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The Study on Pricing Decision and Revenue Allocation of Dual-channel Supply Chain under Customization in Ecology Industry

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Abstract

In a customized dual-channel supply chain system, ecology industry is the major supply chain participants. Based on ecology industry participating in the realization of customized product sales, the online channel and offline channel demand functions are proposed, and markup pricing is regarded as the pricing strategy in this study. The conclusions are summarized as below. (1) In a customized dual-channel supply chain system, proper pricing decisions could realize the overall revenue maximization of a supply chain. (2) Supply chain revenue maximization is determined by the price sensitivity difference between online channel demand and offline channel demand. (3) Practicable ecology industry revenue allocation ratio is related to ecology industry's online sales contribution and offline sales performance.

Keywords: dual-channel supply chain, ecology industry, pricing decision, customization, revenue

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INTRODUCTION

The ecological industry is a modern enterprise established by using ecological engineering methods and various modern advanced science and technology. The eco-industry includes waste, energy and raw material selection, process technology, equipment maintenance management, product production, transportation, consumption and resource utilization.

Under the background of industries with relatively excessive production capability, the concern about customer personalized demand and convenient demand satisfaction is becoming the unanimity of upstream and downstream eco-enterprises in a supply chain. To analyze from the aspect of channels, e-commerce is a ecology product sales realization path different from traditional distribution. It is generally called online channel. On the contrary, traditional distribution channels are called offline channel. According to the participation in e-commerce ecology businesses and the observation of current situation of enterprises in various supply chains, the rapid growth of e-commerce businesses has driven numerous ecology industry selling products through online channels to keep the competitive advantages and promote the market availability of ecology products. In this case, it is inferred that the traditional role of ecology industry in supply chains are changing. One study indicated that consumers were inclined to dual-channel of shopping choice and experiencing (Batarfi et al. 2016). Such a trend was forcing suppliers to introduce direct-sale channels as an essential channel strategy. Another research further explained that the establishment of dual channels, under certain conditions, could benefit eco-industry (Braglia and Zavanella 2003). In fact, eco-enterprises also sensed the meaninglessness of resistance to direct-sale channels, as it could simply push customers' purchase behavior to other places (Cao 2014). For this reason, different levels of participation eco-industry in a supply chain should actively adapt to eco-product distribution channel structure and timely make necessary adjustment.

The structure of single channel changing to dual-channel is the changes to adapt to customers' demand satisfaction. The incentive to promote technology in the process cannot be neglected. Meanwhile, the presentation of consumers' personalized ecology product demands and the tight association between channel structure changes and personalized demand satisfaction should be concerned. Under the assumption of dual-channel structure, online/direct-sale channels shorten the "spatial" distance between ecology product producers and consumers to benefit

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the application of convenient information technology and allow ecology enterprises realizing the collection and storage of customer-related information to further comprehend customers' individual preference. Furthermore, it is indicated that the majority of excellent eco-enterprises have presented the capability to produce customized ecology products satisfying customer preference. Based on advance operating technologies of flexible manufacturing system (FMS) and computer-aided design/manufacturing (CAD/CAM), a eco-enterprise could realize the production of personalized customized ecology products with the cost for mass production, i.e. mass customization (MC), producing customized ecology products with the cost for mass production. Apparently, MC provides the theoretical support for satisfying personalized demands. The massive production cost for customized ecology products lays the foundation of the popularization of personalized ecology product consumption. Accordingly, it is considered that the realization of current consumers' personalized ecology product demands is practicable. In this case, eco-industry should attempt to regard MC as the beneficial supplement of current production strategies, rather than being isolated in traditional eco-industry. It would effectively enrich eco-industry' production capacity and enhance the market share to further acquire more revenue (Chen et al. 2008, 2012).

