, 2020; Gao et al., 2020). Simonov K (2021) explored the current application status of big data in the supply chain and considered that the application of big data in the supply chain can promote the corresponding efficiency in the operation process, realize visualization of supply chain, and also summarize the potential benefits of applying big data to the supply chain. Gawankar, Gunasekaran, & Kamble (2020) considered that the traditional supply chain management strategy brought a lot limitations to the full utilization of big data-driven decision-making and a framework of big data-driven supply chain process management has created in this study. The decision-making of supply chain management had changed from experience-driven to big data-driven decision-making. Jain et al. (2017) identified the existing issues supply chain management by using Delphi method, solved these problems combined with big data analysis technology.

## Dual-Channel Supply Chain

Dual channels can reach potential buyers that cannot be reached by a single channel, so as to expand the market demand of the product. The newly developed direct channels can consolidate and expand market demand for the manufactures, at the same time they also become competitors of retailers which leading to channel conflict to a certain extent.Wallace et al (2004) explored that compared with a single offline channel, dual channels can improve customer satisfaction and ultimately, and finally improve customer loyalty. Dan et al (2012) considered the situation that manufacturers supply retailing services, and analyzed the channel price and service strategy from customer channel preference perspective. The higher the consumer's preference for online channels, the lower the retail price will be. However, if the manufacturers improve their service level, both online and offline retailing prices will increase, and make more profits. Yue and Liu (2006) investigated the information sharing between manufacturers and retailers in the dual channel environment, and found that manufacturers can obtain profit and improve the operation efficiency of supply chain from information sharing. Scholars have studied the differentiated service strategies of the two channels, and show that this differentiated service can expand demand and effectively alleviate channel conflict (Li et al., 2019; Boyaci et al., 2014; Li et al., 2021). More specifically, service quality and service price are considered as the factors for consumers to choose purchase channels, the improvement of retailer service quality may increase manufacturers' profits in dual channels, and the expansion of consumer service sensitivity

may benefit both sides of dual channels (Dumrongsiri et al., 2008; Han et al., 2021). Additionally, whether manufacturers encourage retailers to improve service quality or formulate different online and offline sales strategies, their purpose is to build differentiated distribution channels, and to provide consumers with different consumption experiences and alleviate channel conflicts (Zhao et al., 2017; Delgado et al.,2020; Farsi et al., 2020; Ali et al., 2018; Do Vale et al., 2021).

Previous literature mainly studies the new retailing issues from qualitative aspects, including business model, innovation process and evolution process. Few studies consider the operation of supply chain in new retailing enterprises under the background of big data. Actually, the research on the integration of the new retailing supply chain is the whole channel management and the integration of online and offline from the overall perspective. This paper studies the impact of channel service behavior on centralized decision-making and decentralized decision-making on price, channel demand and revenue when investing in big data information in the new retailing dual channel supply chain environment. And combined with numerical examples, this paper also analyzes and summarizes strategy of service behavior of manufacturers and retailers on each channel in big data environment and provide ideas and theoretical basis for enterprise decision-making.

## CONCEPTUAL MODEL AND FRAMEWORK

The review of the literature provides insights into the development situation of dual supply chain in new retailing. These influencing factors and conclusion from literature are used as an overarching conceptual framework for this study's conceptual modal, data collection, data analysis and solving countermeasures.

### The Essence and Characteristics Of New Retailing Supply Chain

New retailing refers to a new retail model, in which enterprises rely on the Internet to upgrade and transform the production, circulation and sales process of goods by using advanced technical means such as big data and artificial intelligence and psychological knowledge, so as to reshape the retailing business structure and ecosystem, and deeply integrate online services, offline experience and modern logistics. With the continuous evolution of technological innovation, the essence of new retailing supply chain has never changed. New retailing supply chain integrates the whole retail link scientifically and improve the overall operation efficiency. The synchronous development of online and offline retailing also gradually shows the trend of mutual integration and common development.

