Pricing Strategies in a Two-Echelon Supply Chain With Sales Efforts and Channel Conflicts

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ABSTRACT With the increasing popularity of online retail, many manufacturers have opened up their own online marketplaces, which has accelerated competition in the retail market. This paper considers a two-echelon supply chain consisting of a manufacturer and a retailer, where the retailer and the manufacturer sell the same product on their respective online platforms. This sales model creates channel conflicts in the supply chain. In order to explore the impact of this kind of conflict and sales efforts on the supply chain, we constructed consumers’ utility functions when they buy products in different channels as well as a supply chain profit model where there is channel competition and sales efforts. The results show that the severity of channel conflicts affects consumers’ choice of purchasing channels, and excessive channel conflicts will cause consumers to lose interest in shopping, channel conflicts will also make retailers and manufacturers more competitive. In addition, sales efforts can increase channel conflicts. Numerical analysis shows that although channel conflicts weaken the overall profit of the supply chain, it is more beneficial to manufacturers. Finally, we analyze the impact of channel conflicts and sales efforts on consumer surplus. We generate results to provide guidance for the operations of two-echelon supply chains.

INDEX TERMS Channel conflicts, pricing strategies, sales efforts, two-echelon supply chain.

I. INTRODUCTION
Online retail has gradually become the mainstream sales method. Internet Retailers reported that in 2018, the total online consumption of global consumers reached 286 million US dollars, an increase of 18.0% from 243 million US dollars of previous year. In order to cope with this increasingly popular consumption method, some brands (manufacturers) have deployed online retail platforms, such as IBM, Apple and Casio. This has led to a dual-channel supply chain where manufacturers’ online sale channel and retailers’ online channel co-exist.

The core of the dual-channel is that consumers can get an undifferentiated shopping experience in all sales channels while maximizing product profits in the supply chain[1]. To be specific, dual-channel retail refers to the integration of physical store channel, e-commerce channel and mobile application channel to sell goods or services which can meet consumers’ demand for purchase at any time, any place and in any way.

In this type of supply chain where both manufacturers and retailers open up online channels, channel competition is more intense and managerial decisions are more complicated [2]. It is worth emphasizing that these challenges are increasing retailers’ order execution costs on omnichannel sales [3], [4]. In the face of increasing costs, they are controlling costs by increasing prices, increasing delivery costs, or increasing the minimum order for free delivery [5]. In order to gain some management inspiration, this article studies the channel competition and pricing decision problems when manufacturers and retailers open up online channels based on the real industry background.

Motivated by observing the operation problems, and to clarify the general operating rules of the dual-channel supply chains, in this work, we analytically explore the economic impacts and value of sales efforts by considering the price strategies, channel selection and optimal profit. We develop two profit models, manufacturers’ online channel profit model and retailers’ online channel profit model. We first discuss the impacts of sales efforts and channel conflicts on market demand, price and profit. To capture the characteristics of dual-channel supply chains, we then consider how channel conflicts affect consumers purchasing decision. Finally, we investigate how sales efforts affect channel conflicts and the supply chain. Analyzing the model, we derive results on various issues of channel conflicts.
conflicts and generate managerial insights from the analytical findings.

We make three key contributions in this study. First, to the best of our knowledge, this paper is the first analytical study which present the impact of channel conflicts together with sales efforts. Second, we extend the existing literature on dual-supply chain management by capturing the feature of channel conflicts. This feature, that the channel conflicts are affected by sales efforts, is rarely mentioned in previous studies. Third, in spite of the obvious phenomenon in practice that channel conflicts have negative impact on the supply chain, we analytically find that, to some extent, channel conflicts are beneficial to supply chain members.

We organize the rest of the paper as follows: In Section 2 we give a brief review of the related literature to identify the research gap and position our work. In Section 3 we introduce the problem, formulate the model, and discuss the assumptions. In Section 4 we analyze the profit model under different channels. In Section 5 we consider discussion of the model. In Section 6 we present the results of numerical studies conducted to examine the impacts of model parameters on the optimal outcomes. Finally, in Section 7, we conclude the paper and suggest topics for future research.

II. LITERATURE REVIEW

Our research belongs to the research stream for the omnichannel supply chain management which relates to many concepts. This study is related with supply chain channel conflicts, price strategies of supply chain and sales efforts in supply chain.

