COMPETITIVE STRATEGIES IN THE PRESENCE OF CONSUMERS’ EXPECTED SERVICE AND PRODUCT RETURNS

TING ZHANG
Coordinated Innovation Center for Computable Modelling in Management Science
Tianjin University of Finance and Economics
Tianjin 300222, China

SHUHUA CHANG\textsuperscript{*1,2}, YAN DONG\textsuperscript{1} AND JINGYI YUE\textsuperscript{1}
\textsuperscript{1}Coordinated Innovation Center for Computable Modelling in Management Science
Tianjin University of Finance and Economics
Tianjin 300222, China
\textsuperscript{2}Yango University, Fujian 350015, China

KOK LAY TEO
Coordinated Innovation Center for Computable Modelling in Management Science
Tianjin University of Finance and Economics
Tianjin 300222, China
School of Mathematical Sciences, Sunway University, Malaysia

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Abstract. This paper investigates the optimal strategies and profits of dual channel with product returns in the presence of customers’ expected service. Customers’ expected service is related to advertising effort and price. We build a two-stage decision making process to analyze the impact of expected services of customers. In addition, we analyze the parameter sensitivity and compare the competitive equilibrium strategies. The results show that the manufacturer will give a lower wholesale price to the retailer in some case. Furthermore, the dual-channel product returns will discourage advertising effort and the service level of the retailer, but it will enable the manufacturer to provide a higher service level. Thus, for managers, the survey of the expected service of customers is very important for the optimal strategies making, and it should not always blindly exploit the retailer’s profit for the manufacturer. Finally, when the physical store allows unconditional return of goods, the service level of the online channel will be more considerate.

1. Introduction. The rapid development of electronic devices and digital communication have made it attractive for manufacturers to engage in direct channel sales. Many brand manufacturers, including Hewlett-Packard, IBM, Eastman Kodak, Nike, and Apple, have added direct channel operations [32, 41]. Moreover,
many enterprises have set the same price to avoid price competition between channels. Advertising is an effective way to attract customers to buy the product. For retailers, they are closer to customers and are more aware of customers’ needs than manufacturers, and customers’ preferences vary by regions. In order to solve the conflict of interest between manufacturers’ advertisement and retailers’ advertisement, cooperative advertising is the most effective way. Retailers who understand local needs help manufacturers with advertising promotion, and manufacturers commit to retailers to share some or all of the local advertising costs. This is the mechanism of cooperative advertising. For example, General Motors funds about 25% of their dealers’ and car rental agencies’ local advertising costs [11], and Intel Inside cooperative advertising program expenditures were approximately 1.5 billion in 2001. Many studies illustrate that a cooperative advertising strategy can effectively improve overall profits in a dual channel supply chain management [3, 34, 40]. The cooperative advertising model under the dual channel background brings new opportunities and challenges to manufacturers and retailers.

In today’s service economy era, service is the core of modern enterprise competition weapons and it forms an important means of differentiation. Dual channel marketing model provides considerate and convenient product services and is favored by many customers. But shopping online or offline has some differences for customers. The direct marketing channel enables customers to get products and to enjoy convenient logistics service without leaving their homes. However, the traditional retail channels require customers to choose products to enter the store and spend more money and energy, and which channel customers choose depends on their channel preferences. When customers buy products, they will be affected by the advertisement of the products. The higher the level of product advertising is, the higher the level of service expectations is. In addition, price is an important factor for customers to measure product cost performance. The higher the price is, the higher the expected service level of customers is. When a customer chooses a product, no matter which channel he chooses to buy, he will have a minimum expectation of service level for the product in his mind before purchasing. Besides, direct marketing channels will enable customers to directly contact manufacturers and obtain more direct and comprehensive product information. However, because of the online marketing mode and information asymmetry, customers may not be able to directly see the products, and the pre-sales service information may be different from the real information, which may lead to product returns.

Product return is an important and necessary part of the exchange process between enterprises and customers, and it is a severe, costly problem for enterprises [18, 20]. Amazon, the global e-commerce platform giant, generated 7 billion worth of returned products in total in 2018. According to eMarketer data, Amazon’s total sales in U.S. are expected to reach 258.22 billion U.S. dollars, which means that Amazon’s return will account for nearly 2.7% of total sales. Approximately 30% of purchases were returned [10], and the cost of reverse logistics for each product may be very high, including refurbishment and re-packaging [14]. Online channels can only provide services such as pictures and recommendations, and customers cannot directly access products. Due to these limited ability, uncertainty of product performance will be created [35], which increases the probability that the product will fail to meet the customer’s expectations [30]. Failing to meet the expectations of customers will lead to dissatisfaction with the product, which will increase the
possibility of returns. Therefore, it is important to take into account the return behavior of customers due to the gap between the perceived service and the expected service in the direct channel.

Cooperative advertising can improve the profits of manufacturers and retailers, and bring new opportunities for the development of enterprises in the supply chain. Service is the core competitive advantage for enterprises, which is an important weapon of differentiation. Product return brings high costs to enterprises. An important reason for customers to return products is that it does not meet expectations. Potential customers generate service expectations through advertisements and the retail price, and the gap between perceived service and expected service affects customers’ channel choices. It is necessary to study the strategic choices between the direct-channel manufacturer and the traditional retailer when considering the service expectation of customers in the context of cooperative advertising and product returns.

One of the main contributions of our paper is that we take into account the impact of customers’ expected service to the strategies and profits of the supply chain with product returns. There are many studies on service competition and product returns, but many scholars pay attention to product quality or logistics, and rarely consider the impact of customers’ expectations on the supply chain. To fill this gap, we focus on the following research questions: How does the consideration of customers’ expected service affect the service levels and profits of the supply chain with product returns? Specifically, for a firm in a supply chain, when faced with product returns, how to appropriately adjust the service strategy in combination with the expected service to obtain higher profits? In the presence of customers’ expected service, can manufacturers avoid losing profits by raising the wholesale price? Moreover, considering the impact of the expected service, how would the strategies be changed if both channels allow product returns?

To investigate the above questions, we examine the competition in service and advertising cost-sharing between the manufacturer and the retailer in a supply chain, and take into account the impact of expected service of customers. Consider the case for which the manufacturer has two channels to sell products: a direct channel and a local traditional retailer. We assume that the retailer, who is familiar with customer needs, advertises, and the manufacturer will share the cost of advertisement with it. A two-stage decision-making process is used to investigate the optimal strategies of the manufacturer and the retailer. In the first step, the manufacturer decides the wholesale price. In the second step, the service levels of the dual channels are decided while the retailer decides the advertising effort.

Our model helps manufacturers and retailers in dual channel supply chain determine optimal strategies. It also helps make the optimal adjustment strategies under the circumstances that take into account the product return as well as the impact of customers’s expected service. Some effective and interesting results are obtained as follows: (1) If the customer’s expected service is taken into account, the profits of the manufacturer and the retailer will decrease. Indeed, for the situation that takes into account the impact of the expected service of customers, the marginal impact of customers on advertising will decrease while the marginal impact on price will increase. Therefore, using the backward induction, we see that the retailer will pay more effort on advertising and the expected customer demand will be high, and hence the profits will increase. Consequently, the manufacturer will decrease the wholesale price to the retailer. On the other hand, for the situation where the
actual customer demand is not as high as expected, if the advertising effort and the orders of the retailer are high, then the operating costs will increase, and the profits will decrease. (2) If customers are more sensitive to service but less sensitive to advertising, the manufacturer will give a lower wholesale price to the retailer. In this situation, the basic return rate and advertising cost-sharing are low, or the residual value of returned products is relatively low. As a consequence, the retailer will improve the service level and advertising effort, so that the adverse effect brought by product returns can be reduced. (3) For the situation that the product returns of the direct channel is taken into account, the manufacturer should adjust service strategy according to the basic return rate and the marginal impact of service on the returned volume, rather than trying to improve the service level blindly. Only when the basic return rate is low or the impact of service on returned volume is high, the manufacturer should improve the service level of the direct channel. Otherwise, it will only increase its operating costs. (4) When the traditional retail channel allows product returns, the manufacturer will be forced to give a higher service level. Due to dual channel product returns, the wholesale price to the retailer will be dropped, and the advertising effort and the service level of the retailer will decline. To reduce the loss caused by product returns, the manufacturer shall improve the service level.

Some meaningful managerial implications can be summarized as follows. (i) The survey of customers’ expected service is very important for the service strategies and profits of enterprises. (ii) In some cases, manufacturers can adopt the strategy of wholesale price subsidy to physical stores, rather than blindly acquiring profits from retailers. (iii) Under the impact of the expected service of customers, the expected amount of product returns will increase. When the physical stores also allow unconditional return of goods, the service level of online channels will become more considerate.

The rest of the paper is organized as follows. In Section 2, a review of related literature is provided. In Section 3, a two-stage decision-making process is established and the optimal strategies are obtained. The situation of product returns is considered in Sections 4. Numerical analysis is conducted in Section 5, and in Section 6, product returns of the dual channel and the case of the retail price as a decision variable will be considered. Finally, we conclude the paper with discussions, managerial or economic implications and directions for future research in Section 7.

2. Literature review. This section is related to three streams of current research. The first one examines the service competition of dual-channel, the second one studies product returns of the supply chain, and the third one provides a review of relevant research on the expected service of customers. We discuss each of these streams and show where our research is positioned.