It should be clarified that the supply chain management would become more complicated once the dual-channel ecology product supply structure is introduced into current ecology product supply systems (Chiang et al. 2003). When ecology industry in a supply chain or other supply chain participants in non-sales nodes construct the ecology product supply channel directly reaching end consumers, it is inevitable for new channel constructors swallowing the market share of original channel owners and the occurrence of channel conflict (Dan et al. 2012). Moreover, in consideration of the concern about dual-channel to personalized demands in the future, the coordination among supply chain participants becomes a key decision-making problem in the future operation of dual-channel supply chain.

LITERATURE REVIEW

Reviewing the past research on supply chain management (SCM), dual-channel supply chain has been a research hot spot, and pricing decision, channel conflict, and coordination strategy are frequently studied topics (Ding et al. 2016). Being a relatively new supply chain pattern, a dual-channel product supply provides channel convenience for customers but has dual-channel supply chain participants encounter new decision-making problems, where the conflict between online channels and offline channels is inevitable. Besides, relevant research has made meaningful and active attempts on the coordination strategy of supply chains.

Channel Conflict

Regarding the introduction of online channels into traditional supply chain channels, relevant research indicated that introducing online channels could largely result in decreasing wholesale prices of the sales products in retail channels, enhance the profits of enterprises, and eventually have all enterprises acquire higher revenue (Chen et al. 2008, Fruchter and Tapiero 2005). It was the best footnote about the appropriateness of introducing new channels. However, it should be pointed out that channel conflict and contradiction were inevitable in the integration of new/old channels. It was also the primary problem requiring solutions in the channel integration process. Furthermore, past researches indicated that the strategy of online channels enhanced the channel efficiency to significantly promote customer satisfaction (Hanover 1999, Hua et al. 2010). Fruchter and Tapiero have studied the pricing strategy of dual-channel supply chains with dynamic hierarchical game theory and indicated that a eco-enterprise could set the same price in two channels (Huang et al. 2013). It was discovered that customer heterogeneity would affect prices in direct-sale channel, retailers' markup ratio, and the overall profit of the supply chain. Some other scholars have studied the demand diffusion and shared value between online channels and retail channels and indicated that the demand level between two channels could be kept stable under certain conditions and online channels would result in negative effects on retailer performance (Huang et al. 2012, Lei et al. 2014). Under Stackelberg environment, one study considered the coordination strategy of dual-channel supply chain that a dual-channel supply chain would improve the overall efficiency when enhancing the profits of retailers and eco-enterprises (Dan et al. 2012). Another researchers discussed the information sharing and channel structure of vertical and horizontal demands in a dual-channel supply chain and indicated that retailers presented the initiative on information sharing under horizontal integration, not vertical integration (Li et al. 2017). It obviously was an active signal that channel conflict could be released.

From above literatures, current research on dual-channel supply chain focused on revenue optimization and conflict release when eco-enterprises provided single product/standard product through dual channels, little research stressed on satisfying customer demands for standard products and customized products in a dual-channel supply chain (Raju and Roy 2000, Salvador et al. 2009, Shao 2013). In consideration of providing customized products with online channels and offering standard products with traditional channels, one research indicated that adding an online channel for customized products would enhance the profit of the integrated supply chain system (Dinget al. 2016). When there were customized products in the dual-channel supply chain system, the natural advantage of mutual convenience between online channels and customers, where standard products were provided through offline channels (traditional channels) and customized products were provided through online channels, was an advantageous choice.

Channel Coordination

Considering the effect of the introduction of online channels on product delivery processes and customer dialogue modes, past researches considered the strategies of retail service or service competition in dual-channel supply chains (Shao 2013, Takahashi et al. 2011, Tsay and Agrawal 2004). It was wondered how faster product delivery could be realized and how customer service could be enhanced in online/offline channels in the dual-channel supply chain system. Such questions required special concerns about the coordination operation in the dual-channel supply chain system. Chen et al. pointed out the relationship between a eco-enterprises' optimal channel strategy and channel environment. Generally speaking, retail channel showed relatively lower profits than direct-sale channel. Yan and Pei considered that improved retailer service could benefit channel competition and improve supply chain performance. Den et al. emphasized the direct effect of retail service on the overall profit of the system and the pricing strategy of eco-enterprises and retailers. In this case, when the introduction of online channels resulted in conflicts between traditional channels and newly introduced channels, the introduction of coordination mechanisms changed with the attributes of different channels.