A. CHANNEL CONFLICTS

Channel conflicts in supply chain is an essential topic in operation management, and online and offline channel conflicts have attracted growing attention due to the importance for a supply chain. Nie et al. [6] study retailers’ distribution decision with online and offline channel conflicts. They focus on a competitive market and find that retailers prefer the online channel although it has a negative effect. Du et al. [7] examines the integration methods of supply chain facing an online-offline channel conflict. They propose a prerequisite for a consumer to choose the optimal channel. Choi et al. [8] investigate how a fashion supply chain avoids online-offline channel conflicts. They address a franchising contract and the ordering time in the model.

Moreover, some scholars have conducted research on channel conflicts in different scenarios. For example, Soysal et al. [9], Du et al. [10], Guo [11] and Yu et al. [2] consider how consumers preferences affect channel conflicts in a dual-channel structure supply chain. He et al. [12] consider a closed-loop supply chain with dual channels subsidized by government. They believe that different channel structures are encouraged by government. Panda et al. [13] investigate channel coordination problem facing specific social responsibility. In addition, Li et al. [14], Zhou et al. [15], Javadi et al. [1], Radhi and Zhang [16] explore the return policy of a dual supply chain. They mainly research how the return policy impacts order quality. Mohan and Kelle et al. [17] and Yan et al. [3] study delivery time of online channel, the results show that delivery delay has significant impact on customers’ channel preference.

From the above discussion, we can clearly judge that channel conflicts in supply chain of different situation is of importance in supply chains. Similar to previous research, we investigate the channel conflicts problem for dual-channel supply. However, we investigate the supply with two online channels, i.e. manufacturer’s online channel and retailer’s online channel.

B. PRICING STRATEGIES FOR SUPPLY CHAINS

Some schoolers consider the price strategies for supply chains. For the product quality of a dual-channel supply chain, Dai et al. [18] and Ke et al. [19] investigate price problem of dual-channel supply chain facing supply members with characteristic of fair caring and certain belief degrees. Chen et al. [20] observe the impact of product quality in dual-channel supply chains and they believe that high quality of product promotes the profit seeking the increase of profit. Ranjan and Jha [5] analytically find a joint decision-making mechanism of quality and pricing. Zhou et al. [4] and Li et al. [21] discuss the price decision of a dual-channel supply chain with asymmetric information (such as showroaming phenomenon). They claim that uncertain demand leads to the different price in different channels. Rahmani and Yavari [22] suggest that the growingly larger market scale is caused by a disruption of demand. They also believe that as market scale increases, the optimal prices in all channels will be improved. Bernstein and Federgruen [23] consider replenishment strategies of supply chain with competitor retailers and suggest the channels of supply chain should consider retailers’ pricing decision when setting their price strategies.

In the paper, we also investigate the price strategies of a supply chain, however, different with above research, we explore price strategies combining with considering sales efforts and channel conflicts.

C. SALES EFFORTS OF SUPPLY CHAIN

This study is also related to the sales efforts of a supply chain. A couple of researches study different types of sales efforts in supply chains. Especially on the topic of the sales efforts in dual-channel supply chains, Xing and Liu [24], Wang and Song [25] and Cao et al. [26] investigate how demand uncertainty, market share of different channels and consumers' channel preference give impetus to price policy and supply chain coordination. Zhao and Zhang [27] look at sales efforts investment of supply chains. Saha et al. [28] show that sales efforts can improve the profit in some promotion campaigns. Wu [29] analytically finds that sales efforts like advertising strategies are executed by the relationship of different channels’ retail prices. Although sales efforts of supply chain have
been widely investigated, there is little work done on how they are affected by channel conflicts. Our research tries to discuss this issue in a deeper sense.

Different from the above research about dual-supply chains, this paper looks into impact of sales efforts and channel conflict which is commonly found in supply chain management, our study explores those topics in the supply chain with two online channels. Moreover, to make a thorough inquiry on dual-supply chain, we investigate the consumer surplus and gain some insight different with previous research.