There are many studies on service competition in supply chain, but most of these studies are concerned with the competition of manufacturers or retailers, while a small number of them have studied service competition between manufacturers and traditional retailers. Zhou et al. (2008) [44] develop a multi-period product pricing and service investment model to discuss the optimal decisions of one supplier, one traditional manufacturer and one IoT-based manufacturer in a supplier-dominant supply chain under uncertainty. It shows the advantages of the IoT technology in long-term competition. Zhang et al. (2020) [43] consider a dual-channel supply chain network, which consists of multiple competing manufacturers, multiple competing retailers and multiple demand markets. Then, a dual-channel supply chain
network equilibrium model is established to study the price and service decisions. Ali et al. (2018) [1] explore the pricing and service mechanisms of multiple competing retailers under both decentralized and centralized supply chain configurations while considering potential demand disruptions in the retail market. Ding et al. (2018) [8] consider a price and service time sensitive market, in which two retailers compete for the same group of customers and decide independently the service time guaranteed to customers. They find that when price competition intensifies, service competition is de-prioritized, and a longer service time will eventuate. When service competition is fierce, service time is reduced for greater market share. Jena et al. (2019) [15] develop a mathematical model to consider a case where two tour operators compete on price and services to offer tour packages and provide services to customers through a common local operator. Guajardo et al. (2016) [12] analyze the impact of service attributes (warranty length, after-sales service quality) on customer demand in the U.S. automobile industry. The results indicate that service attributes play a compensatory role with respect to product quality, and the joint consideration of product and service is essential for the development of an effective competitive strategy. Jena and Sarmah (2016) [16] study the price and service competition between two remanufacturing firms. One of the main results obtained indicates that when demand variation increases, the direct system can provide a better results in terms of channel profit when compared with other channel configurations. When service elasticity increases, the global system is more profitable due to coordination between the firms and retailers, compared with the channel-wise integrated and decentralized systems. Similar to Jena and Sarmah (2016) [16], Xia et al. (2019) [38] examine the service-level and distribution channel decisions of two competing manufacturers, focusing on how service competition affects the channel structure. Dan et al. (2014) [7] analyze price and service competition between pure play Internet and strong bricks and mortar retailers in dual channel supply chain. They also investigate the influence of retailers, and propose some competitive strategies for traditional retailers under the e-commerce environment. Dumrongsiri et al. (2008) [9] study a dual channel supply chain that competes on price and service quality. The results obtained suggest that an increase in retailer’s service quality may actually increase the manufacturer’s profit in the dual channel, and the manufacturer is likely to be better off in the dual channel than in the single channel when the retailer’s marginal cost is high and the wholesale price, customer valuation and the demand variability are low. Chen et al. (2008) [5] study the dual channel service competition of manufacturers. Many scholars have found that the Nash equilibrium can bring the highest expected profit to the manufacturer [21, 22], and the manufacturer’s profit is higher in the dual channel scenario. Based on these studies, we use the Nash equilibrium to study service competition between the direct channel with product returns and the traditional retail channel.

The dual-channel sales of products do provide convenient for customers, but due to information asymmetric or other reasons, they also lead to a large number of product returns. Omni-channel Retail Survey (2016) reports that the main reason for returns is that customers either do not like the product, or the product does not fit. Other reasons for returns are that products are not as advertised, they arrive damaged or faulty, the wrong product was sent, and in some cases customers had ordered the wrong product themselves. Many researchers have paid more attention to these questions. Xu et al. (2018) [39] develop an analytical framework to understand the effects of customer network-externality (NE) return on purchase
decisions and firms’ decisions and profits, and to provide prescriptions, so firms can better respond to NE effect in E-business environment where customers face valuation uncertainty. Hu et al. (2018) [13] build a product return model by augmenting the classic monopolist’s dynamic pricing framework to study the impact of product returns. The analysis finds that ignoring returns can lead to overpricing. Xia et al. (2016) [37] study the impact of product returns and the retailer’s service investment on the manufacturer’s channel strategies, and they find that the manufacturer should treat its own returns handling cost as a key factor in its channel structure decision. Ren et al. (2014) [28] consider a price and service competition between dual channel. They assume that both the manufacturer and the retailer provide customer returns policies and arrive at an equilibrium price under a centralized and decentralized supply chains with customer returns. The results indicate that, in some cases, both players can get more profits under Nash equilibrium than under Stackelberg game, and prolonging the delivery time may be an effective measure to improve each player’s profits. Li et al. (2013) [19] develop several theoretical models to examine the effects of online distributor’s return policy, product quality and pricing strategy on customers’ purchase and return decisions. Ofek et al. (2011) [23] study the impact of product returns on the strategies of multichannel retailers, and find that when the difference among competing retailers is not too high, having an online channel can actually increase investment in the level of store assistance. Retailers need to be aware that some products should not be traded online due to the high probability of return. Product returns have become an important problem for online sellers nowadays, which has brought huge cost loss [4]. Paolo et al. (2017) [24] study the impact of customer returns on manufacturers’ multichannel sales strategies, and find that a “bricks and clicks channel structure may be the most profitable option for manufacturers, because it can reduce returns without adhering to strict return policies that would hurt sales. It is particularly important for enterprises to recognize reasons for product returns and formulate the optimal strategies. In this paper, we study the impact of customers’ expected service on a dual channel supply chain service strategies with product returns.

One of the most important reasons for online product returns is that the product or service does not meet customers’ expectations. In other words, the primary stimulus (i.e., dissatisfaction) for product returns, basically represents the degree of disparity between expected and perceived product qualities [2]. According to the modern customer-oriented marketing concepts, customers’ demand is an important factor affecting product production and sales. An organization should try to find out not only how its present customers perceive the quality of its services, but also how potential customers perceive the quality of its offerings [31]. For the optimization of customer relationships, it requires enterprises to have a clear understanding of their customers, and then to organize business processes to treat customers individually based on their needs and their values [29]. This is because customers expect enterprises to anticipate their needs and provide consistent service at levels above their expectations [6]. In the current era of service economy, understanding customers’ service expectations is critically important for the sales of the products. Expectations are viewed as what customers feel a service provider should offer rather than what they would offer [26]. Parasuraman et al. (1991) [25] think that understanding customer expectations is a prerequisite for delivering superior service. Put simply, customers expect service companies to do what they are supposed to do. They expect fundamentals, not fantasy; performance, not empty promises.
Customers’ purchase intentions are strongly influenced by service quality [42]. A potential customer may have formed an attitude/opinion about a provider’s service quality, and may have certain expectations for the service, depending on what the potential customer has heard, read, seen, or through word-of-mouth [31]. There are many studies on the service quality and conceptual models of service quality. However, there is still a lack of research to analyze how the gap between expected services and perceived services affects the supply chain. Hence, we would like to fill the gap, and consider the impact of customers’ expected services, which helps enterprises formulate the optimal strategies to avoid unnecessary costs and reduce the loss of profits.

A significant difference between our model and previous studies in terms of service competition and product returns in the supply chain is that we take into account the impact of customers’ expected service when purchasing. Furthermore, we consider the influence of the service gap between expected service and perceived service, and study the optimal strategies for the manufacturer’s dual-channel return supply chain. As we know, the manufacturer sets up a direct channel to provide service to customers but this will weaken the traditional retail channel. The retailer adopts advertising strategy to attract customers and provides realistic experience to customers, and the manufacturer will share the advertising costs with the retailer. In this paper, we assume that customers are heterogeneous in service selection. Some customers like the convenience of logistics provided by online shopping, while others like to experience real products in traditional retail stores, so as to get instant satisfaction. As it is uncertain whether or not product performance will meet customers’ expectations, the possibility of product returns will occur. Therefore, when there is a gap between the perceived service and the expected service of the customer, it is necessary to study the optimal strategies of manufacturers and retailers when product returns are unavoidable.

3. The basic model. Consider a region where there are one manufacturer (referred to as player $M$) and one retailer (referred to as player $R$). The manufacturer has two channel choices: the direct channel and the traditional retail channel, and both channels sell the same product. The direct channel is that the manufacturer sells products directly to customers through Internet of Things (IOT) or other related network technologies. In the traditional retail channel, the manufacturer sells products through the local retailer. The manufacturer’s advertisements are always national and are dedicated to building brand goodwill. Therefore, we do not consider the manufacturer’s advertisement when researching the sales of products in the region. Here, we only consider advertisement of the local retailer, because it has a better understanding of customer needs and preferences in the region. The retailer’s advertising effort is represented by $A$. The manufacturer can freely enjoy the retailer’s advertising benefits, but will share the advertising costs with the retailer. A two-stage decision-making process is used to analyze the optimal strategies of the two parties in the supply chain. Customers’ online and offline purchase behaviors are heterogeneous. Customers with higher acceptance of online shopping may choose direct channels, while the other customers may prefer the traditional retail stores to purchase. Each customer may buy the product from either one of the channels. Here, we do not consider the out of stock situation of direct and retail channels. Since experience has indicated that customers’ channel patronage choices depend largely on non-price factors [32]. In order to avoid price competition, both the direct channel and the traditional retail channel will provide the
same sales price. Similar to Tsay and Agrawal (2000) [33] and Xia et al. (2007) [36],
the service being considered here includes all demand-enhancing activities, such as
purchase assistance and after-sale logistics service. However, in this paper, we separate
advertising from service, because it can exaggerate or deliver false information.
For the traditional retail channel, the retailer chooses its service level $S_r$, and the
service level of in-store service personnel, which includes the professional competence
of the staff and the additional services of the product. The manufacturer
sets its service level $S_d$, which can be expressed in terms of purchase advice and
lead time. Customers perceive the service levels from the direct channel and the
traditional retail channel to be the same as what the manufacturer and the retailer
claim when selling products. In this model, we assume that customers can obtain
product information through advertisement or other means, and decide to choose
which channel to purchase. The parameter $\lambda$ describes the fraction of the driving
component factor of the total demand captured by the direct channel. It also shows
the proportion of customers who choose the direct channel, regardless of price and
service level. The remaining proportion $1 - \lambda$ of customers choose the traditional
retail channel for purchase.

Customers’ expected services refer to the basic additional services that enterprises
need to provide when customers buy products, such as the basic maintenance
services or logistic services for the household appliances. Because customers always
expect enterprises to do what they should do, the expected service is the most basic
additional service [25]. So, we assume that the expected services of online and offline are the same. Many scholars have shown that customers expect products with
high price and high level of advertisement to have high service level. A potential
customer may have certain service expectations, depending on what he may have
seen about the service in the mass media, or through word-of-mouth [31]. One
key influence on customers’ expectation is price. In essence, customers expect the
compny to provide fair services. Customers pay good money, and the company
provides good service in exchange [25]. The expected service of customers is in-
fluenced by advertisement $A$ and the retail price $P$, and is linearly dependent on
advertisement and price:

$$S_e = aA + bP,$$

where $a$ is the marginal impact of advertisement on the expected service, and $b$
represents the marginal impact of price on the expected service of customers. The
parameters $a$ and $b$ are all positive constants.