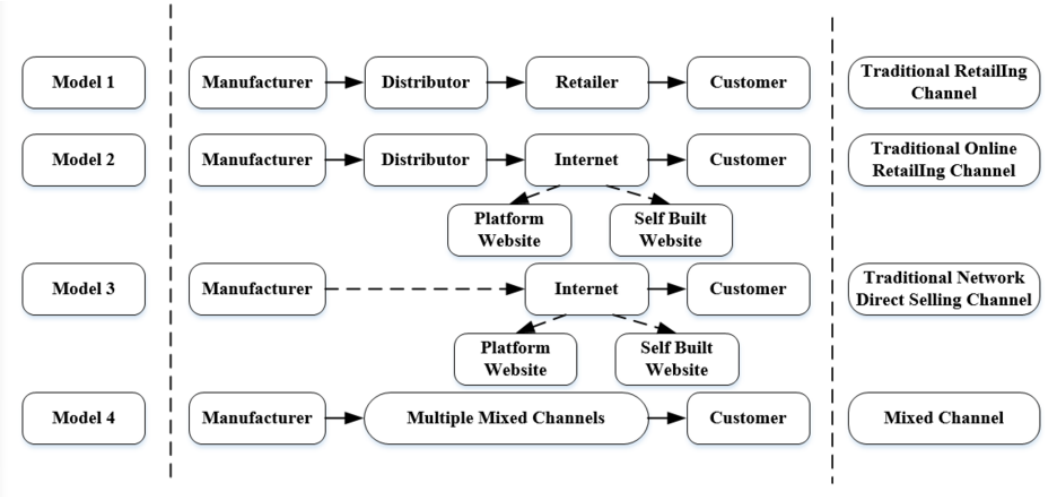
The core of new retailing supply chain is to meet the changing needs of customers, improve customer satisfaction, take customer's experience as the core model, and take into account the relationship between internal employees and upstream and downstream business partners. The enterprises need to realize the integration of commodities and logistics channels while combining online and offline supply chain. Nowadays more and more traditional retailing enterprises innovate their business models through the development of "offline + online" dual channels by using the internet technology and big data. In this business model, it includes not only internal employees of new retailing enterprises, but also upstream manufacturers, downstream distributors and all partners in the omni-channel, and more accurately meet the needs of different customers, and realize the mutual benefit and win-win of all channel partners based on the support and cooperation of cloud computing and big data.

### Traditional Retailing Supply Chain Structure and Process

In the process of traditional retailing channel selection and channel coordination, it is mainly related to manufacturers, retailers and consumers. Due to the different importance of retailing activities, traditional retailers will form different supply chain models, as shown in Figure 1. In the process of traditional channel operation, retailing enterprises have reached a considerable scale and formed different supply chain models. Traditional retailers distribute products from manufacturers

to distributors and retailers, and finally reach consumers. All channels are relatively independent. Manufacturers mainly use one channel for product distribution, and retailing products and services are inconvenient and complex relatively.

**Figure 1. Traditional retailing supply chain structure**




## Operation Process of Dual Channel Supply Chain In New Retailing

Traditional physical retailing is one-way sales and publicity, lacking communication and interaction with channel partners. Nevertheless, the core of the development of "new retailing" supply chain is to meet the increasing requirement of customers, improve customers' satisfaction and focus on customers' experience. At the same time, new retailing takes into account the relationship between internal employees and upstream and downstream business partners. In new retailing era, offline retailers continue to expand and develop their online channels, online retailers continue to set up and develop their offline physical stores at the same time. Online and offline retailers make a concerted effort to maximize the complementarity of channels and achieve an all-win result, which can be observed in Figure 2. Retailers cooperate online and offline to form a complete beneficent cycle network with closed Omni-channel products, services and logistics distribution.

Compared with traditional retailing complex supply chain, new retailing supply chain simplify channel process and easier to make collective decisions from getting the data and information from the internet and technology. With the integration of online and offline channels, retailers have realized integrated operation and management in inventory, sales, settle accounts and marketing service, reduced channel member conflicts, and customers can quickly gain retail shopping experience and services, significantly improving retail efficiency and service level.

The operation process of the new retailing supply chain model can be divided into several parts including manufacturers, retailers and consumers. Instead of depending on simple elements and superposition such as people and hardware, the supply chain needs to realize the technicalization, informatization, visualization and digitization in the new retailing era. It can fully reflect the omnipotence and wisdom of the supply chain, and make most use of big data and technological innovation. Figure 3 displays new retailing dual channel supply chain.