III. THE PROBLEM

We consider a two-echelon supply chain consisting of a manufacturer and a retailer. They sell the same product via their online market respectively. i.e., online sale via the manufacturer’s channel and online sale via the retailer’s channel. We assume that consumers are rational and make their decisions with maximum utility. Moreover, we assume that consumers are heterogeneous with consumption value which is gained via manufacturers’ online channels. we denote the consumption value as $\theta$, and $c$, which are uniformly distributed in $[0,1]$, i.e., $\theta \sim U[0,1]$ and $c \sim U[0,1]$. We denote the probability density function and cumulative distribution function of $\theta$ and $c$ by $f(\theta), f(c)$ and $F(\theta), F(c)$, respectively.

In addition, the sales efforts paid by the manufacturer and the retailer is denoted as $a_m$ and $a_r$, respectively. A certain number of consumers $q_m$ will purchase products from manufacturer’s online channel with price $p_m$, while of the other group of consumers $q_r$ will purchase products from retailer’s online channel with price $p_r$. Because the product is sold by both the manufacturer and the retailer on the online marketplaces, there are channel conflicts $\delta$ in the two-echelon supply chain. Figure 1 illustrates the model structure we discussed. Table 1 summarizes the notions used in the paper.

![FIGURE 1. The impact of channel conflicts on the optimal number of consumers.](image)

We denote the maximum utility that consumers obtained under the manufacturer and the retailer’s online channel as $U_m$ and $U_r$, respectively. For consumers who select the manufacturer’s online channel, the utility is obtained by consumption value through eliminating distributors and manufacturer’s sales efforts. The utility is weakened by the price. For consumers who select the retail’s online channel, the utility is obtained by the retail’s sales efforts, but is weakened by more factors than consumers utility in the manufacturer’s channel. The factors we consider in the retail channel are channel conflicts brought by the manufacturer, purchase price and channel maintenance costs. To simplify analyses, the logistics cost is not considered in the model.

Accordingly, utility function of consumers in the manufacturer and retailer’s online marketplaces can be formulated as $U_m = \theta + a_m q_m - p_m$ and $U_r = a_r q_r - \delta q_m - p_m - c$, respectively.

Note that consumers would purchase products only when they have positive utility. Thus, we have $U_m \geq 0$ and $U_r \geq 0$. Similarly, consumers will choose the manufacturer’s channel if $\theta \geq p_m - a_m q_m$, while consumers will choose the retailer’s channel if $c \leq a_r q_r - \delta q_m - p_r$. Consequently, we have the consumers quantity in the manufacturer and the retailer’s channels as:

$$q_m = \int_{p_m - a_m q_m}^{1} d\theta = 1 + a_m q_m - p_m, \quad (1)$$

$$q_r = \int_{0}^{a_r q_r - \delta q_m - p_r} dc = a_r q_r - \delta q_m - p_r \quad (2)$$

Solve the function, yields

$$q_m = \frac{\delta + 1 - a_m q_m}{\delta + 1 - a_m a_r}, \quad (3)$$

$$q_r = \frac{a_m(1 - p_m) - p_r}{\delta + 1 - a_m a_r} \quad (4)$$

IV. THE MODEL

In this section, we develop profit models of the retailer, the manufacturer and the total supply chain by considering different purchasing channels. In those models, consumers
are rational economic individuals who select from the two channels in order to maximize their consumption utility. We first explore the price strategies of the supply chain to find an optimal channel for consumers. Then, we investigate how channel conflicts affect the supply chain.

Based on the structure of the two-echelon supply chain, the total profit is affected by the price strategies of supply chain members, so the total profit of supply chain consists of the profit of the manufacturer and the retailer. Thus, we obtain the profit function of the supply chain as

\[ \pi_t = \pi_m + \pi_r = q_mp_m + q_rp_r. \]  

(5)

Substituting (1) and (2) into (5), and differentiating \( \pi_t \) once with respects to \( p_m \) and \( p_r \) yields\( \delta \)

\[ \frac{\partial \pi_t}{\partial p_m} = (\delta + 1) - p_r(a_r + a_m) - 2p_m(\delta + 1), \]  

(6)

\[ \frac{\partial \pi_t}{\partial p_r} = a_m - p_m(a_r + a_m) - 2p_r. \]  

(7)

Then we derive the optimal price strategy of the manufacturer and the retailer by equating (6) and (7) to zero and solving the function. Next, we substitute \( p^*_m \) and \( p^*_r \) into \( \pi_m \) and \( \pi_r \), yielding the following results.