The manufacturer sells products to customers through the direct channel, such
as IoT. Similar to [33, 38], we consider the intensity of competition between the two
channels with regards to service behavior. Thus, he demand of customers from the
direct channel is a function of price, the gap between perceived service and expected
service, the retailer’s service and advertisement. More specifically, it is given by

$$D_d = \lambda \alpha - \beta P + \gamma A + \mu (S_d - S_e) - g S_r,$$

where $\alpha$ represents the baseline demand and $\beta$, $\gamma$ and $\mu$ denote, respectively, the
marginal effects of price, advertisement and the gap between the expectation and
reality on the demand. The parameter $g$ denotes the service substitution coefficient
between dual channel, representing the transfer of market demand with service
differences. Here, we assume $\mu > g$, that is, self-service elasticity is greater than
cross-service elasticity. These parameters all are positive. For tractability, the
service cost function is assumed to be a quadratic convex function, similar to [33, 38].
The service cost given by
\[ C_{S_d} = \frac{1}{2} S_d^2. \] (3)
Next, we assume that there is only one retailer, and the demand of the traditional retail channel is
\[ D_r = (1 - \lambda) \alpha - \beta P + \gamma A + \mu (S_r - S_e) - g S_d, \] (4)
where \((1 - \lambda) \alpha - \beta P\) represents the part of the demand affected by price, the parameter \(\mu\) represents the marginal impact of the gap between the retailer’s service and the expected service. The parameter \(g\) indicates that if the service level of the direct channel increases one unit, \(g\) units of the demand will be lost from the traditional retail channel. The service cost is given by
\[ C_{S_r} = \frac{1}{2} S_r^2. \] (5)
The advertisement cost is given by
\[ C_A = \frac{1}{2} A^2. \] (6)
Here, we assume that the retailer advertises and the manufacturer will share the cost, and the parameter \(\tau\) is the proportion. Thus, the total profit of the manufacturer is:
\[ \pi_m = \pi_d + \omega D_r - \frac{1}{2} \tau A^2, \] (7)
where the first term is the revenue of the direct channel, the second term is the retail revenue.
Similarly, the profit of the retailer is given by
\[ \pi_r = (P - \omega) D_r - \frac{1}{2} S_r^2 - \frac{1}{2} (1 - \tau) A^2. \] (8)
Each player tries his best to maximize the profit by choosing the optimal strategies in this game. In this model, the profit functions are as follows:
\[ \pi_m = PD_d + \omega D_r - \frac{1}{2} S_d^2 - \frac{1}{2} \tau A^2, \] (9)
\[ \pi_r = (P - \omega) D_r - \frac{1}{2} S_r^2 - \frac{1}{2} (1 - \tau) A^2, \] (10)
\[ S_e = a A + b P. \] (11)
Substituting the variable \(S_e\) given by Eq. (1) into Eq. (2) and Eq. (4), we obtain
\[ D_d = \lambda \alpha - (\beta + \mu b) P + (\gamma - a \mu) A + \mu S_d - g S_d, \] (12)
\[ D_r = (1 - \lambda) \alpha - (\beta + \mu b) P + (\gamma - a \mu) A + \mu S_r - g S_d. \] (13)
Substituting the variables \(D_d\) and \(D_r\) given by Eq. (12) and Eq. (13) into Eq. (9) and Eq. (10), we have
\[ \pi_m = P [\lambda \alpha - \theta P + \eta A + \mu S_d - g S_r] \\
+ \omega [(1 - \lambda) \alpha - \theta P + \eta A + \mu S_r - g S_d] - \frac{1}{2} S_d^2 - \frac{1}{2} \tau A^2, \] (14)
\[ \pi_r = (P - \omega)[(1 - \lambda)\alpha - \theta P + \eta A + \mu S_r - g S_d] - \frac{1}{2} S^2_r - \frac{1}{2} (1 - \tau) A^2. \]  

(15)

where \( \theta = \beta + \mu b, \eta = \gamma - a \mu \). Here, we can obtain that \( \theta > \beta, \gamma > \eta \), that is, the impact of price on demand increases, the impact of advertising on demand will decrease under the influence of customers’ expected service.

The equilibria of the retailer’s advertising effort, the service level of the traditional retail channel, and the service level of the direct channel are, respectively, given by

\[ A = \frac{\eta (P - \omega)}{1 - \tau}, \]  

(16)

\[ S_r = \mu (P - \omega), \]  

(17)

\[ S_d = \mu P - g \omega. \]  

(18)

The demand of the dual-channel are given by

\[ D_d = \lambda \alpha + \left[ \left( \mu^2 - g \mu - \theta \right)(1 - \tau) + \eta^2 \right] P - \frac{\eta^2 \omega}{1 - \tau}, \]  

(19)

\[ D_r = (1 - \lambda)\alpha + \left[ \left( \mu^2 - g \mu - \theta \right)(1 - \tau) + \eta^2 \right] P - g \omega(1 - \lambda)(1 - \tau)^2, \]  

(20)

Based on the results obtained above, we can see that the higher the wholesale price given by the manufacturer, the lower the service level the retailer is willing to provide; moreover, the retailer will pay less effort on advertising. For the manufacturer, if the wholesale price is higher, it is more profitable to sell the product to the retailer so as to save his own service costs. On the other hand, the higher the retail price, the higher service level of the retailer is willing to provide, which is consistent with reality. According to these results, it is clear from Eq. (19) and Eq. (20), that the wholesale price has a negative impact to the demands of the direct channel and the traditional retail channel. Therefore, if the manufacturer wants to obtain higher profit, it is necessary to formulate an optimal wholesale price strategy based on the actual situation.

Proposition 1. The optimal strategies of the manufacturer and the retailer are, respectively, given by

\[ \omega = \frac{(1 - \lambda)(1 - \tau)^2 \alpha + \left( \mu^2 - \theta \right)(1 - \tau)^2 + \tau \eta^2}{(2 - \tau) \eta^2 + (2 \mu^2 - g^2)(1 - \tau)^2}, \]  

(21)

\[ S_d = \frac{(2 \mu - \mu \tau - g \tau) \eta^2 + (2 \mu^2 - g^2 \mu - \mu^2 g + \theta g)(1 - \tau)^2 P - g \omega(1 - \lambda)(1 - \tau)^2}{(2 - \tau) \eta^2 + (2 \mu^2 - g^2)(1 - \tau)^2}, \]  

(22)

\[ A = \frac{[2 \eta^3 + (\mu^2 \eta + \theta \eta - g^2 \eta)(1 - \tau)] P - \eta \omega(1 - \lambda)(1 - \tau)}{(2 - \tau) \eta^2 + (2 \mu^2 - g^2)(1 - \tau)^2}, \]  

(23)

\[ S_r = \frac{[2 \mu \eta^2(1 - \tau) + \mu(\mu^2 - g^2 + \theta)(1 - \tau)^2] P - \mu \omega(1 - \lambda)(1 - \tau)^2}{(2 - \tau) \eta^2 + (2 \mu^2 - g^2)(1 - \tau)^2}. \]  

(24)
The above proposition shows that if the higher the price is, the higher the wholesale price is, the higher the service level to be provided by the manufacturer and the retailer, and so is the advertising effort.

**Corollary 1.** *The service level and the advertising effort increase in the demand percentage of the direct channel* \( \lambda \), *while the wholesale price decreases with respect to* \( \lambda \).

The managerial implications of Corollary 1 are as follows. When the demand percentage of the direct channel increases, the manufacturer will lower the wholesale price. Furthermore, some subsidies will be given to the retailer. Since the profit of dual channel operation is higher than that of single channel, the demand percentage of the direct channel will increase, and the retailer will improve the service level and pay more advertising effort to attract customers to buy from the traditional retail channel. At the same time, the direct channel of the manufacturer will also improve the service level to retain customers.

### 4. Product returns.

In this section, we consider the situation where online customers are allowed to return the product which is purchased from the direct channel. To model this, we keep the demand functions of the direct channel and the traditional retail channel the same as given by Eq. (2) and Eq. (4), i.e.,

\[
D_{d1} = \lambda \alpha - \beta P + \gamma A_1 + \mu (S_{d1} - S_{e1}) - gS_{r1},
\]

and

\[
D_{r1} = (1 - \lambda) \alpha - \beta P + \gamma A_1 + \mu (S_{r1} - S_{e1}) - gS_{d1}.
\]

Here, we assume that some online customers will return the products, and the returned volume is represented as

\[
R = \phi D_{d1} - \delta (S_{d1} - S_{e1}) = \lambda \phi \alpha - (\phi \theta - \phi \delta) P + (\eta \phi + \delta a) A_1 + (\mu \phi - \delta) S_{d1} - \phi g S_{r1}, \tag{25}
\]

where \( \phi \) and \( \delta \) are two positive parameters. The first term \( \phi D_{d1} \) represents the basic returns independent of the expected service, and the second term \( -\delta (S_{d1} - S_{e1}) \) is the impact of service gap on the product returns. Many products are returned because of service problems, such as the delivery time delay and size mismatch. The quantity of returned products will be reduced when the actual service provided by the direct channel is higher than the service expectation of customers, while it will increase in the opposite case. Since customers can directly and actually experience the service level provided by the retailer in the traditional retail channel, if they are satisfied with the service level, they will buy directly without returning products, and if they are dissatisfied, they will leave the store. Therefore, we are not considering the product returns in the traditional retail channel here.

In Eq. (25), we can see that the marginal effect of the advertising effort on returned volume is positive, which is presented as \( \eta \phi + \delta a > 0 \). The reason can be explained as follows: the better the advertisement introduces the product, the higher the expectations of customers will have, and the gap between the expected service and the actual service will be smaller. After obtaining the goods, customers are more likely to be disappointed with the product, which increases the returned volume of the product. On the contrary, the more considerate and conscientious the seller’s service is, or the better the logistics service is, the fewer the returned volume of the product will be. According to Eq. (25), it is intuitively clear that higher
service level of the traditional retail channel can decrease the product returned volume.

Furthermore, we assume that the manufacturer will receive a product salvage revenue \( r \), which is lower than the sales price \( P \), i.e. \( r < P \), because when a unit product return occurs, the manufacturer will incur processing costs. The manufacturer’s profit function is

\[
\pi_m = P(D_{d1} - R) + \omega D_{r1} + \tau R - \frac{1}{2}S_{d1}^2 - \frac{1}{2} \tau A_1^2,
\]

(26)

where the first term \( P(D_{d1} - R) \) is the revenue from selling returned products that are not returned, the second term \( \omega D_{r1} \) is the revenue from the retailer, and the third term \( \tau R \) is the revenue from selling returned products.