**Figure 2. Dual channel new retailing supply chain structure**

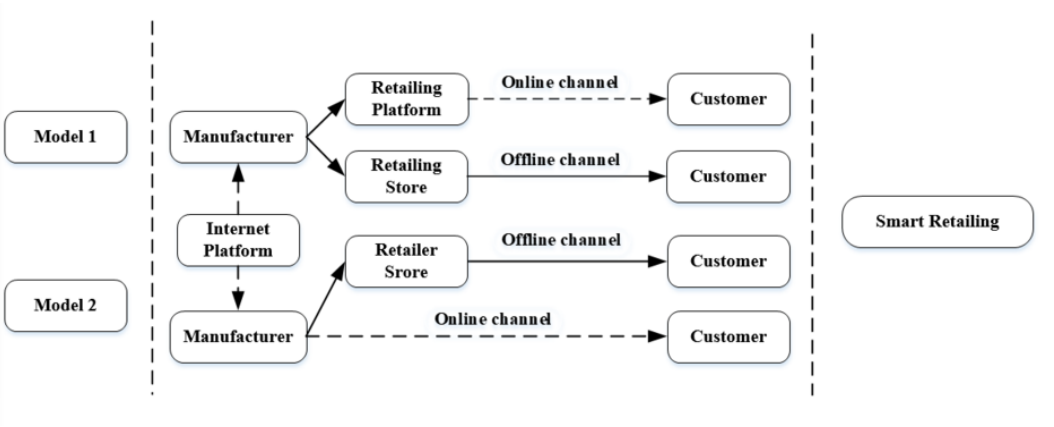
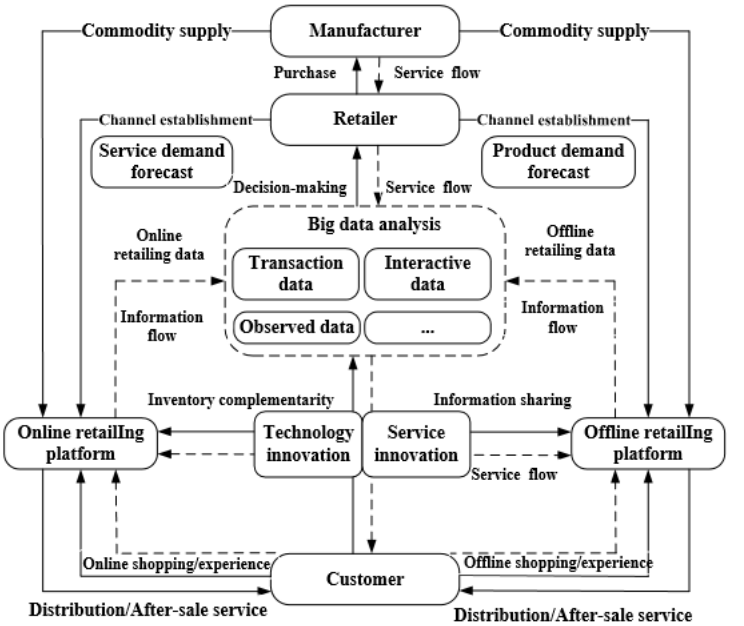



**Figure 3. New retailing dual channel supply chain**




The demand of consumers, the price of goods and the information of competitors are changing rapidly in new retailing. It requires retailing enterprises actively to participate in more advanced consumption and services through technical means, and the supply chain turn into "online and offline + supply chain + big data + comprehensive marketing" model. How to make best use of data and technology is an important issue in the reconstruction and innovation of supply chain organization in the process of new retail enterprises. Retailers rely on advanced information technology to analyze a large number of sales activity data, formulate reasonable purchase plans and send them to suppliers to determine the goods category, order quantity, arrival time and other information required by each

retail channel, so as to meet the supply of retailing goods in online and offline channels. On the other hand, retailers promote the integration of channels through online and offline information sharing and inventory complementarity, provide customers with diversified and personalized shopping scenes and consumption methods, and provide corresponding retailing services according to the demand characteristics of different consumer groups.

Additionally, one of the means for supply chain enterprises to obtain high market competitiveness is to improve the service level under the big data environment. Big data information can also be used to drive the decision-making of dual channel supply chain services and provide relevant factors for service innovation and improvement. Through dual channel big data information analysis, online channels and physical stores can predict the service demand of online and offline channels, analysis the service demand of customers, make corresponding service selection. And then transform the service demand into the production process, promote the innovation and improvement of services, and promote the coordination of the supply chain.

## METHODOLOGY

### Methodology Review and Research Assumptions

The research design is based on the conceptual model and qualitative analysis. In this study, the manufacturer has opened online network channels. Supply chain members obtain data rental, data analysis and data prediction services through big data service companies or its own data department. The manufacturer and retailer provide services for the customer through online and offline channels respectively.

In this study, this paper makes these assumptions in order to satisfy the practical significance.

**Hypothesis 1:** Manufacturers and retailers play a leading role in the market competition and the products produced by the manufacturer can meet the sales and inventory demand of online and offline channel.