Aiming at demand disruption and production cost disruption, some researchers discussed the best pricing and production decision in dual-channel supply chains under concentrated and distributed decision environments (Raju and Roy 2000, Salvador et al. 2009). Another study discussed the best pricing and production decision in dual-channel supply chains as well as the coordination operation strategy under the assumption of demand disruption (Xu et al. 2015). Under demand and production disruption, some scholars realized the coordination of dual-channel supply chains with contracts and discovered that the adjustment of contract parameters could realize the supply chain coordination under demand disruption (Yan and Pei 2009).

When consumers' personalized demands become the manifest demand, participants in different supply chain levels actively exploring the realization of customers' customized demands has become an urgent decision-making affair. Discussing the realization of personalized demands from the aspect of channel structure, i.e. satisfying customized product demands with online channels and satisfying standard product demands with offline channels, might be a practicable choice. By extending the research thinking of one past study (Ding et al. 2016), this study remains the basic channel structure of dual-channel, when the introduction of online channels is confirmed to effectively improve the profit of integrated supply chain systems, to focus on new problems derived from the change of channel structure and discuss the strategy and path to realize revenue maximization.

MODEL AND BASIC HYPOTHESIS

Dual-channel Supply Chain Model

Assuming that a supply chain which could satisfy customers' customized demands is composed of single manufacturer and single eco-entreprise, the eco-enterprises presents the capability to provide standard ecology products and customized ecology products for market demands. Through the replacement or increase/decrease of customized components/parts of standard ecology products, the eco-enterprises could realize the ecology product customized attribute satisfying customer demands in the production process or before the delivery of customized ecology products. In consideration of the diverse ways to satisfy customer demands, a eco-enterprise, based on traditional product delivery channels, establishes online sales channels, i.e. online channels. On the contrary, retailer-oriented traditional ecology product delivery channels are offline channels. The dual-channel supply chain which could satisfy customers' customized ecology product demands is shown in **Fig. 1**.

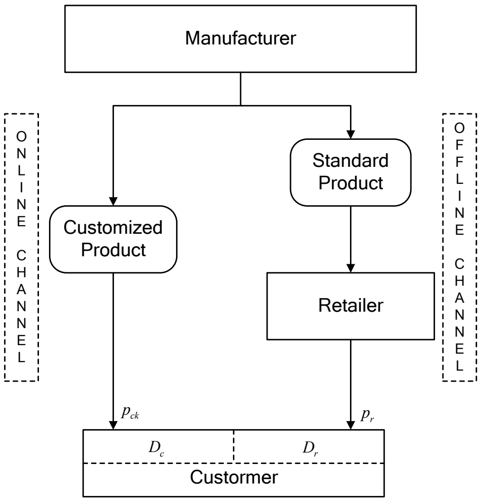

Fig. 1. Base model of DCSC

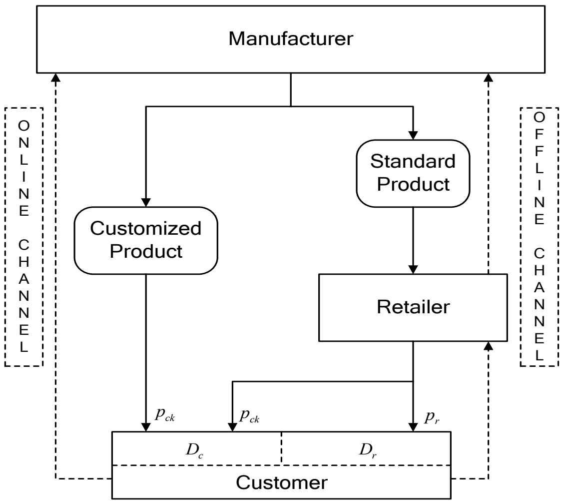

Fig. 2 Revised model of DCSC

Basic Hypothesis

Some hypotheses are given to simplify the research as following.