Similarly, the retailer’s profit function is

\[
\pi_r = (P - \omega)(1 - \lambda)\alpha + \theta P + \eta A_1 + \mu S_{r1} - gS_{d1} - \frac{1}{2}S_{r1}^2 - \frac{1}{2}(1 - \tau)A_1^2.
\]

(27)

Taking the partial derivatives of the profit functions, we obtain the relationships between the variables:

\[
A_1 = \frac{\eta(P - \omega_1)}{1 - \tau},
\]

(28)

\[
S_{r1} = \mu(P - \omega_1),
\]

(29)

\[
S_{d1} = \mu P - g\omega_1 + (\mu\phi - \delta)(r - P).
\]

(30)

According to the results obtained above, it is not surprising to find that there is no change in the relationship between the wholesale price and the service levels, which shows that the wholesale price has negative effects on the service levels of the direct channel and the traditional retail channel.

**Proposition 2.** The Nash equilibrium strategies are as follows:

\[
\omega_1 = \frac{(1 - \lambda)(1 - \tau)^2\alpha + [(\mu^2 - \theta)(1 - \tau)^2 + \tau\eta^2]P}{(2 - \tau)\eta^2 + (2\mu^2 - g\tau)(1 - \tau)^2}
\]

\[
+ \frac{(1 - \tau)[\eta^2(1 - \tau) - \eta(\eta\phi + \delta\alpha)](r - P)}{(2 - \tau)\eta^2 + (2\mu^2 - g\tau)(1 - \tau)^2},
\]

(31)

\[
S_{d1} = \frac{\eta^2(2\mu - \mu\tau - g\tau) + (2\mu^3 - g\tau\mu - g\mu^2 + g\phi)(1 - \tau)^2][r - P - g\alpha(1 - \lambda)(1 - \tau)^2}{(2 - \tau)\eta^2 + (2\mu^2 - g\tau)(1 - \tau)^2}
\]

\[
+ \frac{g(1 - \tau)[\eta(\eta\phi + \delta\alpha) - g\mu\phi(1 - \tau)](r - P)}{(2 - \tau)\eta^2 + (2\mu^2 - g\tau)(1 - \tau)^2}
\]

\[
+ \frac{[(2 - \tau)(\mu\phi - \delta)\eta^2 + 2\mu^2(\mu\phi - \delta)(1 - \tau)^2](r - P)}{(2 - \tau)\eta^2 + (2\mu^2 - g\tau)(1 - \tau)^2},
\]

(32)

\[
A_1 = \frac{[2\eta^3 + \eta(\mu^2 - g^2 + \theta)(1 - \tau)](1 - \tau)(P - \eta(1 - \lambda)(1 - \tau)\alpha}{(2 - \tau)\eta^2 + (2\mu^2 - g\tau)(1 - \tau)^2}
\]

\[
+ \frac{[\eta^2(\eta\phi + \delta\alpha) - g\delta(1 - \tau)](r - P)}{(2 - \tau)\eta^2 + (2\mu^2 - g\tau)(1 - \tau)^2},
\]

(33)
The service level and advertising effort decrease relative to the basic return rate $\phi$, and the whole price increases relative to $\phi$.

When considering product returns, the demand percentage of the direct channel has the same impact on the service level, the advertising effort and the wholesale price. The basic return rate occurs because customers no longer need or want the product after purchasing it, which is not about service or advertising. The occurrence of the basic product returns will damage the profit of the manufacturer in the direct channel, which will inevitably increase the wholesale price to reduce the profit loss. In addition, such unwarranted product returns discourage the manufacturer of the direct channel from providing higher service level. The higher wholesale price will increase the cost of the retailer, causing it to pay less effort on advertising and to provide a lower service level.

Next, we will analyze the strategy changes of the manufacturer and the retailer when considering online product returns of customers. According to the above results, we can see the changes in strategies of the direct channel and the traditional retail channel. They are given by

$$\Delta \omega^1 = \omega_1 - \omega = -\frac{(1-\tau)B(r-P)}{(2-\tau)\eta^2 + (2\mu^2 - g^2)(1-\tau)^2},$$ \hspace{1cm} (35)

$$\Delta S_d^1 = S_d^1 - S_d = \frac{F(r-P)}{(2-\tau)\eta^2 + (2\mu^2 - g^2)(1-\tau)^2},$$ \hspace{1cm} (36)

$$\Delta A^1 = A_1 - A = \frac{E(r-P)}{(2-\tau)\eta^2 + (2\mu^2 - g^2)(1-\tau)^2},$$ \hspace{1cm} (37)

$$\Delta S_r^1 = S_r^1 - S_r = \frac{\mu(1-\tau)B(r-P)}{(2-\tau)\eta^2 + (2\mu^2 - g^2)(1-\tau)^2},$$ \hspace{1cm} (38)

where $B = \eta(\eta\phi + \delta\alpha) - g\delta(1-\tau)$, $E = \eta^2(\eta\phi + \delta\alpha) - g\delta(1-\tau)$, $F = g(1-\tau)[\eta(\eta\phi + \delta\alpha) - g\delta(1-\tau)] + (2-\tau)(\mu\phi - \delta)\eta^2 + 2\mu^2(\mu\phi - \delta)(1-\tau)^2$.

**Proposition 3.** (i) When $B < 0$, then $E < 0$, which means that $\Delta \omega^1 < 0$, $\Delta S_d^1 > 0$, $\Delta A^1 > 0$. That is to say, considering the product returns of the direct channel, the manufacturer will provide a lower wholesale price, and the retailer
will give a higher level of service and pay more effort on advertising. When \( F > 0 \), then \( \Delta S_1^d < 0 \), which means that the manufacturer will provide a lower service level in the direct channel. On the other hand, if \( F < 0 \), then \( \Delta S_1^d > 0 \).

(ii) When \( B > 0 \), which means that \( \Delta \omega^1 > 0 \), then \( \Delta S_1^d < 0 \). Considering the product returns of the direct channel, the manufacturer will provide a higher wholesale price and the retailer will provide a lower service level. If \( E > 0 \), then \( \Delta A^1 < 0 \); if \( E < 0 \), then \( \Delta A^1 > 0 \). If \( F > 0 \), then \( \Delta S_1^d < 0 \); and if \( F < 0 \), then \( \Delta S_1^d > 0 \).

The above proposition indicates that the change of the wholesale price is always accompanied by a decrease of the service level of the retailer. However, the advertising effort and the service level of the direct channel are not always synchronized. When the ratio between the customers’ sensitivity to service substitution and advertising sensitivity is large, that is \( \frac{\eta}{\eta + \delta a} > \frac{\eta \varphi + \delta a}{1 - \tau} \), the manufacturer will give a lower wholesale price to the retailer, so as to reduce the operating costs. As a consequence, the retailer will improve the service level and pay more effort on the advertising to attract more customers. The phenomenon is explained as follows: product returns behavior of customers damages the profit of the manufacturer, so it expects to obtain higher profit from the retail channel. A lower wholesale price can stimulate the retailer to pay more effort on advertising and provide higher service level of the traditional retail channel so as to reduce the volume of the direct channel’s product returns. Moreover, sales of dual channel will increase, and so are the profits of the manufacturer. The manufacturer will provide a higher service level of the direct channel in some situations. The reason is that customers, who buy the product from the direct channel, will return the product if they are not satisfied with the online service or the product does not match their needs, which results in profits loss of the manufacturer. Thus, the manufacturer will provide a higher service level to customers so as to retain the customer. Under a different situation, when the ratio between the customers’ sensitivity to service substitution and advertising sensitivity is small, that is \( \frac{\eta}{\eta + \delta a} < \frac{\eta \varphi + \delta a}{1 - \tau} \), the manufacturer will provide a higher wholesale price to the retailer, so the service level of the traditional retail channel will decrease. The reason is obvious. The increase of the wholesale price will increase the operating cost of the retailer. Thus, in order to pursue more profits, the retailer must decrease the service level so as to reduce the service costs. In this situation, we find that the retailer will pay more effort on advertising. This is because the revenue brought by advertising exceeds the cost, so the retailer is willing to pay more on advertising effort, however, when the advertising cost is higher than the revenue, the advertising effort will be lower than that of the other case.

5. Analysis. In this section, we will carry out numerical analysis. The purpose of the numerical study is to investigate the impact of the customer’s expected service on the strategies and profits of the manufacturer and the retailer. In addition, the sensitivity analysis of parameters will also be conducted.

5.1. The impact of the expected service. This part examines the impact of the customer’s expected service on the strategies and profits of the manufacturer and the retailer. The various parameter values are given as follows: \( \alpha = 20, \beta = 0.8, \gamma = 0.5, \mu = 0.8, g = 0.7, P = 8, a = 0.05, b = 0.1, \lambda = 0.4, \tau = 0.65, \delta = 0.2 \). Table 1 shows the results.
Table 1. The impact of the expected service

|   | $\omega$ | $S_d$ | $S_r$ | $A$ | $Q_d$ | $Q_r$ | $\pi_m$ | $\pi_r$ |
|---|---------|-------|-------|-----|-------|-------|---------|---------|
| $a = b = 0$ | 6.0174 | 2.1878 | 1.5861 | 2.8323 | 3.6562 | 6.7535 | 67.2808 | 10.7280 |
| $a \neq 0, b \neq 0$ | 6.1059 | 2.1259 | 1.5153 | 2.4894 | 2.7451 | 5.8292 | 55.5396 | 8.8085 |
| change | + | - | - | - | - | - | - | - |

Table 1 shows that the manufacturer and the retailer will overestimate their profits if customers’ expected service is not taken into account.

