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Abstract

Purpose – The purpose of this paper is to determine the optimal sale effort deployment under dual-channel distribution which combines a traditional brick and mortar retail channel from the partner retailer and an online direct channel from the manufacturer.

Design/methodology/approach – A sales effort competition game is set up in the dual-channel distribution between the manufacturer and the retailer. Demand under sales efforts is determined based on the consumer valuation, consumer's channel preference and sales efforts. Then, the optimal sales effort deployment is studied with a game theory approach which allow the retailer and the manufacturer to maximize their own profit.

Findings – Consumer's channel preference is a key parameter of the demand assignment in the dual-channel distribution. Interestingly, the optimal sales effort and the profit of the manufacturer and the retailer can be limited by the other's efficiency of sales effort. The finding suggests that the manufacturer and the retailer should collaborate to enhance the efficiency of the sales effort. It also shows that the manufacturer can utilize the direct channel as an important marketing channel even though no profit is obtained through the direct channel.

Research limitations/implications – This research provides a new method to model the sales effort in the dual-channel distribution. The optimal sales efforts based on the consumer behavior are determined. However, since this study assumes a consistent product price across channels, the results is not applicable for a retailer who can set their own price.

Practical implications – It is a win-win situation for adoption of the dual-channel distribution although the manufacturer can benefit more. Additionally, direct channel can be used as an effective marketing channel.

Originality/value – This research contributes to a better understanding of demands in dual-channel distribution under sales efforts. Additionally, the research results provide a useful framework of sales effort deployment under different consumers' channel preferences in the dual-channel distribution.

Keywords Game theory, Channel preference, Customer's valuation, Dual-channel distribution, Sales effort

Paper type Research paper

1. Introduction

With highly securitized online payment supported by financial institutions and low-cost delivery service provided by the third-party logistics, an increasing number of consumers are beginning to shop online. It leads to the fact that B2C e-commerce has grown into an important part of the retail industry. On the one hand, the B2C

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e-commerce sales worldwide reached 1,233 billion US dollars in 2013. Moreover, the global B2C e-commerce sales is forecasted to be 2,356 billion US dollars in the next five years (Statista, 2015). On the other hand, the B2C e-commerce sales as a percentage of global gross domestic product (GDP) has steadily increased since 2009 and reached 0.92 percent of global GDP in 2013. It is expected to rise continuously to 1.61 percent in 2018 (Statista, 2015). In this case, a number of manufacturers adopted the dual-channel distribution strategy, such as Nike and IBM.

When dual-channel distribution is deployed, there are many benefits for the manufacturers and retailers. Considering the worldwide accessibility of the internet; manufacturers can connect with a wider range of potential consumers through the internet. Additionally, more data on consumers can be collected and analyzed for formulating marketing and production strategy (Chiang *et al.*, 2003). Besides, the marginal cost of selling additional products online is low. Besides, it also has been shown that the direct channel can protect manufacturers from demand dropping by retail channel (Stern *et al.*, 1996). Consumers can benefit from the dual-channel distribution as detailed information on the product is available to support the consumer's decision through the direct channel.

Retailers argue that their profit is reduced due to "channel conflict" as orders on the direct channel should be placed through the traditional retail channel (Chiang *et al.*, 2003). Home Depot, the largest retailer of home improvement and construction in the USA, informed suppliers to stop selling online, otherwise, the partnership will be ended (Brooker, 1999). In order to avoid "channel conflict," some manufacturers like Levis Strauss & Co. have closed down the direct channel (online store). There are manufacturers who tried to persuade retailers that a different market segment is targeted by the direct channel (Keenan, 1999). Some manufacturers adopted a different branding strategy such as SVSOUND (Melewar *et al.*, 2010). In order to avoid "channel conflict," SVSOUND provides their products under brand the "SVSOUND" to the retailer while selling products branded as "SBS-01" online.