**Hypothesis 2:** The profits of manufacturers and retailers are affected by channel price, channel service level and big data information investment cost. Manufacturers and retailers improve customers' shopping experience by providing high-quality channel services. Although it is faster and more convenient for customers to buy goods through Internet channels, customers cannot go to the store for detailed selection and get personal shopping experience. The service level provided by manufacturers is lower than that provided by retailers. So $s_2 > s_1 > 0$ .

**Hypothesis 3:** In the dual channel supply chain, one is to obtain consumer big data information through big data service companies, and its cost is $c_f$ , the other is that manufacturers obtain their internal big data information by investing a certain cost $c_i$ . When using big data information to optimize the production process of dual channel supply chain, the cost optimization coefficient is $\delta$ .

### Demand Model Construction

Referring to the relevant literature of constructing channel demand function of supply chain and according to the service cost proposed by Tsay and Agrawal (2004), Demand function by Dan (2012), the study proposes the service cost is:. $\mathrm{c}\left(s_i\right) = \frac{1}{2} k_i s_i^2, k_i > 0, i = 1,2$ . k is service cost coefficient. The larger the k, the higher the service cost is. Retailers can communicate directly with customers through the physical stores, generally the service cost of offline retail channels is lower than that of online network channel. Based on the relevant literature and assumptions, the demand function of

network channel and retailing channel considering channel service behavior in dual channel supply chain system is:

Network channel demand function: $D_1 = l_1 - \gamma p_1 + \alpha s_1 + \beta_1 p_2 - p_1 + \beta_2 s_1 - s_2$ (1)

Retailing channel demand function: $D_2 = l_2 - \gamma p_2 + \alpha s_2 + \beta_1 p_1 - p_2 + \beta_2 s_2 - s_1$ (2)

Manufacturer's revenue: $R_1 = p_1 - \delta c\left(s_1\right) - c_f - \delta c_0 - c_i D_1 + (\mathrm{w} - \delta c_0 - c_i) D_2$ (3)

Retailer's Revenue: $R_2 = p_2 - w - \delta c\left(s_2\right) - c_f D_2$ (4)

D is the demand of channel, $l$ is the channel scale. $\gamma$ is elasticity coefficient of demand to price. $p$ is the channel sale price. $\alpha$ is elasticity coefficient of demand to service. s is the channel service level, $\beta_1$ is transfer coefficient of demand to price differentiation, $\beta_2$ is transfer coefficient of demand to service differentiation. $\delta$ is cost optimum coefficient. $c_i$ is big data investment cost. $c_f$ is Manufacturers' investment in internal big data costs. Number 1 and number 2 represent network channel and retailing channel, symbol * represents optimal solution.

## Centralized Decision-Making Model

In centralized decision-making, manufacturers and retailers have the same objectives and make decisions together in order to maximize the overall profit of the supply chain. Manufacturers sell goods through online channels and provide customers with a certain level of channel services through online channels. Retailers obtain retail channel goods through manufacturers and provide channel services to retail channel customers. Manufacturers and retailers obtain big data resources through big data service companies.

Online network channel demand function:

$$\mathrm{D}_1^{CD} = l_1 - \gamma p_1^{CD} + \alpha s_1 + \beta_1 p_2^{CD} - p_1^{CD} + \beta_2 s_1 - s_2 \quad (5)$$

Offline retailing channel demand function:

$$\mathrm{D}_2^{CD} = l_2 - \gamma p_2^{CD} + \alpha s_2 + \beta_1 p_1^{CD} - p_2^{CD} + \beta_2 s_2 - s_1 \quad (6)$$

Total revenue of supply chain:

$$R^{CD} = p_1^{CD} - \delta c\left(s_1\right) - c_f - \delta c_0 - c_i \mathrm{D}_1^{CD} + p_2^{CD} - \delta c\left(s_2\right) - c_f - \delta c_0 - c_i \mathrm{D}_2^{CD} \quad (7)$$

According to reverse induction: let $\frac{\partial \mathrm{R}^{CD}}{\partial p_1^{CD}}=0$, $\frac{\partial \mathrm{R}^{CD}}{\partial p_2^{CD}}=0$, and get proposition (1).