According to Table 1, we can see that when the expected service of customers is not taken into account, the manufacturer and the retailer tend to provide customers with a higher service level, and the retailer pays more advertising effort to attract customers. Customer demand is determined by advertising effort and service. The manufacturer and the retailer predict they can obtain higher profits with higher demand, and hence they are willing to provide higher service level and advertising effort. And the manufacturers will also be willing to give a lower wholesale price in order to encourage the retailer to sell more products. But in reality, the actual demand is not as great as expected, despite the increase of the operating costs. Thus, the profits of the manufacturer and the retailer will reduce. This undesirable scenario is because the impact of the expected service by the customers is not taken into consideration.

5.2. Sensitivity analysis. In this subsection, we will investigate the impact of the related parameters on decisions and profits. However, we will not repeat the explanations on the impact of the demand percentage of the direct channel $\lambda$ and the influence of basic return rate $\phi$ on decision-making. Here, we will mainly study the impacts of the cost-sharing ratio $\tau$ on the decision-making and profits. The impacts of $\lambda$ and $\phi$ on profits will also be discussed in this subsection. In the following table, “↗” and “↘” indicate increase and decrease, respectively.

Table 2. Sensitivity analysis

|   | $A$ | $\omega$ | $S_d$ | $S_r$ | $Q_d$ | $Q_r$ | $\pi_m$ | $\pi_r$ |
|---|-----|---------|-------|-------|-------|-------|---------|---------|
| $\tau$ | ↗ | ↘ | ↗ | ↘ | ↗ | ↘ | ↗ | ↘ |
| $\delta$ | ↗ | ↘ | ↗ | ↘ | ↗ | ↘ | ↗ | ↘ |
| $\mu$ | ↗ | ↘ | ↗ | ↘ | ↗ | ↘ | ↗ | ↘ |
| $g$ | ↗ | ↘ | ↗ | ↘ | ↗ | ↘ | ↗ | ↘ |
| $\gamma$ | ↗ | ↘ | ↗ | ↘ | ↗ | ↘ | ↗ | ↘ |
| $a$ | ↗ | ↘ | ↗ | ↘ | ↗ | ↘ | ↗ | ↘ |
| $r$ | ↗ | ↘ | ↗ | ↘ | ↗ | ↘ | ↗ | ↘ |

* Some parameters are analyzed only within ranges.

Parameter $\tau$ represents the advertising cost-sharing ratio of the manufacturer to the retailer. The advertising effort increases as the manufacturer’s cost-sharing ratio increases. It is intuitively clear that the retailer will pay more advertising effort if the manufacturer is willing to share more costs. The above table shows that when the cost-sharing ratio is small, the wholesale price will decrease, and when this ratio is big, the wholesale price will increase. The service level of dual channel increases in relation to the cost-sharing ratio when this ratio is small, but if the ratio is big, the service level will decrease. When the manufacturer shares...
a lower ratio of advertising costs, but will reduce the wholesale price to stimulate
the operation of the retailer. In this situation, the retailer is still willing to provide
a higher level of service to customers, so as to improve its competitiveness. The
manufacturer’s profit increases in relation to the cost-sharing ratio. The retailer’s
profit increases with respect to the cost-sharing ratio first, and when the ratio is
much bigger, the retailer’s profit will decrease. It is clear that the manufacturer can
always maintain its profit by controlling the wholesale price. However, when the
manufacturer shares most of the advertising cost, it will raise the wholesale price to
deprive the retailer’s profits to make up the loss of his profits, so the retailer’s profit
will decrease. From Table 2, we can see that a higher wholesale price and a lower
cost-sharing ratio of advertising will not increase the profit of the manufacturer.
Thus, it is important for the manufacturer to give a reasonable wholesale price to
the retailer and share most of the advertising costs in accordance with the actual
situation.

Parameter $\mu$ represents the marginal impact of service on the customer demand.
Table 2 shows that the higher the sensitivity of customers to service, the lower the
wholesale price is, the higher the service level of dual channel is, the more advertising
effort the retailer is willing to pay. First, for the manufacturer, when customers are
less sensitive to the service of the direct channel, opening the direct channel can
only increase operating costs, so the manufacturer gives up the direct channel and
chooses to benefit from the traditional channel. The wholesale price subsidy reduces
the cost of the retailer, which makes the retailer pay more advertising effort and
improve the service level. Thus, the profits of the manufacturer and the retailer will
increase. When customers are more sensitive to service of the direct channel, it is
more advantageous for the manufacturer to open the direct channel. The wholesale
price subsidy can encourage the retailer to improve the service level and advertising
effort, and promote customers’ demand for the direct channel at the same time.
The improvement of the service level of the direct channel is higher than that of
the traditional retail channel. However, the advertising cost is high, and hence the
profit of the retailer will decrease.

Parameter $g$ represents the cross-influence of dual-channel services, which can
also be expressed as the substitutability of services. According to our analysis, as
service substitutability increases, the manufacturer will raise the wholesale price,
which will make the retailer to reduce the advertising effort and the service level.
As a competitor, the manufacturer will also reduce the service level of the direct
channel. In addition, the greater the service substitution between the two channels
is, the stronger the erosion effect of the direct channel on the traditional retail
channel will be. This will lead to less profit for the retailer.

Parameter $\gamma$ represents the effect of advertising on customers’ demand. When
customers are less sensitive to advertising, the cost of advertising will reduce the
profit of the retailer. Therefore, only when customers are sensitive to advertising,
will the retailer advertise. The greater the marginal impact of advertising on cus-
tomer demand is, the greater the investment in advertising by the retailer will be.
Since the benefits of advertising effort exceed the costs, the manufacturer is willing
to encourage the retailer to advertise by giving a lower wholesale price. However,
with the increase of advertising costs, the manufacturer’s operating cost will in-
crease, causing it to ask for a high wholesale price. In addition, the promotion
of advertising effort will increase customers’ expectations of service, so the service
levels of the direct channel and the traditional retail channel will increase.
Parameter $\delta$ denotes the marginal impact of service on the returned volume. The bigger the parameter is, the greater the impact of the service on product returns will be. In the case of returns, the manufacturer will generally promote the service level of the direct channel to satisfy customers. At the same time, the manufacturer hopes that the retailer can improve the service level of the traditional retail channel to reduce the amount of returned products in the direct channel. As a result, it will give wholesale price subsidies to the retailer at the first stage, such that the wholesale price will decrease with the increase of marginal impact of service on returns, while the service level of dual channel will improve. A lower wholesale price will prompt the retailer to increase its advertising effort, which, though costly, is more profitable for both the manufacturer and the retailer. The reason why sales volume of the traditional retail channel decreases with the increase of $\delta$ is that the service level of the direct channel increases faster than that of the traditional retail channel.

Parameter $a$ denotes the marginal impact of price on the expected service of customers. The bigger the $a$ is, the greater the impact of the expected service has on the demand, and thus the higher the manufacturer’s loss will be, so it will raise the wholesale price. The increase of the wholesale price increases the cost of the retailer causing it to provide a lower service level, which in turn will reduce the service level in the direct channel. As a consequence, the retailer will reduce the advertising effort so as to make up for some losses. Reduced advertising effort and reduced service level will cause a decline in the sales of dual channel, and hence hurting the profits of the manufacturer and the retailer.

Parameter $r$ represents the residual value of the returned product. The smaller the value of $r$ is, the higher the processing cost of returned products is, and the greater the difference between residual price and product price is. According to the analysis, we conclude that the smaller the residual value is, the lower the wholesale price will be, and the higher the service level is, the more the retailer’s advertising effort is. Thus, the sales of dual channel increase, but at the same time, the direct channel return quantity increases, the manufacturer’s profit rises before falling fast, and the retailer’s profit decreases. The returned product brings huge cost pressure to the manufacturer, and the lower the residual value of returned products is, the greater the profit loss to the manufacturer is. As a traditional retailer in a weak position in the supply chain, its profit will also be eroded. As the cost increases, that is, the residual value decreases, the manufacturer will adopt a strategy of reducing the wholesale price. On the one hand, it alleviates channel conflicts; on the other hand, it encourages the retailer to improve the service level and reduce product returns in the direct channel. In order to reduce returned products, the manufacturer will improve the service level of the direct channel, while the retailer will also improve the service level of the traditional retail channel to increase its competitiveness.

Figure 1 shows that the profit of the manufacturer increases with the increase of the demand percentage of the direct channel $\lambda$. Figure 2 shows that with the increase of $\lambda$, the retailer’s profit will increase first, and then it will decrease when the percentage is higher.

As $\lambda$ increases, the service levels of the manufacturer and the retailer increase, but the wholesale price will decrease. When the demand percentage of the direct channel is low, the manufacturer has no incentive to operate the direct channel, because the costs always outweigh the benefits, which will damage the manufacturer’s profit. For the retailer, when more customers are willing to buy products in
physical stores, it only needs to provide the level of service that customers expect. However, with the decline of this proportion, more and more customers are willing to accept the direct channel, and the retailer needs to improve the service level to retain customers. At this time, the manufacturer will also need to improve the service level to enhance the competitiveness of the direct channel. In addition, the manufacturer’s wholesale price for the retailer decreases in relation to $\lambda$, such that it encourages the operation of the traditional retail channel on the one hand, and motivates the retailer to pay more effort on advertising on the other hand.

Figure 3 demonstrates that the profit of the manufacturer decreases with the increase of the basic return rate, and Figure 4 demonstrates that the profit of the retailer increases when the ratio is smaller, but it will decrease when the ratio is bigger.

According to Corollary 3, the higher the basic return rate is, the lower the service level and advertising effort are, and the higher the wholesale price will be. It is clear that product returns of the direct channel bring costs to the manufacturer, such as logistics and disposal costs, which seriously damages the profits. The average loss caused by product returns to the manufacturer and the retailer is approximately 3.8% [27]. The manufacturer understands that product returns will inevitably result in higher costs, causing it to increase the wholesale price to the retailer. Moreover,
as the cost increases, the manufacturer is not willing to share more advertising cost with the retailer, which makes the retailer pay less effort to advertising. Product returns discourage the manufacturer from providing high-quality service. A lower service level of the direct channel will be provided when the basic return rate is higher. For the retailer, higher wholesale price increases the operating costs, making it to provide a lower level of service to customers.