Although there are arguments for "channel conflict," direct channel online sales is modest at best (Chiang *et al.*, 2003). The dual-channel distribution strategy has been widely accepted by firms of varies industries. However, the sales operation of the manufacturer and the retailer is facing challenges by the dual-channel distribution. This research aims at determining the optimal sales effort deployment for both the manufacturer and the retailer in a dual-channel distribution. Besides we try to figure out the impact of sales efforts on the profit of retail channel and direct channel. We refer to sales effort as activities of both the manufacturer and the retailer for increasing demand such as advertisement. We formulate this problem in two stages. In the first stage, we determined the demand of each channel by assuming rational consumers who try to maximize their utility in the purchasing process. Then, the retailer and the manufacturer deploy their optimal sales efforts according to the demand and the response of each other. Additionally, we assume the price of a product is fixed and consistent in both the retail channel and the direct channel online.

This paper is organized as follows. Section 2 presents a literature review of the dual-channel distribution, and identify the research gaps. Section 3 shows the research model by considering the consumers' valuation and sales effort, channel preference and demand. In Section 4, the optimal sales effort strategy is determined, followed by discussion of the results. A numerical experiment is then conducted in Section 5 to further verify the results. Finally, conclusions are drawn in the last section.

2. Literature review

There have been many previous research studies that discussed dual-channel distribution with respect to pricing, channel conflict and channel coordination.

Pricing of a product under dual-channel distribution is an important issue for both the manufacturer and the retailer. Generally, a Stackelberg game is modeled between the manufacturer and the retailer. The manufacturer is the Stackelberg leader, who sets the direct price and wholesale price in the first place. Then retailer determines the retail price based on the direct price and wholesale price. Fruchter and Tapiero (2005) assumed there was less valuation of the product online in a decentralized dual-channel distribution due to the limited product information. They found that the optimal pricing strategy should set the same price in the retail channel and the direct channel. Tsay and Agrawal (2004) further analyzed dual-channel distribution with the assumption that the demand of each channel is in proportional to the total demand. They indicated that the manufacturer and the retailer can increase their profits by reducing the wholesale price. Cattani *et al.* (2006) analyzed a special case in which the retailer has strong bargaining power so that the manufacturer could only set the wholesale price but the price of the direct channel follows the retail price set by the retailer. They found the optimal wholesale price and retail price could always maximize the manufacturer's profit. Martín-Herrán and Taboubi (2015) investigated the pricing strategy of the dual-channel distribution in a dynamic approach. They found there is a time interval where a dual-channel distribution with an independent retailer performs better than a dual-channel distribution with retail channel controlled by a manufacturer.

Some scholars argued that "channel conflict" is not always true. Rhee and Park (2000) stated that dual-channel distribution is an optimal strategy for both the manufacturer and the retailer when the consumers share similar valuation of products through different channels. Balasubramanian (1998) modeled a multi-channel distribution with a direct channel online. The research shows that a direct channel online is an efficient tool to control the information broadcast to consumers. Chiang *et al.* (2003) built a dual-channel distribution model based on the consumer's acceptance of the direct channel (online store). It has been found that the dual channel is not efficient, but the direct channel is an efficient mechanism for controlling the product's price in the retail channel.

To avoid channel conflict and achieve coordination in a decentralized dual-channel distribution, Ryan *et al.* (2013) discussed a modified revenue sharing contract and a gain/loss sharing contract. They found when the retailer owned the large share of the market, the manufacturer could apply these contracts to formulate pricing strategy. However, Bernstein and Federgruen (2005) argued that the manufacturer should reveal the cost information under the revenue sharing contract. Cai *et al.* (2009) showed that the price discount contacts and pricing schemes could reduce channel conflict, which benefit the retailer and manufacturer through the retail channel. Furthermore, they discussed the situation the retailer when the manufacturer as the Stackelberg leader. They concluded that the Stackelberg leader may not have the advantages of the Stackelberg follower. Taylor (2002) stated that the linear rebate contract can achieve coordination no matter whether demand is influenced by sales efforts or not. However, Krishnan *et al.* (2004) argued that buying back unsold units will reduce the profit of a supply chain, where a higher buy back price leads to lower profits. Chen *et al.* (2012) stated the contract on the wholesale price between the manufacturer and the retailer can only benefit the retailer but not the manufacturer. However, adding a two-part tariff or profit-sharing agreement leads to a win-win situation.