(1) Eco-enterprise produces customized ecology products and standard ecology products indistinguishably.

(2) Customized ecology product delivery is completed through online channels and standard ecology product delivery is completed through offline channels.

(3) p_{ck} is the delivery price of customized ecology products, where k could be any values in $(1,2,\cdots,N)$, N, a countable positive integer, stands for the total transformed ecology products realized in a eco-enterprise's customization process, p_r is the market price of standard ecology products, and D_c and D_r stand for online channel/offline channel customer demands.

(4) A eco-enterprise's customer quoted delivery lead-time (QDL) is within the customer accepted range.

(5) Consumers could effectively distinguish customized ecology products and standard ecology products, and give personalized demand information feedback to eco-enterprises.

(6) Customized ecology products could be regarded as the results of standard ecology products increase/decrease allocation or components replacement.

Optimal Decision

Taking hypotheses (5) & (6) as the bases of online channel and offline channel participants, the modified supply chain model is shown in **Fig. 2**. Assuming the sales prices of standard ecology products and customized ecology products as p_r and p_{ck}, respectively, the production cost of standard ecology products is c_p and the wholesale price is c_r. To simplify current research questions, retail prices in offline channels equal the wholesale prices, $c_r = p_r$. Besides, assuming the production cost of customized ecology products c_{ck}, markup pricing is the channel pricing strategy and the markup ratio is set m that $c_r = p_r = c_p(1+m)$, $p_{ck} = c_{ck}(1+m)$. Then the demand functions can be written as following.

$$D_r = (1-\theta)a - \alpha_r c_p(1+m) + \rho\sum_{k=1}^{N}\frac{c_{ck}(1+m)}{N} + \beta_r l_c - \psi_r\eta_c \quad (1)$$

$$D_c = \theta a - \sum_{k=1}^{N}\frac{\alpha_{ck}c_{ck}(1+m)}{N} + \rho c_p(1+m) - \beta_c l_c + \psi_c\eta_c \quad (2)$$

Assuming α_{ck} as a constant, $\alpha_{ck} = \alpha_c$, the possible difference in price sensitivity to customized ecology products among different online channel customers is ignored when considering the interaction between prices and channel demands. In this case, demand functions (1) & (2) could be further rewritten as

$$D_r = (1-\theta)a - \alpha_r c_p(1+m) + \rho(1+m)\sum_{k=1}^{N}\frac{c_{ck}}{N} + \beta_r l_c - \psi_r\eta_c \quad (3)$$

$$D_c = \theta a - \alpha_c(1+m)\sum_{k=1}^{N}\frac{c_{ck}}{N} + \rho c_p(1+m) - \beta_c l_c + \psi_c\eta_c \quad (4)$$

In current dual-channel supply chain system, one eco-enterprise's profit is composed of online channel profit $\pi_{1,c}$ and offline channel profit $\pi_{1,r}$. Since the previous condition of $c_r = p_r$ exists in retail channel pricing, retailer profit $\pi_{2,r} = 0$. Dual-channel profit discussed in this study is then transformed into the discussion of eco-enterprise's online/offline channel profit. The specific profit function is shown as below.