Proposition (1): In centralized decision-making process, the optimal pricing strategy of network channel and retail channel is: $p_1^{CD^*}$, $p_2^{CD^*}$.

$$p_1^{CD^*}=\frac{l_1 r+\left(l_1+l_2\right)\beta_1+\left(\alpha r+\alpha\beta_1+r\beta_2\right)s_1+\left(\alpha\beta_1-r\beta_2\right)s_2}{2r\left(r+2\beta_1\right)}+\frac{\delta c\left(s_1\right)+c_f+\delta c_0+c_i}{2} \tag{8}$$

$$p_2^{CD^*}=\frac{l_2 r+\left(l_1+l_2\right)\beta_1+\left(\alpha r+\alpha\beta_1+r\beta_2\right)s_2+\left(\alpha\beta_1-r\beta_2\right)s_1}{2r\left(r+2\beta_1\right)}+\frac{\delta c\left(s_2\right)+c_f+\delta c_0+c_i}{2} \tag{9}$$

And then proof, using second derivatives to $p_1^{CD}$, $p_2^{CD}$ respectively, and get Hessian Matrix:

$$H_1\left(p_1^{CD},p_2^{CD}\right)=\begin{bmatrix}\frac{\alpha^2 r^{BD}}{\alpha\left(p_1^{CD}\right)^2} & \frac{\alpha^2 r^{BD}}{\alpha p_1^{CD}\alpha p_2^{CD}}\\ \frac{\alpha^2 r^{BD}}{\alpha p_2^{CD}\alpha p_1^{CD}} & \frac{\alpha^2 r^{BD}}{\alpha\left(p_2^{CD}\right)^2}\end{bmatrix}=\begin{bmatrix}-2r-2\beta_1 & 2\beta_1\\ 2\beta_1 & -2r-2\beta_1\end{bmatrix} \tag{10}$$

Because $-2r-2\beta_1<0, \left(-2r-2\beta_1\right)^2-4\beta_1^2>0$, so $H_1\left(p_1^{CD},p_2^{CD}\right)$ is negative definite matrix, and formula (8) and (9) are the unique optimal solution.

In centralized decision-making model, the maximum demand of network direct channel and traditional retailing channel respectively are:

$$D_1^{CD^*}=\frac{l_1+\left(\alpha+\beta_2\right)s_1-\beta_2 S_2-\left(r+\beta_1\right)\delta c\left(s_1\right)+\beta_1\delta c\left(s_2\right)-r\left(\delta c_0+c_i+c_f\right)}{2} \tag{11}$$

$$D_2^{CD^*}=\frac{l_2+\left(\alpha+\beta_2\right)s_2-\beta_2 S_1-\left(r+\beta_1\right)\delta c\left(s_2\right)+\beta_1\delta c\left(s_1\right)-r\left(\delta c_0+c_i+c_f\right)}{2} \tag{12}$$

According to the optimal profit solution, the maximum total income of the dual channel supply chain is:

$$R^{CD^*}=\frac{\left[M_1-2r\left(r+2\beta_1\right)\left(\delta c\left(s_1\right)+c_f+\delta c_0+c_i\right)\right]M_2^{'}+\left[M_3-2r\left(r+2\beta_1\right)\left(\delta c\left(s_2\right)+c_f+\delta c_0+c_i\right)\right]M_4^{'}}{4r\left(r+2\beta_1\right)} \tag{13}$$

And

$$M_1 = l_1 r + \left(l_1 + l_2\right)\beta_1 + \left(\alpha r + \alpha\beta_1 + r\beta_2\right)s_1 + \left(\alpha\beta_1 - r\beta_2\right)s_2$$

$$M_2^{'} = l_1 + \left(\alpha + \beta_2\right)s_1 - \beta_2 s_2 - \left(r + \beta_1\right)\delta c\left(s_1\right) + \beta_1\ \delta c\left(s_2\right) - r\left(c_f + \delta c_0 + c_i\right)$$

$$M_3 = l_2 r + \left(l_1 + l_2\right)\beta_1 + \left(\alpha r + \alpha\beta_1 + r\beta_2\right)s_2 + \left(\alpha\beta_1 - r\beta_2\right)s_1$$

$$M_4^{'} = l_2 + \left(\alpha + \beta_2\right)s_2 - \beta_2 s_1 - \left(r + \beta_1\right)\delta c\left(s_2\right) + \beta_1\ \delta c\left(s_1\right) - r\left(c_f + \delta c_0 + c_i\right)$$

## Decentralized Decision-Making Model

In the decentralized decision-making model, Manufacturers and retailers make Stackelberg game with the goal of maximizing their own profits. The manufacturer is the forerunner to set the online channel sales price according to the predicted retail channel price, and then the retailer determines the retail channel price.