Next, we will analyze the sensitivity of the parameters to determine the changes in the strategies of the manufacturer and the retailer when the direct channel allows for product returns. In Table 3, notations “+” and “−” indicate “> 0” and “< 0”, respectively. If $B < 0$, then $\Delta \omega^1 < 0, \Delta S^1_r > 0$; if $E < 0$, then $\Delta A^1 > 0$; and if $F < 0$, then $\Delta S^1_d > 0$.

| $g$ | $\gamma$ | $\phi$ | $\delta$ | $\tau$ | $\mu$ | $a$ |
|-----|---------|--------|---------|--------|-------|-----|
| +→− | −→+ | −→+ | +→− | −→+ | +→− | +→− |
| $E$ | +→− | −→+ | −→+ | +→− | −→+ | − | − |
| $F$ | − | − | −→+ | +→− | − | − | − |

* See Appendix Table 1 for details.

From Eqs. (35)-(38) and Table 3, we can see that the service level of the traditional retail channel always changes with the change of the wholesale price given by the manufacturer to the retailer, but the change of advertising effort level of the retailer is not synchronous. In addition, the change of the manufacturer’s service level is only related to the basic return rate and the marginal impact of service on the returned volume, and it has no relationship with other parameters.

According to the results of our numerical simulation, the following conclusions can be drawn: (i) The service level of the direct channel will change with the change of the basic return rate and the marginal influence of the service gap on the product returned volume. When the basic return rate is low or the service gap is sensitive to the product returned volume, the manufacturer will improve the service level. (ii) By analyzing the sensitivity of parameters, it is found that when the manufacturer offers a lower wholesale price, the retailer is more willing to provide a higher level of service. The reasons are as follows: on one hand, the reduction of the wholesale price reduces the costs of the retailer and makes it more willing to provide a high service quality; on the other hand, in the case of customer returns, in order to retain customers, the manufacturer will improve the service level of the direct channel, and the retailer will also improve the service level of the traditional retail channel in order to enhance its competitiveness.

6. Extensions.

6.1. Product return of dual-channel. In this section, we will expand the model to allow customers who buy products from the traditional retail channel to return products. On the website of International Consumer Rights Protection Day on March 15, 2018, the China Consumers Association launched a campaign to advocate the promise of returning products to stores without any reason, which kicked off the promise nationwide. Many enterprises have carried out the promise of returning goods without any reason for seven days in physical stores, for example, Suning Tesco, Gome, Wal-Mart and Jingdong Mall. Here, we assume that $\psi D_r$ represents
the basic returns, the returned product does not affect the resale, and the processing
cost of each product is \( c \). To model this, we keep the demand functions of the direct
channel and the traditional retail channel the same as given by Eq. (2) and Eq. (4), i.e.,

\[
D_d = \lambda \alpha - \beta P + \gamma A + \mu (S_d - S_c) - g S_r,
\]

and

\[
D_r = (1 - \lambda) \alpha - \beta P + \gamma A + \mu (S_r - S_c) - g S_d.
\]

The direct channel’s returned volume is given by

\[
R_M = \phi D_d - \delta (S_d - S_e)
\]

\[
= \lambda \phi \alpha - (\phi \theta - \delta b) P + (\eta \phi + \delta a) A + (\mu \phi - \delta) S_d - \phi g S_r.
\]

(39)

The traditional retail channel’s returned volume is given by

\[
R_r = \psi D_r.
\]

(40)

The manufacturer’s profit function is given by

\[
\pi_{m2} = P(D_d - R) + \omega D_r + r R_M - \frac{1}{2} S_d^2 - \frac{1}{2} \tau A^2
\]

\[
= P[\lambda \alpha - \theta P + \eta A + \mu S_d - g S_r]
\]

\[
+ \omega[(1 - \lambda) \alpha - \theta P + \eta A + \mu S_r - g S_d] - \frac{1}{2} S_d^2 - \frac{1}{2} \tau A^2
\]

\[
+ (r - P)[\lambda \phi \alpha - (\phi \theta - \delta b) P + (\eta \phi + \delta a) A + (\mu \phi - \delta) S_d - \phi g S_r],
\]

(41)

and the retailer’s profit function is

\[
\pi_{r2} = (P - \omega) D_r - \frac{1}{2} S_r^2 - \frac{1}{2} (1 - \tau) A^2 - c \delta D_r
\]

\[
= (P - \omega - c \delta)[(1 - \lambda) \alpha - \theta P + \eta A + \mu S_r - g S_d] - \frac{1}{2} S_r^2 - \frac{1}{2} (1 - \tau) A^2.
\]

(42)

Here, the first term \((P - \omega) D_r\) is the sale revenue, the second term \( \frac{1}{2} S_r^2 \) and third
term \( \frac{1}{2} (1 - \tau) A^2 \) are the service and advertising cost, respectively, and the fourth
term \( c \delta D_r \) is the cost of handling returned products.

**Proposition 4.** The optimal strategies of the manufacturer and the retailer are
given by

\[
\omega_2 = \frac{(1 - \lambda)(1 - \tau)^2 \alpha + [(\mu^2 - \theta)(1 - \tau)^2 + \tau \eta^2] P}{(2 - \tau) \eta^2 + (2 \mu^2 - g^2)(1 - \tau)^2}
\]

\[
+ \frac{(1 - \tau)[g \delta (1 - \tau) - \eta (\eta \phi + \delta a)] (r - P)}{(2 - \tau) \eta^2 + (2 \mu^2 - g^2)(1 - \tau)^2} - \frac{c \delta [\eta^2 + \mu^2 (1 - \tau)^2]}{(2 - \tau) \eta^2 + (2 \mu^2 - g^2)(1 - \tau)^2},
\]

(43)

\[
S_{d2} = \frac{[\eta^2 (2 \mu - \mu \tau - g \tau) + (2 \mu^3 - g^2 \mu - \mu g^2 + g \theta)(1 - \tau)^2] P}{(2 - \tau) \eta^2 + (2 \mu^2 - g^2)(1 - \tau)^2}
\]

\[
+ \frac{[g \eta (1 - \tau)(\eta \phi + \delta a) + (2 - \tau)(\mu \phi - \delta) \eta^2 + (2 \mu^3 \phi - 2 \mu^2 \delta - g^2 \mu \phi)(1 - \tau)^2] (r - P)}{(2 - \tau) \eta^2 + (2 \mu^2 - g^2)(1 - \tau)^2}
\]

\[
- \frac{\alpha (1 - \lambda)(1 - \tau)^2 - gc \delta [\eta^2 + \mu^2 (1 - \tau)^2]}{(2 - \tau) \eta^2 + (2 \mu^2 - g^2)(1 - \tau)^2},
\]

(44)
A2 = \frac{[2\eta^3 + \eta(\mu^2 - g^2 + \theta)(1 - \tau)]P - \eta(1 - \lambda)(1 - \tau)\alpha + c\psi\eta(g^2 - \mu^2)}{(2 - \tau)\eta^2 + (2\mu^2 - g^2)(1 - \tau)^2} + \frac{[\eta^2(\eta\phi + \delta a) - g\delta(1 - \tau)(r - P)]}{(2 - \tau)\eta^2 + (2\mu^2 - g^2)(1 - \tau)^2}, \tag{45}

S_{r2} = \frac{[2\mu\eta^2(1 - \tau) + \mu(\mu^2 - g^2 + \theta)(1 - \tau)^2]P - (1 - \lambda)(1 - \tau)^2\mu\alpha + c\psi\mu(g^2 - \mu^2)}{(2 - \tau)\eta^2 + (2\mu^2 - g^2)(1 - \tau)^2} + \frac{\mu(1 - \tau)[\eta(\eta\phi + \delta a) - g\delta(1 - \tau)(r - P)]}{(2 - \tau)\eta^2 + (2\mu^2 - g^2)(1 - \tau)^2}. \tag{46}

The above proposition indicates that the basic return rate and the processing cost of returned products of the retailer have negative impacts on the wholesale price, advertising effort and the service level of the traditional retail channel. However, they have a positive impact on the service level of the direct channel, which is quite surprising. The reasons will be explained later.

The respective changes of strategies of the manufacturer and the retailer are given by

\Delta \omega^2 = \omega_2 - \omega_1 = -\frac{c\psi[\eta^2 + \mu^2(1 - \tau)^2]}{(2 - \tau)\eta^2 + (2\mu^2 - g^2)(1 - \tau)^2}, \tag{47}

\Delta S^2_d = S_{d2} - S_{d1} = \frac{g\psi[\eta^2 + \mu^2(1 - \tau)^2]}{(2 - \tau)\eta^2 + (2\mu^2 - g^2)(1 - \tau)^2}, \tag{48}

\Delta A^2 = A_2 - A_1 = \frac{c\psi(g^2 - \mu^2)}{(2 - \tau)\eta^2 + (2\mu^2 - g^2)(1 - \tau)^2}, \tag{49}

\Delta S^2_r = S_{r2} - S_{r1} = \frac{c\psi(g^2 - \mu^2)}{(2 - \tau)\eta^2 + (2\mu^2 - g^2)(1 - \tau)^2}. \tag{50}

The above results show that the manufacturer will lower the wholesale price, and the retailer will pay less advertising effort and reduce the service level when taking into account product returns of the traditional retail channel. However, the service level of the direct channel will increase, because the existence of basic return rate of the traditional retail channel will reduce the profit of the retailer, and cause the manufacturer to provide a lower wholesale price to subsidize the operating costs of the retailer. In addition, customers’ unreasonable returns will make the retailer unwilling to provide higher service level, because no matter how considerate the service is, some customers always choose to return the product, which has nothing to do with the service. Based on our calculations, it can be concluded that the cost of unreasonable product returns for customers in traditional retail channels is greater than the total cost and revenue saved by reducing the service level and lowering the manufacturer’s wholesale price subsidy to the retailer. Therefore, the retailer pursuing profit maximization will pay less advertising effort. From the perspective of the manufacturer, the reduction of the retailer’s service level will promote the product demand of the direct channel, but it will also increase the volume of customer product returns of the direct channel. Thus, the manufacturer
will improve the service level of the direct channel. Finally, from the perspective of
the profits of the manufacturer and the retailer, product returns in the traditional
retail channel will also lead to the loss of profits, and the higher the basic return
rate, the more serious the loss of profit will be.