Online profit:

$$\pi_{1,c} = (1+m)\sum_{k=1}^{N} c_{ck}\, D_c - \left(\left(\frac{h_1 q_c}{2}\right)\left(1-\frac{D_c}{q_c}\right) + D_c \sum_{k=1}^{N}\frac{c_{ck}}{N}\right) \quad (5)$$

Considering the countability of customized ecology product variety in online channels, there is customized ecology product average cost c_c which could satisfy weighted conditions, and $\sum_{k=1}^{N} c_{ck} = Nc_c$. (3), (4) & (5) could be further rewritten as followings.

$$D_r = (1-\theta)a - \alpha_r c_p(1+m) + \rho(1+m)c_c + \beta_r l_c - \psi_r \eta_c \quad (6)$$

$$D_c = \theta a - \alpha_c(1+m)c_c + \rho c_p(1+m) - \beta_c l_c + \psi_c \eta_c \quad (7)$$

Online profit:

$$\pi_{1,c} = (1+m)c_c D_c - \left(\left(\frac{h_1 q_c}{2}\right)\left(1-\frac{D_c}{q_c}\right) + c_c D_c\right) \quad (8)$$

Offline profit:

$$\pi_{1,r} = (1+m)c_p D_r - \left(\frac{h_1 q_r}{2} + c_p D_r\right) \quad (9)$$

where h_1 is a eco-enterprise's stockholding cost coefficient, q_r and q_c are a retailer's order quantity and a eco-enterprise's production lot, respectively. An eco-enterprise's batch conversion cost is not included in the possible cost project in this study. As the example of (5), the two costs are stockholding cost and production cost. Besides, stock cost in this study is calculated by referring to one past research (Yue and Liu 2006). The calculation of an eco-enterprise's online profit is referred to the supply chain structure in **Fig. 2**, where a retailer is also an important participant in customized ecology product sales. However, the deserved revenue of a retailer participating in customized ecology product sales is not considered in the calculation of online sales profit in (5).

In the parameter setting in this study, c_c and c_p, which are constant, are the initial variables of the system. When considering the effect of variables on the dual-channel supply chain, m becomes the key variable; and, once m is given the value, the channel pricing mechanism is confirmed. The channel optimal decision therefore could be given as following process. $\pi_{1,c}$ and $\pi_{1,r}$ are respectively calculated the first and second derivatives of m. Through simple calculation, then we can get:

$$m^* = \frac{\left(\theta a - \beta_c l_c + \psi_c \eta_c - \frac{1}{2}h_1\alpha_c\right)c_c + 2\rho c_c c_p - \alpha_c c_c^2 + \left((1-\theta)a + \beta_r l_c - \psi_r \eta_c + \frac{1}{2}h_1\rho\right)c_p - \alpha_r c_p^2}{2\left(\alpha_c c_c^2 + \alpha_r c_p^2 - 2\rho c_c c_p\right)} \quad (10)$$

m^* is the condition of π_{total} acquiring the extreme. In this case, to ensure the extreme acquired with π_{total} as the maximum value, it should satisfy $\frac{\partial^2 \pi_{total}}{\partial m^2} < 0$,

i.e. $\frac{\partial'' \pi_{1,c}}{\partial m^2} + \frac{\partial^2 \pi_{1,r}}{\partial m^2} < 0$,

then

$$c_c\left(\rho c_p - \alpha_c c_c\right) + c_p\left(-\alpha_c c_p + \rho c_c\right) < 0 \quad (11)$$

From the above we can obtain

$$\frac{c_c}{c_p} < \frac{\alpha_c c_p - \rho c_c}{\rho c_p - \alpha_c c_c} = \frac{a - \frac{\rho}{\alpha_c}\frac{c_c}{c_p}}{\frac{\rho}{\alpha_c} - \frac{c_c}{c_p}} \quad (12)$$

where $\frac{c_c}{c_p} = \lambda_1$, $\frac{\rho}{\alpha_c} = \lambda_2$, then (15) can be rewritten as $\lambda_1 < \frac{1-\lambda_1\lambda_2}{\lambda_2-\lambda_1}$, i.e.

$$(\lambda_1 - \lambda_2)^2 + 1 - \lambda_2^2 > 0 \quad (13)$$

Apparently, the sufficient condition for (13) is $1 - \lambda_2^2 > 0$, i.e. $\lambda_2^2 < 1$. Considering the non-negativity of parameters set in our study. It is also the basic condition for current dual-channel supply chain system's maximum revenue.