Online network channel demand function:

$$\mathrm{D}_1^{DD} = l_1 - \gamma p_1^{DD} + \alpha s_1 + \beta_1 p_2^{DD} - p_1^{DD} + \beta_2 s_1 - s_2 \tag{14}$$

Offline retailing channel demand function:

$$\mathrm{D}_2^{DD} = l_2 - \gamma p_2^{DD} + \alpha s_2 + \beta_1 p_1^{DD} - p_2^{DD} + \beta_2 s_2 - s_1 \tag{15}$$

Revenue of manufacturer:

$$R_1^{DD} = p_1^{DD} - \delta c\left(s_1\right) - c_f - \delta c_0 - c_i \mathrm{D}_1^{DD} + (\mathrm{w} - \delta c_0 - c_i)\mathrm{D}_2^{DD} \tag{16}$$

Revenue of retailer:

$$R_2^{DD} = \left(p_2^{DD} - w - \delta c\left(s_1\right) - c_f\right)\mathrm{D}_2^{DD} \tag{17}$$

According to reverse induction, this paper can get proposition (2): In decentralized decision-making process, the optimal pricing strategy of network channel and retail channel is: $p_1^{DD^*}$, $p_2^{DD^*}$.

$$p_1^{DD^*} = \frac{\left(2r + \beta_1\right)l_1 + \left(l_1 + l_2\right)\beta_1 + \beta_1\left(r + \beta_1\left(2w + \delta c\left(s_2\right) + c_f - \delta c_0 - c_i\right)\right) + As_1 + Bs_2}{4r^2 + 8r\beta_1 + 2\beta_1^2)} + \frac{\delta c\left(s_1\right) + \delta c_0 + c_f + c_i}{2} \tag{18}$$

$$p_2^{DD^*} = \frac{l_2}{\left(2r + \beta_1\right)} + \frac{\left(2rl_1 + 2l_1\beta_1 + l_2\beta_1\right)\beta_1 + \left(r + \beta_1\right)F + Cs_1 + Ds_2}{2\left(4r^2 + 8r\beta_1 + 2\beta_1^2\right)\left(r + \beta_1\right)} + \frac{\beta_1\left(\delta c\left(s_1\right) + \delta c_0 + c_f + c_i\right)}{4\left(r + \beta_1\right)} \tag{19}$$

F=[(w+ $\delta c\left(s_2\right)+c_f$ ) $(4r^2+8r\beta_1+3\beta_1^2)$ + $\beta_1^2\left(w-\delta c_0-c_i\right)$ ]

Find the second partial derivative of equation (17) for $p_2^{DD}$ , and get $\frac{\alpha^2 R_2^{DD}}{\partial(p_2^{DD})^2}=-2r-2<0$ , so $\frac{\partial R_2^{DD}}{\partial p_2^{DD}}=0$ , it can get the unique optimal solution $p_2^{DD^*}$ . And then bring $p_2^{DD^*}$ to (4-16), Find the second partial derivative of equation for $p_1^{DD}$ , it can get $\frac{\alpha^2 R_1^{DD}}{\partial(p_1^{DD})^2}<0$ , so $\frac{\partial R_1^{DD}}{\partial p_1^{DD}}=0$ , it can get the unique optimal solution $p_1^{DD^*}$ , so the optimal pricing strategy of network channel and retail channel is: $p_1^{DD^*}$ , $p_2^{DD^*}$ .

Bring ( $p_1^{DD^*}$ , $p_2^{DD^*}$ ) into formula (14) and formula (15): When investing in big data information of decentralized decision-making, the maximum demands of online direct sales channels and traditional retail channels are:

$$D_1^{DD^*}=\frac{N_1+\beta_1\left(r+\beta_1\right)F-(2r^2+4r\beta_1+\beta_1^2)^2\left(\delta c\left(s_1\right)+\delta c_0+c_f+c_i\right)-2\beta_1(r+\beta_1)^3\left(2w+\delta c\left(s_2\right)-\delta c_0+c_f-c_i\right)}{2\left(4r^2+8r\beta_1+2\beta_1^2\right)\left(r+\beta_1\right)} \tag{20}$$

$$D_2^{DD^*}=\frac{N_2-(r+\beta_1)^2F+\left(r\beta_1+\beta_1^2\right)\left(2r^2+4r\beta_1+\beta_1^2\right)\left(\delta c\left(s_1\right)+\delta c_0+c_f+c_i\right)+2\beta_1^2(r+\beta_1)^2\left(2w+\delta c\left(s_2\right)+\delta c_0+c_f+c_i\right)}{2\left(4r^2+8r\beta_1+2\beta_1^2\right)\left(r+\beta_1\right)} \tag{21}$$