6.2. The retail price is a decision. In this section, similar to Zhou et al. (2018)
[44] and Zhang et al. (2020) [43], we consider the case in which the retail price
is a decision variable. In this situation, the retailer decides the retail price. The
sequence of this event is as follows: (1) the manufacturer decides the wholesale
price; (2) service levels of the dual channels and the advertising effort are decided;
(3) the retailer decides the retail price. Table 4 shows the impacts of the expected
service on the strategies and profits.

| $a = b = 0$ | $\omega$ | $S_d$ | $S_r$ | $A$ | $P$ | $\pi_m$ | $\pi_r$ |
|-------------|---------|-------|-------|-----|-----|---------|---------|
| 7.2135 | 7.5698 | 3.0290 | 5.4090 | 10.9997 | 47.9312 | 1.7613 |
| $a \neq 0, b \neq 0$ | 6.4174 | 6.7444 | 2.5324 | 4.1064 | 9.5829 | 38.4156 | 2.5834 |
| change | $-$ | $-$ | $-$ | $-$ | $-$ | $+$ | $+$ |

Table 4 demonstrates that when the expected service is taken into consideration,
the retail price, the service levels, the advertising effort and the wholesale price will
decrease, the profit of the manufacturer will decrease, and the profit of the retailer
will increase.

From Eqs. (12) and (13), we can see that when customers’ expected service is
taken into consideration (when $a \neq 0, b \neq 0$), customers’ sensitivity to the retail
price will increase and the sensitivity to the advertising effort will decrease. That
is to say, if the manufacturer and the retailer ignore the impact of the expected
service, they will predict that customers are less sensitivity to the retail price,
and therefore will give customers higher retail price, while the manufacturer gives a
higher wholesale price to the retailer. In addition, when customers’ expected service
is not considered, the sensitivity to advertising effort will be higher, so the retailer
will provide a higher level of advertising effort to meet the needs of customers.
Furthermore, due to higher retail price of product and higher advertising effort,
customers have higher expectation of service, so the manufacturer and the retailer
will provide customers with higher service level. Therefore, for the manufacturer,
when taking into account the expected service of customers, the reduction in dual-
channel revenue is greater than the reduction of cost, and so the profit will decrease.
For the retailer, his revenue is less affected, and the cost is reduced, so the profit
will increase.

7. Conclusions and future research. With the development of customer-
oriented modern marketing concepts, satisfying the needs of customers has be-
come the starting point and destination of enterprise operation. Customers expect
companies to do what they are supposed to do and provide the services required
by the product, not the service they can provide. However, for enterprises, dual-
channel sales can bring more profits. More and more manufacturers are aware of
this advantage and have established the direct channel. The direct channel pro-
vides convenient logistics and consulting service, but the customers cannot feel the
physical products. On the other hand, the traditional retail channel provides the
environment for the customers to experience the product. For those products purchased through the direct channel that need to be touched and experienced, when the customers find that they do not match their needs, they will return the products. This paper considers the impact of customer service expectation on demand, and investigates the optimal strategies for the manufacturer and the retailer in dual channel with product returns. The manufacturer adopts the same price strategy to sell product in the direct channel and the traditional retail channel, the retailer advertises and the manufacturer shares part of the cost. Due to the asymmetry of information, product returns occur.

We summarize some main results for the supply chain with product returns as follows: (1) Taking into account the expected service of customers, the profits of the manufacturer and the retailer will decrease. (2) When customers are sensitive to service and are not sensitive to advertising, and the basic return rate and advertising cost-sharing rate are low, the manufacturer will give a lower wholesale price to the retailer, which can promote the retailer to improve the service level and advertising effort so as to reduce the adverse effect of product returns. (3) For the scenario where the direct channel allows for product returns, the manufacturer should adjust service strategy according to the basic return rate and the marginal impact of the service on the returned volume, rather than blindly improving the service level. When the basic return rate is low and the impact of service on the returned volume is high, the manufacturer should improve the service level of the direct channel. (4) In the presence of the product returns of dual channel, the manufacturer should adopt a wholesale price subsidy strategy to encourage the retailer. However, unconditional product returns in the traditional retail channel will hurt the profit of the retailer, making it unwilling to provide high level of service and pay more effort on advertising at the same time. As a consequence, the returned volume of the direct channel increases, which will promote the manufacturer to improve service level.

We have demonstrated that the model can provide some valid management research directions. However, considering the heterogeneity of customers, our model needs to be further improved. A more complete research direction is that demand depends on customers' valuation of products and shopping experience, which is considered to be the expected utility of products purchased by customers. In our model, we assume that the retailer sells all the returned products, which is too idealistic. Thus, the other meaningful follow-up research is to consider the situation that the retailer returns the returned products to the manufacturer. In addition, under the background of New Retail, retail prices of online and offline sellers have gradually become consistent. However, many products still maintain a pattern of inconsistent prices, and online prices are always lower than those in physical stores. Therefore, in order to improve the versatility of the model, it makes sense to expend it to price inconsistency. Finally, we only consider the case where the manufacturer has one retailer and only sells one product, it is impossible to use a dynamic strategy for a product in all branches and in all sizes independently [17]. Thus, the case of multiple product branches and many distributors is worth studying.

Appendix.

Proof of Proposition 1.
Substitute Eqs. (16)-(20) into Eq. (9). Taking the partial differentiation of the manufacturer’s profit function i.e., Eq. (21), and then setting the result obtained to zero, it gives
\[ \frac{\partial \pi_m}{\partial \omega} = 0 \Rightarrow \omega = \frac{(1 - \lambda)(1 - \tau)^2\alpha + [(\mu^2 - \theta)(1 - \tau)^2 + \tau \eta^2]P}{(2 - \tau)\eta^2 + (2\mu^2 - g^2)(1 - \tau)^2}. \]

Now, substituting Eq. (21) into Eqs. (16)-(18), Eqs. (22)-(24) follow readily. 

**Proof of Corollary 1.**

\[ \frac{\partial \omega}{\partial \lambda} = \frac{-(1 - \tau)^2\alpha}{(2 - \tau)\eta^2 + (2\mu^2 - g^2)(1 - \tau)^2} < 0, \]

\[ \frac{\partial S_d}{\partial \lambda} = \frac{g(1 - \tau)^2\alpha}{(2 - \tau)\eta^2 + (2\mu^2 - g^2)(1 - \tau)^2} > 0, \]

\[ \frac{\partial A}{\partial \lambda} = \frac{\eta(1 - \tau)\alpha}{(2 - \tau)\eta^2 + (2\mu^2 - g^2)(1 - \tau)^2} > 0, \]

\[ \frac{\partial S_r}{\partial \lambda} = \frac{\mu(1 - \tau)^2\alpha}{(2 - \tau)\eta^2 + (2\mu^2 - g^2)(1 - \tau)^2} > 0. \]

**Proof of Proposition 2.** Substitute Eqs. (28)-(30) into Eq. (26). By taking the differentiation of the manufacturer’s profit function i.e., (Eq. (31)), and then setting the results obtained to zero, it gives

\[ \frac{\partial \pi_{m1}}{\partial \omega_1} = 0 \Rightarrow \omega_1 = \frac{(1 - \lambda)(1 - \tau)^2\alpha + [(\mu^2 - \theta)(1 - \tau)^2 + \tau \eta^2]P}{(2 - \tau)\eta^2 + (2\mu^2 - g^2)(1 - \tau)^2} \]

\[ + \frac{(1 - \tau)[g\delta(1 - \tau) - \eta(\eta \phi + \delta \alpha)](r - P)}{(2 - \tau)\eta^2 + (2\mu^2 - g^2)(1 - \tau)^2}. \]

Now, substituting Eq. (31) into Eqs. (28)-(30), we obtain Eqs. (32)-(34).

**Proof of Corollary 2.**

\[ \frac{\partial \omega_1}{\partial \lambda} = \frac{-(1 - \tau)^2\alpha}{(2 - \tau)\eta^2 + (2\mu^2 - g^2)(1 - \tau)^2} < 0, \]

\[ \frac{\partial S_{d1}}{\partial \lambda} = \frac{g(1 - \tau)^2\alpha}{(2 - \tau)\eta^2 + (2\mu^2 - g^2)(1 - \tau)^2} > 0, \]

\[ \frac{\partial A_1}{\partial \lambda} = \frac{\eta(1 - \tau)\alpha}{(2 - \tau)\eta^2 + (2\mu^2 - g^2)(1 - \tau)^2} > 0, \]

\[ \frac{\partial S_{r1}}{\partial \lambda} = \frac{\mu(1 - \tau)^2\alpha}{(2 - \tau)\eta^2 + (2\mu^2 - g^2)(1 - \tau)^2} > 0. \]

**Proof of Corollary 3.**

\[ \frac{\partial \omega_1}{\partial \phi} = \frac{-(1 - \tau)\eta^2(r - P)}{(2 - \tau)\eta^2 + (2\mu^2 - g^2)(1 - \tau)^2} > 0, \]

\[ \frac{\partial S_{d1}}{\partial \phi} = \frac{[g\eta^2(1 - \tau) + \mu\eta^2(2 - \tau) + 2\mu^3(1 - \tau)^2 - \mu g^2(1 - \tau)^2](r - P)}{(2 - \tau)\eta^2 + (2\mu^2 - g^2)(1 - \tau)^2} < 0, \]
\[
\frac{\partial A_2}{\partial \phi} = \frac{\eta^3(r - P)}{(2 - \tau)\eta^2 + (2\mu^2 - g^2)(1 - \tau)^2} < 0,
\]

\[
\frac{\partial S_{r2}}{\partial \phi} = \frac{\mu \eta^2(1 - \tau)(r - P)}{(2 - \tau)\eta^2 + (2\mu^2 - g^2)(1 - \tau)^2} < 0.
\]

Taking the partial derivatives of the profit functions given by Eq. (41) and (42), the relationships between the variables and the wholesale price are obtained as follows:

\[
A_2 = \frac{\eta(P - \omega - c\psi)}{1 - \tau},
\]

\[
S_{r2} = \mu(P - \omega - c\phi),
\]

\[
S_{d2} = \mu P - g\omega + (\mu\phi - \delta)(r - P).
\]

The changes of decision due to the influence of parameters are given in Table 1.

Proof of Proposition 4.