Game theory, as an effective and powerful tool for analyzing the situation where one participant's payoff is impacted by others' action, has been widely adopted in the optimization problems in supply chain research. The studies we mentioned above are related to game theory. Since Nash (1950) is the first scholar who introduced the concept of equilibrium in a non-cooperative n-person game. Aumann (1959) discussed the cooperative game and the game has further extended to infinite period. In this research, we discussed a one-period non-cooperative game of sales effort in the dual-channel distribution between manufacturer and retailer. According to the game theory, the best response of the retailer and the manufactured can be found by the first-order condition of their own utility function. The final equilibrium should be the interaction point of the best response functions of the manufacturer and the retailer.

Sales effort deployment, as an essential part of business operation, has been widely study in traditional retailer distribution models (Rangaswamy *et al.*, 1990; Howick and Pidd, 1990; Lodish *et al.*, 1988; Lightfoot and Harris, 2003). Nevertheless, we found few research studies focussed on the sales effort deployment in dual-channel distribution. Tsay and Agrawal (2004) discussed the sales efforts in the dual-channel distribution where the total demand is only determined by sales efforts of both channel. The demand of each channel are fractions of the total demand which they assign α of total demand to direct channel while $(1-\alpha)$ of total demand to retail. Then, they discussed the impact of α to the sales effort deployment. Besides, they assumed the price is same across different channel but average cost of the product is different due to the different handling cost by different channel. Compared with the study of Tsay and Agrawal (2004), we determine the demand by the assumption that the consumers are rational to maximize their utility in the transaction. At the same time, the full information is provided, which allow consumers to compare the utility of different channel and choose the channel with larger utility. In the following sections, optimal sales effort deployment in dual-channel distribution is studied. Furthermore, interaction between sales activities of manufacturer and retailer is discussed.

3. Demand in the dual-channel distribution

In this section, a model of customer' choice under sales efforts is introduced based on the customer's valuation of the product and customer's channel preference to determine the demand in each channel. We assume customers purchase the product with positive utility. Furthermore, a consumer will make the transaction based on the channel that gives higher expected utility. Then, the demand of the retail channel and the direct channel can be determined.

3.1 Sales effort on consumers' valuation

In this part, we introduce the consumers' valuation on the product and how sales effort impact on it. We assume each consumer has a heterogeneous valuation (v) of the product. The distribution function of valuation ($n(v)$) indicates the number of consumers who share the specific valuation v. We define the distribution with the following properties: $n(v)$ is a continuous function such that:

$$v = 0, \quad n(v) = 0 \tag{1}$$

$$v = \infty, \quad n(\infty) = 0 \tag{2}$$

$$\text{Any } v\epsilon R_{+} n(v) \geqslant 0 \tag{3}$$

Let $N(v) = \int_0^v n(v)dv$, indicates the number of consumers who have valuation between [0, v]. Additionally, we normalized the market size to one. Therefore, $N(v)$ is a monotonically increasing function such that:

$$v = 0, \quad N(v) = 0 \tag{4}$$

$$v = \infty, \quad N(\infty) = 1 \tag{5}$$

In this research, we measure sales effort in proportion to the increasing demand. For instance, if the original demand is D, the demand will increase to $(1+s)D$ while a sales effort s is put on the market. We define the distribution of the consumer's valuation under sales effort (s) as ($n'(v)$), such that:

$$n'(v) = n(v)(1+s_d+s_r-s_r \times s_d) \tag{6}$$

where s_r is the sales effort from retail channel; s_d, the sales effort from direct channel; $s_t = s_d + s_r - s_r \times s_d$, the overall sales effort on the market; and $s_r \times s_d$, the overlap between the sales efforts from the retail channel and the direct channel online. Figure 1 shows a numerical example of the overall sales effort on the market in a dual-channel distribution. It illustrates the overall sales effort distribution under sales efforts from both the direct channel and retail channel.