**Lemma 1:** The optimal price of the manufacturer is

\[ p^*_m = \frac{2(\delta + 1) - (a_m + a_r)}{4(\delta + 1)(a_m - a_r)}. \]  

(8)

The optimal price of the manufacture is

\[ \pi^*_m = \frac{2(\delta + 1)(a_m - a_r)}{4(\delta + 1)(a_m - a_r)}. \]  

(9)

The optimal profit of the supply chain is

\[ \pi^*_s = \frac{a_m + a_r}{4(\delta + 1)(a_m - a_r)}. \]  

(10)

Then we derive the optimal price strategy of the manufacturer and the retailer by equating (6) and (7) to zero and solving the function. Next, we substitute \( p^*_m \) and \( p^*_r \) into \( \pi_m \) and \( \pi_r \), yielding the following results.

**Lemma 2:** The optimal price of the manufacturer is

\[ p^*_m = \frac{2(\delta + 1) - (a_m + a_r)}{4(\delta + 1)(a_m - a_r)}. \]  

(11)

The optimal profit of the supply chain is

\[ \pi^*_s = \frac{a_m + a_r}{4(\delta + 1)(a_m - a_r)}. \]  

(12)

**Lemma 3:** The optimal consumers quantity of the manufacturer is

\[ q^*_m = \frac{2(\delta + 1)}{(a_m + a_r)}. \]  

(13)

The optimal consumers quantity of the retailer is

\[ q^*_r = \frac{a_m + a_r}{4(\delta + 1)(a_m - a_r)}. \]  

(14)

By analyzing the equilibrium solutions of profit functions that we formulate, the optimal price strategies of the manufacturer and the retailer, the optimal profits of each of them and of the total supply chain are obtained.

The analytical results indicate that the sales efforts exist in the manufacturer or the retailer and the optimal price of the manufacturer and the retailer is not independent with the channel conflicts, the optimal profit and consumer quantity in the supply chain. We believe that this result from the fact that consumers are free to choose the channels, which promote price competition and the level of sales efforts of supply chain members.

**A. SELECTION OF CHANNELS**

To investigate channel conflicts, we consider the price, profit and consumer quantity in different channels. With different channel conflicts level, the manufacturer and the retailer have different operation strategies. Now we explore the optimal strategies of supply chain under channel conflicts. Subtracting \( p^*_r \) from \( p^*_m \), \( \pi^*_p \) from \( \pi^*_m \) and \( q^*_r \) from \( q^*_m \), define:

\[ \Delta p^*_p = p^*_m - p^*_r, \]  

(15)

\[ \Delta \pi^*_p = \pi^*_m - \pi^*_r, \]  

(16)

\[ \Delta q^*_r = q^*_m - q^*_r. \]  

(17)

By analyzing (8), (9) and (10), we yield the following results.

**Proposition 1:** The optimal profit of the manufacturer is larger than optimal profit of the retailer when \( \delta > \frac{a_m(a_m - a_r)}{2(a_m + a_r)} - 1 \); The optimal profit of the manufacturer is smaller than optimal profit of the retailer when \( \delta < \frac{a_m(a_m - a_r)}{2(a_m + a_r)} - 1 \); the retailer and the manufacturer have the same optimal profit when \( \delta = \frac{a_m(a_m + a_r)}{2(a_m - a_r)} - 1 \).

Proposition 1 shows that the price of the same product in different channel has differences, which is determined by channel conflicts. The online market channel that the consumer chooses is related to conflict level, the retailer or the manufacturer’s sales efforts. In addition, we can see that the greater the sales efforts of the manufacturer, the more serious the channel conflicts are in the supply chain from proposition 1. This is because the retailer controls the sales channel in traditional retail markets. The participation of the manufacturer in the online sales channel increases the price competition. Thus, sales efforts of the manufacturer promote the channel conflicts.

**Proposition 2:** The optimal profit of the manufacturer is greater than that of the retailer when \( \delta > \frac{(a_m + a_r)(3a_m - a_r)}{4(a_m - a_r)} - 1 \);

The optimal profit of the manufacturer is smaller than optimal profit of the retailer when \( \delta < \frac{(a_m + a_r)(3a_m - a_r)}{4(a_m - a_r)} - 1 \); The retailer and the manufacturer have the same optimal profit when \( \delta = \frac{(a_m + a_r)(3a_m - a_r)}{4(a_m - a_r)} - 1 \).