REVENUE ALLOCATION

When the offline channel sales in dual-channel supply chain satisfies $c_r = p_r$, a retailer's traditional sales competency income becomes zero. In this case, retailer competency set in the dual-channel supply chain system in this study is transformed into the services of ecology product show, user experiencing, and customized information delivery (it might be the possible development direction of future offline channel competency). Consequently, when considering the system revenue allocation, above functions presented by retailers in the dual-channel supply chain system are the important weighted variables to determine the revenue.

According to the set contribution mechanism of offline channels to the realization of customized ecology product sales in **Fig. 2**, the proportion of the online sales realized through offline channels in the customized ecology product gross sales is μ. Moreover, considering the profit $\pi_{1,r}$ realized through traditional offline sales, the single-product profit is the difference between offline channel selling prices and ecology product supply prices. In previous discussions, the ecology product whole price c_r is the same as the ecology product sales price p_r through offline channels, i.e. $c_r = p_r$. The ecology product whole price through offline channels therefore could be understood as the direct supply price of standard ecology products. In this case, a retailer's standard ecology product sales could not be reported as zero, although it is set $\pi_{2,r} = 0$ previously. Retailers, as an important part to realize standard ecology product sales, are affirmed the profit contribution as a primary consideration in the revenue allocation mechanism design.

Based on above analyses, the deserved revenue allocation share of retailers, as an important channel participant, in the dual-channel supply chain system set in this study is designed based on offline and online sales contribution. Assuming the deserved supply chain revenue share of a retailer as ξ, ξ is the function of μ and v, where v is the retailer's contribution in the standard ecology product sales. According to previous assumption,

$$\mu = \frac{\pi_{1,c}}{\pi_{total}} \tag{14}$$

the value of v is directly proportional to gross sales created by offline channels that

$$v = \frac{D_r}{(D_r + D_c)} \tag{15}$$

Furthermore, assuming the function relations between ξ and μ, v as $\xi = g(\mu, v)$, the values of μ and v, under confirmed online channel and offline channel profits and demands, are confirmed that the deserved revenue share of retailers in the dual-channel supply chain could be given, according to the revenue allocation function $\xi = g(\mu, v)$. The specific function expression of ξ is also worth further discussion, but it is not discussed in this study. In previously given settings of μ and v, they are actually associated variables. It could be judged that keeping constant pricing rules, when μ is larger, i.e. the higher proportion of online channel profit, would result in larger online channel sales contribution. It would therefore reduce the sales amount completed through offline channels, i.e. smaller offline channel demand D_r, that the value of v is presumed smaller. When the conditions in the previous inference are reversed, the conclusion is opposite.

CONCLUSION AND PROSPECTS

Under the condition of ecology product customization being an available option, the dual-channel supply chain system provides a new option for customers' ecology product purchase decision. In this case, online/offline channels, as the options of sales path, are promoted to customers. In face of differential sales channels and ecology product attributes, how customers would make choices is an interesting question and is worth discussion. Under the assumption of dual-channel supply chain system, it is proposed in this study that customer demands for both standard ecology products and customized ecology products could be satisfied in the channel. The preliminary conclusion and the value of this study are summarized as below.

Theoretical Contribution

The preliminary research conclusion contains three parts.

(1) Under the condition of setting m as the pricing markup parameter in the dual-channel supply chain system, the second derivative of m is calculated through the total profit function π_{total} in the supply chain system. The research points out the existing condition for $\frac{\partial^2 \pi_{total}}{\partial m^2} < 0$,

i.e. $c_c(\rho c_p - \alpha_c c_c) + c_p(-\alpha_c c_p + \sigma c_c) < 0$.