3.2 Customer's channel preference

In this part, we define the customer's channel preference between the direct channel online and the traditional retail channel as θ. Let 1 to be the neutral value of the customer's channel preference. In this case, $\theta = 1$ means that consumers can buy

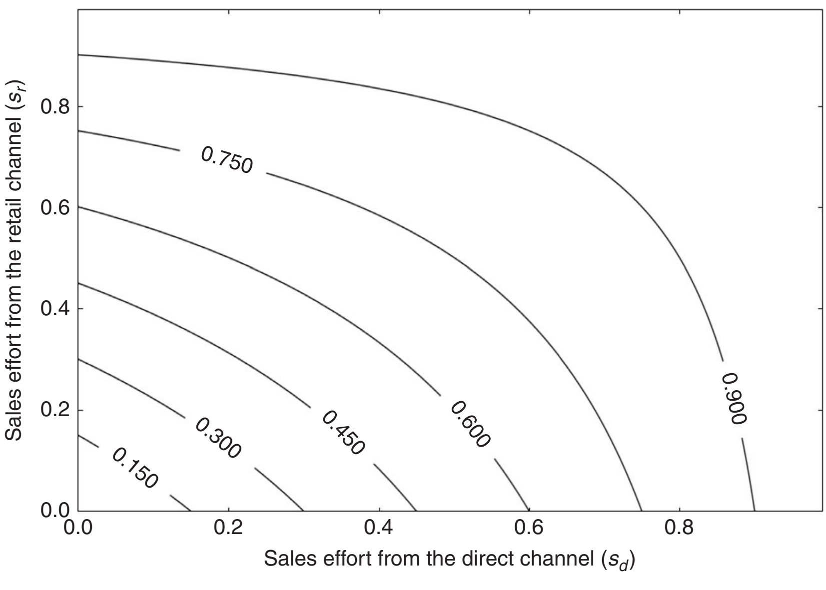

Figure 1.
Overall sales effort ($s_t = s_d + s_r - s_r s_d$) on the market

the product either in the retail channel or in the online direct channel. $\theta > 1$, means that consumers prefer the direct channel more than the retail channel. $\theta < 1$ indicates that consumers prefer the retail channel more than the direct channel.

Although shopping online has been widely accepted by consumers for its convenience, consumers may still prefer the retail channel than the direct channel ($\theta < 1$). Kacen *et al.* (2013) conducted a survey and showed that the mean channel preference ranges from 0.8 to 0.92 for durable and non-durable goods. Consumers prefer to buy the product through traditional retail channel due to the low-service quality in the direct channel online (Devaraj *et al.*, 2002).

Based on the consumers' channel preference, the consumer's expected value of the product is θv in the direct channel online while the expected value of the product is v in the retail channel. Due to consumers' preference of channels, there is a valuation deviation between the direct and the retail channels, $v(1-\theta)$.

3.3 Demand in direct channel and retail channel

In the dual-channel distribution, we assume a consistent price of the product is fixed as p in both the direct channel and the retail channel. Anthem Marketing Solutions (2015) released a semi-annual report of online and offline pricing of consumer goods, which included a number of regularly, purchased categories. It showed that 71 percent of reviewed items have the same price across the retail channel and the online direct channel. Moreover, 88 percent of hardware/home improvement items had the same price both offline and online.

When a customer purchases a product in a retail channel, consumers not only consider product price p but also the channel access cost. For instance, when a customer decides to buy a product from a retail store, it involves traveling cost and time cost. As a customer intends to buy the product on the direct channel, it involves the delivery fee and the time spent on waiting for delivery. We define the access cost of the direct channel as c_d, and access cost of the retail channel as c_r. As the direct channel on the internet is much more convenient for accessing, we assume that the access cost of the retail channel is larger than the direct channel, $c_r > c_d$.

According to the assumptions above, the utility of customers π_c is set when they purchase through direct channel or retail channel as:

$$\pi_c = \begin{cases} v - p - c_r, & \text{if purchased from retail channel} \\ \theta v - p - c_d, & \text{if purchased from direct channel} \end{cases} \quad (7)$$

We assume all the consumers try to maximize their utility in the purchase process. If the product cannot provide positive utility to the consumer, the consumer will walk away. Otherwise, the customer will choose the channel, which gives larger utility to the consumer in the transaction. For consumers whose product valuation meets the condition: $v - p - c_r \geqslant 0$ ($v \geqslant p + c_r$), they will consider buy the product from the retail channel. We define the minimum valuation required for purchase from retail channel, v^r, as the sum of the price and access cost of retail channel, $v^r = p + c_r$. Similarly, the minimum valuation for purchasing from the direct channel is v^d, which should be the sum of price of the product and access cost of the direct channel over the channel preference, $v^d = (p + c_d)/\theta$. When both channels have positive utility to a consumer, he or she will choose the channel with the larger utility. Then, the breakeven valuation (v^{rd}) for channel selection is the valuation with the same utility by both channels,

$v - p - c_r = \theta v - p - c_d$. Therefore, we have a breakeven valuation value $v^{rd} = (c_r - c_d)/(1-\theta)$. When $\theta > 1$, consumers who have a valuation larger than v^{rd} will select direct channel (online sales). Correspondingly, for $\theta < 1$, consumers who have valuation larger than v^{rd} will select the retail channel.