Proposition 2 indicates that the retailer and manufacturer’s sales efforts would affect their profit and adjusting their sales efforts can effectively balance the profit of different channels. For the manufacturer, similar to proposition 1, greater sales efforts would enhance channel efforts of the supply chain.

From proposition 2, we know \( \frac{\partial \pi^*_s}{\partial \delta} = 2(a_m - a_r) \). Thus, the retailer’s sales efforts have a non-monotonic impact on channel conflicts, which is dependent on sales efforts of the retailer and manufacturer. Contrary to our intuition, the retailer’s insistence on sales efforts does not always reduce channel conflicts.

**Proposition 3:** The optimal consumer quantity of the manufacturer is larger than optimal profit of the retailer when \( \delta > \frac{a_m + a_r}{2} - 1 \); The optimal consumer quantity of the manufacturer is smaller than optimal profit of the retailer when \( \delta < \frac{a_m + a_r}{2} - 1 \); The retailer and manufacturer have the same optimal consumer quantity when \( \delta = \frac{a_m + a_r}{2} - 1 \).

Proposition 3 states that when channel conflicts are serious, consumers tend to buy products from the manufacturer’s online store. However, consumers’ perception of channel conflicts as compared to brands is not obvious. Because consumers’ perception of channel conflicts is measured by
product price, which is influenced by sales efforts of the supply chain. So we get the insight of proposition 3.

For consumers and brands’ channels selection, they will gain different benefits under different channel conflicts level and sales efforts. Both the retailer and manufacturer’s online channels may be an optimal option for the supply chain. Moreover, the retailer and manufacturer’s sales efforts also affect the consumers and brands’ channels selection.

B. EFFECT OF CHANNEL CONFLICT

After evaluating the selection strategies of different channels in Section 4.1, we now explore the impacts of channel conflicts on consumers and the supply chain. We have obtained the optimal consumers quantity and profit of the supply chain in lemma 2 and lemma 3, judge the significantly influence of channel conflict is essential for improve the profitability of the supply chain.

Now, differentiating \( q_m^* \) and \( q_r^* \) once with respect to \( \delta \) respectively yields,

\[
\frac{\partial q_m^*}{\partial \delta} = -\frac{2(a_m + a_r)^2}{[4(\delta + 1) - (a_m + a_r)^2]^2}
\]  
(11)

\[
\frac{\partial q_r^*}{\partial \delta} = -\frac{4(a_m + a_r)}{[4(\delta + 1) - (a_m + a_r)^2]^2}
\]  
(12)

Obviously, \( \frac{\partial q_m^*}{\partial \delta} < 0, \frac{\partial q_r^*}{\partial \delta} < 0 \), then yielding the following result.

**Proposition 4:** The optimal consumer quantity of retailers and manufacturers decrease with the channel conflict \( \delta \).

Proposition 4 indicates that consumers are not willing to purchase products when facing a serious channel conflict. Online sales channels improve offline after-sales service costs and reduce service quality. This leads to consumers dissatisfaction, which significantly reduces consumers trust in the product.

Next, we analyze the impact of channel conflicts on overall profit of supply chain. Differentiating \( \pi_r^* \) once with respect to \( \delta \) yields

\[
\frac{\partial \pi_r^*}{\partial \delta} = -\frac{(a_m + a_r)^2}{[4(\delta + 1) - (a_m + a_r)^2]^2}
\]  
(13)

Obviously, we have \( \frac{\partial \pi_r^*}{\partial \delta} < 0 \), then yield the following result.

**Proposition 5:** The optimal profit of the whole supply chain decreases with the channel conflict \( \delta \).

Proposition 5 shows that channel conflicts have negative effects on the supply chain, which is consistent with the conclusion of Proposition 4. Because channel conflicts lead to a waste of corporate resources and increased difficulty in price management, as well as dissatisfaction among distributors. As the result, the profit of overall supply chain will drop. Different from the conflicts between online and offline channels, the conflicts between two online channels will further increase price competition. Thus, the profitability of supply chain decline.