Bring ( $p_1^{DD^*}$ , $p_2^{DD^*}$ , $D_1^{DD^*}$ , $D_2^{DD^*}$ ) into formula (16) and formula (17), the maximum benefits of manufacturers and retailers in the supply chain respectively are:

$$R_1^{DD^*}=\frac{\left(p_1-\delta c\left(s_1\right)-\delta c_0-c_f-c_i\right)Q_4+\left(w-\delta c_0-c_i\right)Q_5}{2\left(4r^2+8r\beta_1+2\beta_1^2\right)\left(r+\beta_1\right)}$$

$$R_2^{NDD^*}=\frac{\left(p_2-w-\delta c_0-c_f\right)Q_5}{2\left(4r^2+8r\beta_1+2\beta_1^2\right)\left(r+\beta_1\right)}$$

The maximum total revenue of dual channel supply chain is:

$$R^{DC^*}=R_1^{DD^*}+R_2^{DD^*} \tag{22}$$

$$Q_4 = \left(4r^3 + 10r^2\beta_1 + 2\beta_1^2\right)l_1 + \left(2r^2\beta_1 + 4r\beta_1^2 + \beta_1^3\right)l_2 + \beta_1\left(r+\beta_1\right)F - (2r^2 + 4r\beta_1 + \beta_1^2)^2\left(\delta c\left(s_1\right) + \delta c_0 + c_f + c_i\right) - 2\beta_1(r+\beta_1)^3\left(2w + \delta c\left(s_2\right) - \delta c_0 + c_f - c_i\right) + [C\beta_1 - 2\left(r+\beta_1\right)^2 A + 2\left(r+\beta_1\right)\left(4r^2 + 8r\beta_1 + 2\beta_1^2\right)\left(\alpha+\beta_1\right)]$$
$$s_1 + [D\beta_1 - 2\left(r+\beta_1\right)^2 B - 2\beta_2\left(r+\beta_1\right)\left(4r^2 + 8r\beta_1 + 2\beta_1^2\right)]s_2$$

$$Q_5 = \left(4r\beta_1^2 + 2r^2\beta_1 + 2\beta_1^3\right)l_1 + \left(4r^3 + 12r^2\beta_1 + 11r\beta_1^2 + 3\beta_1^3\right)l_2 - (r+\beta_1)^2 F + \left(r\beta_1 + \beta_1^2\right)(2r^2 + 4r\beta_1 + \left(\left(r+\beta_1\right)A + 2\beta_2\left(r+\beta_1\right)\left(4r^2 + 8r\beta_1 + 2\beta_1^2\right)\right]s_1 - \left[D + Dr - 2\left(r+\beta_1\right)B - 2\left(\pm+\beta_2\right)\left(r+\beta_1\right)\left(4r^2 + 8r\beta_1 + 2\beta_1^2\right)\right]s_2$$

## Comparison Between Centralized Decision-Making and Decentralized Decision-Making

According to proposition above, it can be illustrated the service level of manufacturers and retailers and big data will affect the pricing and profit in different decision-making situation. Based on the literature and profit function in this paper, it can make an inference: when the cost of investing in big data information satisfies $2c_f + 2c_i$ <(1- $\delta$ ) (c( $s_1$ )+ c( $s_2$ )+2 $c_0$ ), the total revenue of dual channel supply chain will increase after investing in big data information. The demonstrate process shows below.

To compare the income before and after big data information investment in the dual channel supply chain and assume $\Delta R_1$ and $\Delta R_2$, which represent revenue increment in centralized decision-making and decentralized decision-making. If it assumed that optimal profit function under centralized decision-making is $R^{NCD^*}$, optimal profit function under decentralized decision-making is $R^{NDD^*}$, when $\Delta R_1 = R^{CD^*} - R^{NCD^*} > 0$, and $2c_f + 2c_i$ <(1- $\delta$ ) (c( $s_1$ )+ c( $s_2$ )+2 $c_0$ ). Similarly, when $\Delta R_2 = R^{DD^*} - R^{NDD^*} > 0$, it satisfied $2c_f + 2c_i$ <(1- $\delta$ ) (c( $s_1$ )+ c( $s_2$ )+2 $c_0$ ). The demonstration process illustrated it can not necessarily make the supply chain benefit increase when investing in big data information in a dual channel supply chain, the investment cost needs to meet a certain threshold $2c_f + 2c_i$ <(1- $\delta$ ) (c( $s_1$ )+ c( $s_2$ )+2 $c_0$ ). Only when the investment cost is within this threshold, the total income of dual channel supply chain will increase.