When $\theta > 1$, it can be shown that value of v^{rd} is smaller than zero, and $v^d = \left((p + c_d)/\theta\right) < v^r = p + c_r$. There always be $v^{rd} < 0 < v^d < v^r$. In this case, consumers whose valuation is larger than v^d will buy the product from the direct channel online. Other consumers whose valuation is smaller than v^d will walk away without any transaction. Intuitively, sales effort from the retail channel is zero while demand of the retail channel (D_r) is zero.

When $\theta < 1$, there is a relationship between the minimum purchase valuations $v^d < v^r < v^{rd}$[1]. In this case, consumers whose valuation is larger than v^{rd} will buy the product from the retail channel. Then, we consider the case $v^r < v^d$ under $\theta < 1$. Following the same proof as above, it can be shown that: $v^{rd} < v^r < v^d$. Consumers, whose valuation is larger than v^r, will buy the product from the retail channel.

In summary, demand in the direct channel and the retail channel under different consumers' channel preferences is:

$$D_d = \begin{cases} \left(1 - N\left(\frac{p+c_d}{\theta}\right)\right)(1 + s_d) & \text{if } \theta > 1 \\ \left(N\left(\frac{c_r - c_d}{1-\theta}\right) - N\left(\frac{p+c_d}{\theta}\right)\right)(1 + s_r + s_d - s_d s_r) & \text{if } \frac{p+c_d}{p+c_r} < \theta < 1 \\ 0 & \text{if } \theta < \frac{p+c_d}{p+c_r} \end{cases} \tag{8}$$

$$D_r = \begin{cases} 0 & \text{if } \theta > 1 \\ \left(1 - N\left(\frac{c_r - c_d}{1-\theta}\right)\right)(1 + s_r + s_d - s_d s_r) & \text{if } \frac{p+c_d}{p+c_r} < \theta < 1 \\ (1 - N(p + c_r))(1 + s_r + s_d - s_d s_r) & \text{if } \theta < \frac{p+c_d}{p+c_d} \end{cases} \tag{9}$$

where $c_r > c_d$ is assumed.

4. Sales effort deployment in dual-channel distribution

In this part, a decentralized dual-channel distribution is modeled. The price of a product is p in both the retail channel and the direct channel (online). The average cost of the product is c for the manufacturer. The manufacturer offers a wholesale price ω to the retailer for every single product. Since the retailer is independent of the manufacturer, a sale effort setting game between the manufacturer and the retailer is formed. The objective of the manufacturer and the retailer is to maximize their profits by deploying sales effort independently. We assume the manufacturer and the retailer share common knowledge about the demand of both the direct channel online and the retail channel. The structure of model is shown in Figure 2.

Corresponding to the sales effort either from the retail channel and the direct channel online, there are the costs of sales effort. We assume the cost of the sales effort is linear to the quadratic of the sales effort. There have been many previous research studies related to retailing with similar cost structure (Lau *et al.*, 2010; Iyer, 1998). We define sales effort cost as C_s such that: $C_s = \eta s^2/2$ where s is the sales effort, and η is the cost of the sales effort. Let η_r and η_d be the costs of the sales effort in the retail and direct channels.