From Eqs. (41) and (42), we obtain

\[
\frac{\partial \pi_{m2}}{\partial S_d} = 0 \Rightarrow S_d = \mu P - g\omega + (\mu\phi - \delta)(r - P), \quad (51)
\]

\[
\frac{\partial \pi_{r2}}{\partial S_r} = 0 \Rightarrow S_r = \mu(P - \omega - c\phi), \quad (52)
\]

\[
\frac{\partial \pi_{r2}}{\partial A} = 0 \Rightarrow A = \frac{\eta(P - \omega - c\phi)}{1 - \tau}. \quad (53)
\]

Substitute Eqs. (51)-(53) into Eq. (41). By taking the partial derivative of the manufacturer’s profit function, we obtain the optimal wholesale price \( \omega_2 \) (Eq. (43)):

\[
\frac{\partial \pi_{m2}}{\partial \omega_2} = 0 \Rightarrow \omega_2 = \frac{(1 - \lambda)(1 - \tau)^2\alpha + [(\mu^2 - \theta)(1 - \tau)^2 + \tau \eta^2]P}{(2 - \tau)\eta^2 + (2\mu^2 - g^2)(1 - \tau)^2}
\]

\[
+ \frac{(1 - \tau)[g\delta(1 - \tau) - \eta(\eta\phi + \delta a)](r - P)}{(2 - \tau)\eta^2 + (2\mu^2 - g^2)(1 - \tau)^2}
\]

\[
- \frac{c\psi[\eta^2 + \mu^2(1 - \tau)^2]}{(2 - \tau)\eta^2 + (2\mu^2 - g^2)(1 - \tau)^2}.
\]

Then substituting Eq. (43) into Eqs. (51)-(53), Eqs. (44)-(46) follows readily.

REFERENCES

[1] S. M. Ali, M. H. Rahman, T. J. Tumpa, A. A. M. Rifat and S. K. Paul, Examining price and service competition among retailers in a supply chain under potential demand disruption, Journal of Retailing & Consumer Services, 40 (2018), 40–47.

[2] R. E. Anderson, Consumer dissatisfaction: The effect of disconfirmed expectancy on perceived product performance, Journal of Marketing Research, 10 (1973), 38–44.

[3] P. D. Berger, J. Lee and B. D. Weinberg, Optimal cooperative advertising integration strategy for organizations adding a direct online channel, Journal of the Operational Research Society, 57 (2006), 920–927.
[4] J. Chen and P. C. Bell, The impact of customer returns on pricing and order decisions, *European Journal of Operational Research*, 195 (2009), 280–295.
[5] K-Y. Chen, M. Kaya and Ö. Özer, Dual sales channel management with service competition, *Manufacturing & Service Operations Management*, 10 (2008), 654–675.
[6] I. J. Chen and K. Popovich, Understanding customer relationship management (CRM): People, process and technology, *Business Process Management Journal*, 9 (2003), 672–688.
[7] B. Dan, Z. J. Qu, C. Liu, X. M. Zhang and H. Y. Zhang, Price and service competition in the supply chain with both pure play internet and strong bricks-and-mortar retailers, *Journal of Applied Research & Technology*, 12 (2014), 212–222.
[8] Y. Ding, X. Gao, C. Huang, J. Shu and D. Yang, Service competition in an online duopoly market, *Omega*, 77 (2018), 58–72.
[9] A. Dumrongsi, M. Fan, A. Jain and K. Moinzadeh, A supply chain model with direct and retail channels, *European Journal of Operational Research*, 187 (2008), 691–718.
[10] F. Gao and X. M. Su, Online and Offline Information for Omnichannel Retailing, *Manufacturing & Service Operations Management*, 19 (2008), 84–98.
[11] J. Green, Still pulling the strings, but locally, too, *Brandweek*, 41 (2000), 34–42.
[12] J. A. Guajardo, M. A. Cohen and S. Netessine, Service competition and product quality in the U.S. automobile industry, *Management Science*, 62 (2016), 1860–1877.
[13] X. Hu, Z. Wan and N. N. Murthy, Dynamic pricing of limited inventories with product returns, *Manufacturing & Service Operations Management*, (2018), 1–18.
[14] M. Jahre, Households waste collection as a reverse channel, *International Journal of Physical Distribution & Logistics Management*, 25 (1995), 39–55.
[15] S. K. Jena and P. L. Meena, Price and service competition in a tourism supply chain, *Service Science*, 11 (2019).
[16] S. K. Jena and S. P. Sarmah, Price and service co-opetition under uncertain demand and condition of used items in a remanufacturing system, *International Journal of Production Economics*, 173 (2016), 1–21.
[17] M. Kiessling, S. Kurz and J. Rambau, The integrated size and price optimization problem, *Numerical Algebra Control & Optimization*, 2 (2017), 609–693.
[18] J. A. P. Kumar, Are product returns a necessary evil? Antecedents and consequences, *Journal of Retailing*, 73 (2009), 35–51.
[19] Y. Li, L. Xu and D. Li, Examining relationships between the return policy, product quality, and pricing strategy in online direct selling, *International Journal of Production Economics*, 144 (2013), 451–460.
[20] A. Minnema, T. H. A. Bijmolt, S. Gensler and T. Wiesel, To keep or not to keep: effects of online customer reviews on product returns, *Journal of Retailing*, 92 (2016), 253–267.
[21] J. F. Nash, Equilibrium points in n-person games, *Proceedings of the National Academy of Sciences*, 36 (1950), 48–49.
[22] J. Nash, Non-cooperative games, *Annals of Mathematics*, 54 (1951), 286–295.
[23] E. Ofek, Z. Katona and M. Sarvary, “Bricks and clicks”: The impact of product returns on the strategies of multichannel retailers, *Marketing Science*, 30 (2011), 42–60.
[24] L. Paolo, P. Morteza and H. Terry, The impact of consumer returns on the multichannel sales strategies of manufacturers, *Production and Operations Management*, 27 (2017), 323–349.
[25] A. Parasuraman, L. L. Berry and V. A. Zeithaml, Understanding customer expectations of service, *Sloan Management Review*, 32 (1991), 39–48.
[26] A. Parasuraman, V. A. Zeithaml and L. L. Berry, Servqual: A multiple-item scale for measuring consumer perceptions of service quality, *Journal of Retailing*, 64 (1988), 12–40.
[27] J. A. Petersen and V. Kumar, Can product returns make you money?, *Sloan Management Review*, 51 (2010), 84–91.
[28] L. Ren, Y. He and H. Song, Price and service competition of dual-channel supply chain with consumer returns, *Discrete Dynamics in Nature and Society*, 2014 (2014), Art. ID 565603, 10 pp.
[29] D. Renner, Customer relationship management: A new weapon in your competitive arsenal, *Siebel Magazine*, 1 (2000).
[30] R. T. Rust, J. J. Inman, J. Jia and A. Zahorik, What you don’t know about customer-perceived quality: the role of customer expectation distribution, *Marketing Science*, 18 (1999), 77–92.
[31] A. Shah, C. Zeis, H. Regassa and A. Ahmadian, Expected service quality as perceived by potential customers of an educational institution, *Journal of Marketing for Higher Education*, 9 (2000), 49–72.

[32] A. A. Tsay and N. Agrawal, Channel conflict and coordination in the e-commerce age, *Production and Operations Management*, 13 (2004), 93–110.

[33] A. A. Tsay and N. Agrawal, Channel dynamics under price and service competition, *Manufacturing & Service Operations Management*, 2 (2000), 372–391.

[34] W. Wang, Cooperative advertising in a dual channel, *2009 International Conference on Business Intelligence and Financial Engineering*, (2009).

[35] D. Weathers, S. Sharma and S. L. Wood, Effects of online communication practices on consumer perceptions of performance uncertainty for search and experience goods, *Journal of Retailing*, 83 (2007), 393–401.

[36] Y. Xia and S. M. Gilbert, Strategic interactions between channel structure and demand enhancing services, *European Journal of Operational Research*, 181 (2007), 252–265.

[37] Y. Xia, T. Xiao and G. P. Zhang, The impact of product returns and retailer’s service investment on manufacturer’s channel strategies, *Decision Sciences*, 48 (2016), 918–955.

[38] Y. Xia, T. Xiao and G. P. Zhang, Service investment and channel structure decisions in competing supply chains, *Service Science*, 11 (2019).

[39] L. Xu, Y. Li, K. Govindan and X. Yue, Return policy and supply chain coordination with network-externality effect, *International Journal of Production Research*, 57 (2020), 102199.

[40] R. Yan, S. Ghose and A. Bhatnagar, Cooperative advertising in a dual channel supply chain, *International Journal of Electronic Marketing and Retailing*, 1 (2006), 99.

[41] W. S. Yoo and E. Lee, Internet channel entry: A strategic analysis of mixed channel structures, *Marketing Science*, 30 (2011), 29–41.

[42] V. A. Zeithaml, L. L. Berry and A. Parasuraman, The behavioral consequences of service quality, *Journal of Service Research*, 18 (1996), 31–46.

[43] G. Zhang, G. Dai, H. Sun, G. Zhang and Z. Yang, Equilibrium in supply chain network with competition and service level between channels considering consumers’ channel preferences, *Journal of Retailing and Consumer Services*, 57 (2020), 102199.

[44] Z. P. Zhou, X. B. Liu, J. Pei, P. M. Pardalos and H. Cheng, Competition of pricing and service investment between Iot-based and traditional manufacturers, *Journal of Industrial and Management Optimization*, 14 (2018), 1203–1218.

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E-mail address: tiazhanga@stu.tjufe.edu.cn
E-mail address: shuhua55126.com
E-mail address: dy19930127@126.com
E-mail address: yuejingyi25@163.com
E-mail address: k.l.teo@curtin.edu.au
Table 1. The changes of decision due to the influence of the parameters

| g | γ | φ | δ | τ | µ | a |
|---|---|---|---|---|---|---|
| 0 > | 0 > | 0 > | 0 > | 0 > | 0 > | 0 > |
| 0 > | 0 > | 0 > | 0 > | 0 > | 0 > | 0 > |
| 0 > | 0 > | 0 > | 0 > | 0 > | 0 > | 0 > | 0 > |
| 0 > | 0 > | 0 > | 0 > | 0 > | 0 > | 0 > |
| B | E | F | G | H | I | J |

TABLE 1. The changes of decision due to the influence of the parameters.