While the existence of channel conflicts will gradually upgrade and optimize the two channels, it will facilitate better competition and promote the effective improvement of channel circulation efficiency. Proposition 4 and proposition 5 indicate that channel conflicts are harmful to the supply chain. To avoid serious conflicts and optimize product marketing channels, effective channel adjustments based on different product development stages are required.

V. DISCUSSION

In section IV, we studied the profit model of supply chain under different channels. The supply chain implements the optimal decisions according to the degree of channel conflicts. However, it is worthwhile to discuss whether the sales efforts will impact the supply chain. In addition, we also should understand what impact sales efforts have on consumer surplus. To this end, we explore the relationship between the sales efforts of the manufacturer and the retailer, and figure out the price sensitivity along with sales efforts. Next, we investigate the impact of sales effort on consumers specifically.

A. IMPACT OF SALES EFFORTS ON PRICING

Undoubtedly, the level of sales efforts leads to the change of price. When \( a_m = a_r \), obviously, we have \( p_m^* = \frac{a_m}{2}, p_r^* = 0 \); When \( a_m < a_r \), we have \( p_m^* > 0, p_r^* < 0 \). Those two results do not match the actual situation, so, they are discarded. In fact, the manufacturer’s selling products sales directly through online marketplace will squeeze the retailer’s profits. High sales efforts of the manufacturer make the retailer adopt price subsidy strategy, i.e. \( p_r^* < 0 \), which erodes the profits of the supply chain.

Now, we consider \( a_m > a_r \), in which condition we must have \( p_r^* > 0 \). Then, let \( p_m^* > 0 \), yields \( \delta > \frac{a_m (a_m + a_r)}{a_r} - 1 \).

Differentiating \( p_m^* \) and \( p_r^* \) once with respect to \( \delta \) respectively, yield,

\[
\frac{\partial p_m^*}{\partial \delta} = \frac{2(a_m^2 - a_r^2)}{[4(\delta + 1) - (a_m + a_r)^2]^2}
\]  
(14)

\[
\frac{\partial p_r^*}{\partial \delta} = \frac{(a_r - a_m)(a_m + a_r)^2}{[4(\delta + 1) - (a_m + a_r)^2]^2}
\]  
(15)

Apparently, we have \( \frac{\partial p_m^*}{\partial \delta} > 0, \frac{\partial p_r^*}{\partial \delta} < 0 \) where \( a_m > a_r \), and observe the optimal price decision, the following proposition is provided.

**Proposition 6:** The sales efforts of the manufacturer must larger than that of the retailer under the channel conflicts \( \delta > \frac{a_m (a_m + a_r)}{a_r} - 1 \). The optimal price of the manufacturer increases with the channel conflicts, for the retailer, the result is the opposite.

Proposition 6 shows that in order to set an active pricing strategy, the manufacturer also creates channel conflicts while making sales efforts. The manufacturer needs to put
in more sales efforts than the retailer to ensure an aggressive pricing strategy. Usually, consumers are more loyal to the retailer’s online sales channels, thus the manufacturer needs to pay attentions to increase sales efforts to gain the market share.

Therefore, a high level of channel conflicts improves the optimal price of the manufacturer while leading to the decline of the optimal price of retailer. The retailer should therefore adopt low pricing strategy to attract consumers.

B. CONSUMER SURPLUS
The consumer surplus depends on the utility function at the average optimal price level and the average optimal consumer level. Following Choi and He [30] and Wen and Siqin [31], we investigate consumer surplus in different channels.

The consumer surplus of the manufacturer and retailer at the average optimal price and the optimal consumers quantity is expressed as:

$$s_m = \int_0^1 \left( \theta + a_m q_m^* - p_m^* \right) f(\theta) d\theta,$$

(16)

$$s_r = \int_0^1 \left( a_r q_r^* - \delta q_m^* - p_r^* - c \right) f(c) dc.$$

(17)

Then, we have

$$\Delta s = s_m - s_r.$$

(18)

Substitute (16) and (17) into (18), yield

$$\Delta s = \left[ \frac{1}{p_m^* - a_m q_m^* - 1 - (p_r^* - a_r q_r^* + \delta q_m^*)} \right] \times \left[ \frac{1}{p_m^* - a_m q_m^* - 1 + (p_r^* - a_r q_r^* + \delta q_m^*)} \right].$$

(19)

Let $A = p_m^* - a_m q_m^* - 1$, $B = p_r^* - a_r q_r^* + \delta q_m^*$. Then, we have $\Delta s = A^2 - B^2$. Obviously, when $A^2 \geq B^2$, we have $\Delta s \geq 0$; when $A^2 < B^2$, we have $\Delta s < 0$.