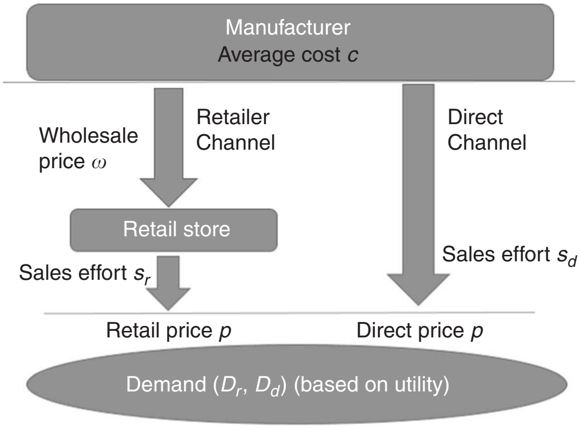

Figure 2.
Structure of a decentralized dual-channel distribution

Then, the profit of the retailer can be modeled as the revenue through the retail channel minus the sales effort cost of the retail channel:

$$\pi_r = (p-\omega)D_r - \frac{\eta_r s_r^2}{2} \tag{10}$$

The profit of the manufacturer is the overall revenue from the direct channel and wholesale from the retail channel minus sales effort cost of the direct channel:

$$\pi_m = (\omega-c)D_r + (p-c)D_d - \frac{\eta_d s_d^2}{2} \tag{11}$$

According to the demand function above and the utility of the manufacturer and the retailer, the optimal sales effort can be determined by game theory in the following scenarios. The optimal sales efforts under three different types channel preference are tabulated in Table I. (the proof of uniqueness and existence is provided in the Appendix) From the Table I, it can be found that: first, when consumers only choose the direct channel, $\theta > 1$, the optimal sales effort from the manufacturer increases with the revenue of the direct channel, $(p-c)(1-N((p+c_d)/\theta))$, decreasing with the cost of the sales effort of direct channel, η_d. Second, when consumers choose both the direct channel online and the retailer channel for purchasing, $1 > \theta > \left((p+c_d)/(p+c_r)\right)$, the optimal sales efforts from the manufacturer and the retailer decrease with the cost of the sales efforts of both direct channel and retailers, η_d and η_r. Third, when consumers only choose the retailer channel for purchasing, $\left((p+c_d)/(p+c_r)\right) > \theta > 0$, then, the optimal sales effort of the retailer increases with the cost of the sales effort of manufacturers. At the same time, the optimal sales effort of the manufacturers decrease with the cost of the sales effort of the retailers.

Furthermore, a number of propositions are presented as follows:

P1. When consumers prefer a direct channel (online store) rather than a retail channel, the optimal sales effort increase with preference of direct channel, with an upper boundary of $(p-c)/\eta_d$.

Channel preference θ	$\theta > 1$	$1 > \theta > \frac{p+c_d}{p+c_r}$	$\frac{p+c_d}{p+c_r} > \theta > 0$
Marginal value relationship	$1 > v^r > v^d$	$1 > v^{rd} > v^r > v^d$	$v^d > v^r > v^{rd}$
Sales effort of retail channel s_r^*	0	$\frac{(l+m)l-\eta_d l}{(l+m)l+\eta_d\eta_r}$	$\frac{ab-\eta_d a}{ab-\eta_d\eta_r}$
Sales effort of direct channel s_d^*	k/η_d	$\frac{(l+m)(l-\eta_r)}{(l+m)l+\eta_d\eta_r}$	$\frac{ab-\eta_r b}{ab-\eta_d\eta_r}$
Sales effort overlap $s_d^* \times s_r^*$	0	$\frac{(l+m)(l-\eta_r)(l+m-\eta_d)l}{((l+m)l+\eta_d\eta_r)^2}$	$\frac{(ab-\eta_d a)(ab-\eta_r b)}{(n-\eta_d\eta_r)^2}$

Notes: $k = (p-c)(1-N((p+c_d)/\theta))$, profit of the manufacturer in direct channel without sales effort if $\theta > 1$; $l = (\omega-c)(1-N((c_r-c_d)/(1-\theta)))$, profit of the manufacturer in retail channel without sales effort if $1 > \theta > (p+c_d)/(p+c_r)$; $m = (p-c)(N((c_r-c_d)/(1-\theta))-N((p+c_d)/\theta))$, profit of the manufacturer in retail channel without sales effort if $1 > \theta > (p+c_d)/(p+c_r)$; $a = (p-\omega)(1-N(p+c_r))$, profit of the manufacturer in retail channel without sales effort if $(p+c_d)/(p+c_r) > \theta > 0$; $b = (\omega-c)(1-N(p+c_r))$, profit of the manufacturer in retail channel without sales effort if $(p+c_d)/(p+c_r) > \theta > 0$; where $c_r > c_d$, $v^r = p+c_r$, $v^d = (p+c_d)/\theta$, $v^{rd} = (c_r-c_d)/(1-\theta)$