Accordingly, it is judged that the system revenue maximization, under confirmed parameters, is an optimal decision problem with solutions. In other words, the revenue maximization in the dual-channel supply chain system, under customized ecology products, is a practical decision problem with the optimal solution.

(2) Aiming at the extended discussion of unequal conditions in (11), when the variables $\lambda_1 = \frac{c_c}{c_p}$ and $\lambda_2 = \frac{\rho}{\alpha_c}$ are introduced, (11) is equivalent to (13). As a result, it could be substituted with the sufficient condition in (13), i.e. the inequality $1 - \lambda_2^2$. In current research, the parameters in the model satisfy non-negative condition, $\lambda_2 = \frac{\rho}{\alpha_c} > 0$, i.e. $0 < \lambda_2 < 1$. In consideration of the non-negativity of λ_2 value, the sufficient condition for the dual-channel supply chain acquiring the maximum value is $\lambda_2 < 1$, i.e. $\rho < \alpha_c$, where ρ is the factor in the price interaction between channel demands and α_c is the sensitivity of online channel demands to online channel pricing. The condition of $\rho < \alpha_c$ is explained that the revenue maximization of the research question exists in the optimal solution, when the interactive price sensitivity between channel demands is lower than the sensitivity of online channels to prices. It is one of the research conclusions. In this case, it is also inferred that the sensitivity of online channel demands to ecology

product prices is the key factor in the realization of the overall revenue maximization in the channel, when customization is considered in the dual-channel supply chain. When the price sensitivity of online channel demands is higher than the price sensitivity between channels, the overall revenue maximization of the dual-channel supply chain could be realized. As a result, it is judged that consumer sensitivity to channel prices, in the customized dual-channel supply chain, is the key factor in channel revenue. The differential characteristics of channels, ecology products, and sales objects therefore should be taken into account in the modeling and model optimization process.

(3) In this study, when other parameters are fixed, the m^* value is the sole condition of π_{total} maximization. The parameter m determines the pricing markup relationship among participants in the supply chain system. That is, once the set c_c and c_p are constants, the pricing rules in various hierarchies in the supply chain are confirmed.

Practical Value

In the research hypotheses, customers are assumed as ecology product difference and price sensitive perception objects which could respond to differential ecology product attributes and attractive prices. In the research process, an interesting research situation is purposely designed. The clearly different channel design between offline channels and online channels in past similar research is modified as a coordinated dual-channel product sales system (Ding et al. 2016). Retailers, when completing standard ecology product sales, would actively utilize the advantage of direct contact with customers for customized ecology product sales through online channels. The role setting in the system thoroughly considers the practicable coordination between online and offline channels, when a party in the supply chain operating body is the leader of the supply chain; and, the coordination among supply chain participants could assist in the realization of the overall revenue maximization in the channel (Zhang et al. 2015). It reveals a new model of coordination among supply chain participants in the dual-channel supply chain system in this study. Besides, it also indicates that, when customization becomes an option in customers' ecology product purchase decision, the price sensitivity of online channel demands and the price sensitivity between channels are comparable variables and could affect the realization of revenue maximization in the dual-channel supply chain system. The practice of such a research conclusion means that the price sensitivity difference between ecology products and channel demands needs to be confirmed before introducing differential ecology products.

Research Prospects

Under the customized dual-channel supply chain system structure, the solution for participant revenue in various supply chain levels is given. When the specific value of m^* is further confirmed, the solution of supply chain participants' revenue could be transformed into numerical solution. It is the basis for successive case study. As an initial outcome of the research, the proportion of retailers' total revenue in the dual-channel supply chain is $\xi = g(\mu, v)$, the function of μ and v; and, the values of μ and v determine the actual sales amount proportion of retailers' online revenue contribution and offline sales channel. The research merely discusses the effect of previous two variables on the values of μ and v, but not involves in the function related to μ and v. It could be concerned in the successive research.

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