Accordingly, it is reasonable that channel conflicts and sales efforts have significant impacts on the two-echelon supply chain.

VI. NUMERICAL STUDIES
We investigate the impact of model parameters on the two-echelon supply chain. Firstly, we explore the impact of channel conflicts, in which we set the model parameters as follows: $a_m = 0.8$, $a_r = 0.2$, $\delta = \{0.1, 0.9\}$. Then we consider the impact of efforts under fixed channel conflicts $\delta = 0.5$. The sales efforts of the manufacturer and retailer are investigated respectively. While the retailer’s sales efforts level remains the same ($a_r = 0.2$), the manufacturer’s sales efforts varies from 0.3 to 1. While the manufacturer’s sales effort level remains the same ($a_m = 0.8$), the retailer’s sales effort varies from 0.1 to 0.7. To examine the relationship between sales efforts and channel conflicts, we set $a_r = \{4.4, 7\}$, $a_m = 5$ and $a_m = \{4.4, 7\}$, $a_r = 5$ in section 6.3, respectively.

A. IMPACT OF CHANNEL CONFLICTS
As discussed in proposition 4, proposition 5, and proposition 6, channel conflicts have a significant impact on consumers and the supply chain. Figure 2 shows that channel conflicts have a negative impact on consumer quantity of both the manufacturer and retailer, whereas they have a greater impact on the retailer, which cannot be observed in the above propositions. Because the retailer is a traditional sales channel, its customers are more sensitive to channel conflicts. The decline in service levels caused by channel conflicts has a more significant impact on retailers.

Figure 3 shows that channel conflicts have a negative impact on the price of retailer whereas have a positive impact on that of manufacture. Obviously, an increase in the price of the manufacturer results in a decrease in the price of the retailer. Channel conflicts increase price competition. Figure 3 tells us a complementary result, which is an inevitable result of price competition.

Figure 4 shows that channel conflicts have a negative impact on the profit of supply chain. It should be noted that this result is the sum of the effects of channel conflicts on the profits of the manufacturer and retailer, respectively. On the whole, profits in the supply chain are reduced by channel conflicts. Although reducing channel conflicts will harm the
interests of supply chain members, it is beneficial to the entire supply chain.

Consequently, the supply chain needs to dialectically consider the impact of channel conflicts. The channels we considered are online channel for both the manufacturer and retailer, the difference of the impact on the manufacturer and retailer are also relative with the online marketplace.

**B. IMPACT OF SALES EFFORTS**

We can observe the impact of sales efforts on supply chain decisions from Figures 5 to 6.

Figure 5 (a) and Figure 5 (b) show that sales efforts have a positive effect on the number of consumers, both for the manufacturer and retailer. However, we surprisingly find that if the manufacturer enhances the efforts level and the retailer remain unchanged, the consumer quantity of the retailer will be larger than that of the manufacturer in a certain range of sales efforts, beyond that range, the manufacturer would have more customers than the retailer. If the retailer enhances the efforts level and the manufacturer remain unchanged, the result is just the opposite. In other words, the manufacturer or the retailer should keep high level of sales efforts to attract customers.
Figure 6 (a) and Figure 6 (b) show that an increase in manufacturer’s sales efforts level will lead to a decrease in their price and an increase in the price of the retailer. Similarly, an increase in the retailer’s sales efforts level will lead to a decrease in their price and an increase in the price of the manufacturer. Combined with Figure 3, this result illustrates the negative impact of sales efforts on prices. Because increasing sales efforts also increase price competition.

Figure 7 shows that better sales efforts by any member of the supply chain will increase the total profits of the supply chain. Although the impact of sales efforts on their own prices is negative, the positive impact on other members offsets these negative factors, and this continues to increase the profit of the supply chain.

Overall, sales efforts are encouraged because there is a positive impact on the supply chain, which can balance the loss of profit from channel conflicts.