Table I. The optimal sales effort strategy to max profit under different channel preference θ

Proof: As consumers only purchase from the direct channel, the optimal sales effort of the manufacturers is:

$$s_d^* = \frac{(p-c)\left(1-N\left(\frac{p+c_d}{\theta}\right)\right)}{\eta_d} \quad (12)$$

Consider $\partial s_d^*/\partial N((p+c_d)/\theta) = -1 < 0$ and the fact that $N(v)$ is a monotonically increasing function, $\partial s_d^*/\partial((p+c_d)/\theta)$ is always less than zero. Therefore, the optimal sales effort increase with the preference of direct channel $(\partial s_d^*/\partial\theta) > 0$. In the other words, even if all consumers choose the direct channel, the sales department of the manufacturer should have more sales activity while the consumers' preference for the direct channel is increasing. There is an upper boundary of sales effort of the manufacturer given as:

$$\lim_{\theta\to\infty} s_d^* = \lim_{\theta\to\infty} \frac{(p-c)\left(1-N\left(\frac{p+c_d}{\theta}\right)\right)}{\eta_d} = (p-c)/\eta_d \quad (13)$$

Assume the manufacturers make the optimal sales effort on the market, and the contributed profit (CP) should be the revenue increased by the sales activities minus the cost of the sales effort. Therefore, the manufacturers' CP by the sales effort is shown below, when all consumers choose the direct channel:

$$CP = \frac{(p-c)^2\left(1-N\left(\frac{p+c_d}{\theta}\right)\right)^2}{2\eta_d} = 0.5(p-c)\left(1-N\left(\frac{p+c_d}{\theta}\right)s_d^*\right) \quad (14)$$

It shows that the CP of the manufacturer is half of the increased revenue by the sales effort when the optimal sales effort is made.

P2. In the dual-channel distribution, the retailer's profit could be limited by the sales effort cost of the manufacturer. The manufacturer's profit is limited by the cost of the sales effort of the retailer.

Proof: The optimal sales efforts of the manufacturer and the retailer can be presented in following form:

$$s_r^* = \frac{(l+m-\eta_d)l}{(l+m)l+\eta_d\eta_r} \tag{15}$$

$$s_d^* = \frac{(l+m)(l-\eta_r)}{(l+m)l+\eta_d\eta_r} \tag{16}$$

From the equations above, it can be seen that the optimal sales effort of direct channel, s_r^* will be less than zero while the cost of the sales effort by direct channel η_d is larger than the total profit manufacturer gained from retail channel and direct channel without sales effort, $l+m$. At the same time the optimal sales effort from direct channel s_d^* will be a negative value when the cost of the sales effort by retail channel η_r is larger than manufacturer's profit from retail channel without sales effort l. However, the sales effort can only be larger or equal to zero. In this case, no sales effort will be expected from the retail channel or the online direct channel. Therefore, the retailer's profit and the manufacturer's profit cannot be maximized to its potential maximum due to the low efficiency of the sales effort of the other channel. We define the threshold sales effort of the direct channel and retail channel as:

$$\widehat{\eta_d} = l+m \tag{17}$$

$$\widehat{\eta_r} = l \tag{18}$$

where: $l = (\omega-c)\left(1-N\left((c_r-c_d)/(1-\theta)\right)\right)$; and $m = (p-c)\left(N\left((c_r-c_d)/(1-\theta)\right)-N\left((p+c_d)/\theta\right)\right)$.

In order to avoid a negative optimal sales effort, it is suggested that the manufacturer and the retailer collaborate with each other to maintain the cost of the sales effort at a low level.

P3. When customers only buy the product from the retail channel, the optimal sales efforts from the manufacturer and the retailer are the same in reaching the potential maximum profits.

Proof: When only the retail channel has demand, the optimal sales efforts from the manufacturer and the retailer are:

$$s_d^* = \frac{ab-\eta_r b}{ab-\eta_d\eta_r} \tag{19}$$

$$s_r^* = \frac{ab-\eta_d a}{ab-\eta_d\eta_r} \tag{20}$$

where $a = (p-\omega)(1-N(p+c_r))$; and $b = (\omega-c)(1-N(p+c_r))$.