Additionally, make partial derivation of big data information investment cost $c_f + c_i$ and retailing channel service level $s_1$ $and$ $s_2$, $\frac{\partial\left(c_f + c_i\right)}{\partial s_1} = -\frac{\left(\alpha r + \alpha\beta_1 + r\beta_2\right)}{r\left(r + 2\beta_1\right)} < 0$, $\frac{\partial\left(c_f + c_i\right)}{\partial s_2} = -\frac{(\alpha\beta_1 - r\beta_2)}{r(r + 2\beta_1)} < 0$ it shows that cost of investing in big data information in network channels and retail channels $c_f$+$c_i$ and channel service level $s_1$ and $s_2$ are the negative correlation. When the cost of investing in big data information increases, the corresponding channel service level decreases. That is with the increase of big data information investment in the supply chain, supply chain members obtain more external information of customers, optimize the original cost in the supply chain, and reduce the channel service level required in the supply chain. At the same time, the increase of channel service level can reduce the cost of investing in big data information, because it easier to obtain external information such as customer needs and preferences with the improvement of channel service level. So as to reduce the cost of big data. Therefore, there is a close relationship between investing in big data information and channel service level. The enterprises can reduce the cost of the supply chain and increase the overall income of the supply chain through joint improvement.

## DISCUSSION AND CONCLUSION

This study contributes to the academic research that attempts to illustrate the channel decision-making considering service behavior in big data situation. In this paper, the researchers construct the demand

model and income model of manufacturers and retailers, analyze the centralized decision model and decentralized decision model of manufacturers and retailers by using the method of Stackelberg game. The findings show that in the dual channel supply chain, the channel price is directly proportional to the channel service level provided by manufacturers and retailers. When investing in big data information, the cost of big data information needs to satisfy a certain threshold and then the supply chain members make more profit. The channel price is directly proportional to the cost optimization coefficient. When investing in big data information, the cost of investing in big data is inversely proportional to the channel service level. And when the cost of investing in big data information increases within a certain threshold range, the channel service cost coefficient decreases. Investing in big data within a certain threshold can obtain consumer preferences, improve service quality, expand consumer demand, and make the dual channel supply chain obtain more profits. In the decision-making of the two situations, the total profit of the centralized decision-making is the largest one in the supply chain. Therefore, enterprises should make good use of the value of big data information, so as to better grasp the market law.

The results of this study provide relevant insights for enterprise supply chain members. By using big data technology, new retailing enterprises can obtain information inside and outside, grasp consumer preferences, optimize the original cost of the enterprise, and formulate development strategies. Introducing big data into the supply chain is a positive measure for retailing enterprise. In a certain investing range increasing investment in big data, enterprises can continuously excavate valuable big data information, make full use of big data technology, optimize the cost in the process of production and sales, and promote the continuous development and growth of enterprises.

Another important and innovative insight reveals the close relationship between investment big data information and channel service level. Actively strengthen the construction of big data public information platform and the cooperative relationship between itself and other enterprises in the supply chain. The awareness of big data analysis can improve the ability of supply chain risk management. And at the same time, the new retailing enterprises provide high-quality channel service level, and establish a good and stable relationship with customers.

The channel decision-making set by manufacturers and retailers in the process of dual channel supply chain management is related to many factors. Based on the findings in this study, the searchers suggest the supply chain enterprises should comprehensively consider various factors in the supply chain, including big data, member channel service behavior etc. Supply chain enterprises should also improve their decision-making level by technical means such as big data, and make effective development strategies for enterprises. Deeply analyze the relationship between supply chain pricing and these factors, and formulate scientifically and reasonably service strategies, so as to attract more consumers and create more benefits.

This paper discussed how suppliers and retailers compete and cooperate online and offline under the dual channel supply chain, and enriched the theoretical methods and decision-making to the conflict between retailers under dual channels. It also enriched the theoretical research of new retailing under dual channel supply chain. A coordination mechanism is proposed for the research of competition and cooperation theory in new retailing dual channel supply chain. Meanwhile, new retailing supply chain enterprises can recognize the relationship between big data and supply chain in the business operation, and then help enterprises to make strategic decisions more suitable for enterprises development and improve the decision-making level of supply chain enterprises. Future research on decision making and coordination strategies of dual channel supply chain, multi-channel supply chain, and closed-loop supply chain which composed of multiple manufacturers and retailers are needed. This research provides insight into how service behavior influences the decision-making in dual-channel supply chain under the background of big data, there is not much research on the behavior of customers, prices and other influencing factors. There is also a need to highlight the role of customers and big data service Company. Finally, research is needed to consider corresponding coordination strategy in retailing practices, and assess contract model of supply chain coordination in big data environment.

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