C. RELATIONSHIP BETWEEN CHANNEL CONFLICTS AND SALES EFFORTS

Propositions 1 to 3 indicate that channel conflicts will cause consumers to choose different channels for purchase. The manufacturer and retailer’s pricing strategies also change with the level of channel conflicts. In essence, this phenomenon is caused by sales efforts of the manufacturer and retailer.

Figure 8 shows the impact of sales efforts on price channel conflicts. In terms of pricing strategy, as figure 8 (a) shows, the increase of the retailer’s sales efforts will reduce channel conflicts, while increased sales efforts of the manufacturer will increase channel conflicts. In terms of profit, as figure 8 (b) shows, the sales efforts increase the channel conflicts, and the retailer’s sales efforts have a greater impact on conflicts. In terms of consumer quantity, as figure 8 (c) shown, manufacturers and retailers’ sales efforts have the same impact on channel conflicts.

Analysis shows that the impact of sales efforts on channel conflicts is non-monotonic. This is due to the differences between the online channels of the retailer and manufacturer. Generally speaking, the market response is more sensitive to the retailer’s behaviour, because the retailer is the traditional channel for consumers to buy products, which has a higher level of service. These differences lead to the results shown in Figure 8.

VII. CONCLUSION

Online sales are an important part of the retail world. As more and more manufacturers join the retail sector through online sales, market competition has become more intense. In this paper, we consider a two-echelon supply chain consisting of a manufacturer and a retailer that sells the same products via online marketplaces. We explore how the sales efforts and channel conflicts affect the decision of supply chains and consumers.

Through analytical study, we have the following major findings. First, channel conflicts level and sales efforts will influence consumers’ selection. Specifically, when channel conflicts are serious, consumers tend to buy products from the manufacturer’s online store. Second, channel conflicts are harmful to the supply chain. Consumers are not willing to purchase products facing a serious channel conflict. High sales efforts of the manufacturer will increase channel conflicts of the supply chain. Third, channel conflicts have opposite effects on pricing for the manufacturer and retailer. High channel conflicts increase optimal price of manufacturers whereas reduce that of retailers decline.

Numerical studies show that although channel conflicts has negative impacts on the supply chain, it is beneficial to supply chain members. Sales efforts has positive impacts on the supply chain, but it is harmful to other supply chain members.
In addition, the impacts of channel conflicts on sales efforts are not monotonous.

This study generates insightful guidelines regarding the optimal price strategies considering channel conflicts and sales efforts. For further research, it will be interesting to explore the case where the supply chain has a different channel structure, and compare the optimal price and profit of different channel structures. This model can be popularized and applied to multichannel supply chain. In respect to the research of online channel, the impact of logistics will be considered. Furthermore, the strategies such as probability sales and pre-sales of traditional retailers in responding to the impact of online retailers can be explored.

**APPENDIX**

Proof of lemmas: Substitute (3) and (4) into (5), yields

\[ \pi_t = \frac{1}{(\delta+1)} \frac{p_m + a \alpha_m - p_m (a_0 + a_m) - p_0 ^2 (\delta+1)}{a_0 + a_m} + \frac{1}{2} \delta + a_0 - a_1 \]

The Hessian matrix \( \pi_t \) with respect to \( p_m \) and \( p_m \) is given as

\[ H = \frac{1}{(\delta+1)^2} \frac{1}{a_0 + a_m} \]

We consider \( 4(\delta+1) > (a_0 + a_m)^2 \), thus, we have \( H > 0 \), \( \pi_t \) is a strictly concave function, and its maximum value exists.

**Proof of propositions 1-3:** We have

\[ \Delta p^* = p - p^* = \frac{1}{4}(\delta+1) \frac{(a_0 + a_m) - a_m (a_0 + a_r) - a_m (a_0 + a_m)}{4(\delta+1) - (a_0 + a_m)^2} \]

\[ \Delta q^* = \frac{1}{4}(\delta+1) \frac{(a_0 + a_m) - a_m (a_0 + a_m)}{4(\delta+1) - (a_0 + a_m)^2} \]

when \( \Delta p^* = 0 \), we have \( \delta = \frac{a_0 (a_0 + a_m)}{a_0 + a_m - 1} \); When \( \Delta q^* = 0 \), we have \( \delta = \frac{a_0 + a_m}{4} - 1 \).

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