Since the profit of the manufacturer and the retailer increase with the optimal sales effort, we try to maximize the optimal sales effort with respect to the cost of the sales effort of the manufacturer and the retailer that managed by operation of the manufacturer and the retailer. The following equations show the optimal condition of the costs of sales effort:

$$\frac{\partial s_d^*}{\partial \eta_d} = \eta_d \left(ab - \eta_r b\right)\left(ab - \eta_d \eta_r\right)^{-2} = 0 \tag{21}$$

$$\frac{\partial s_r^*}{\partial \eta_r} = \eta_r \left(ab - \eta_d a\right)\left(ab - \eta_d \eta_r\right)^{-2} = 0 \tag{22}$$

It should be noted that following equation must hold in order to meet the optimal condition above:

$$\eta_r(\omega - c) = \eta_d(p - \omega) \tag{23}$$

It is important for the retailer and the manufacturer to maintain the cost based on the retail price, wholesale price and average cost. If we consider the Equations (19) and (20) according to Equation (23), it indicated the optimal sales effort from the retailer is equal to the optimal effort from the manufacturer:

$$s_d^* = s_r^* \tag{24}$$

5. Numerical example

In this section, a numerical example of sales effort deployment is demonstrated. We assume the consumers' valuation distribution is a standard lognormal distribution with total 10,000 consumers. The lognormal distribution is the distribution $Y = \ln(X)$, where X is a standard normal distribution. The probability distribution function and cumulative distribution fit our assumption about the consumer valuation distribution (Equations (1)-(5)). The price of a product is set as US$5 in both the direct channel online and the retail channel. The manufacturer offers a wholesale price of US$4.5 to the partner retailer. The manufacturer's average cost of the product is US$4. For the consumers, the accessing cost of the retail channel is US$0.6 while the access cost of direct channel (online store) is US$0.1. At the same time, the retailer's sales effort rate is 0.1 while the sales effort' cost of the manufacturer is 0.2.

According to model introduced above, we can have a breakeven channel preference between the retail channel only and both the direct channel online and the retail channel of $(p+c_d)/(p+c_r) = 0.91$. We present the optimal sales efforts and corresponding demand and profits under different channel preferences as follows. (Table II).

While the direct channel dominates the market due to high-consumer preference ($\theta = 1.1$), it shows that a large sales effort from the manufacturer (2.65) is needed to reach the optimal profit, which also shows the potential market size is huge. The product sold through the direct channel has increased 265 percent to 19,442 units compared to sales of 5,312 units without sales effort. It leads to a profit of US$12,378 which is more than twice the profit without sales effort. When all consumers choose the direct channel, Figure 3 shows that the optimal sales effort from the manufacturer in relation to the consumers' preference. At the same time, the increasing rate slows down with consumers' channel preference. According to the *P1*, the upper boundary of sales effort is $(p-c)/\eta_d$ which tends to a value of 5. It can be found that when consumer's channel preference is relative low, taking the value of 2, the optimal sales effort is

Table II.
Example of sales effort deployment under different channel preference

Channel preference	1.1 (direct channel only)		0.95 (both channels)		0.8 (retail channel only)	
s_r^*	0		0.29		0.19	
s_d^*	2.65		0.1		0.92	
$s_r \times s_d$	0		0.029		0.17	
	Without sales effort	With sales effort	Without sales effort	With sales effort	Without sales effort	With sales effort
D_r	0	0	2,337	3,181 (36%)*	4,527	8,745 (93%)*
D_d	5,315	19,442 (265%)*	2,366	3,220 (36%)*	0	0
π_r	0	0	1,168.5	1,548 (32%)*	2,264	4,354 (92%)*
π_m of R	0	0	1,168.5	1,590 (36%)*	2,264	4,362 (93%)*
π_m of D	5,315	12,378 (133%)*	2,366	3,211 (36%)*	0	−838
π_m total	5,315	12,378 (133%)*	3,535.5	4,801 (36%)*	2,264	3,534 (56%)*

Notes: "π_m of R" is the manufacturer's profit from the retail channel; "π_m of D" is the manufacturer's profit from the direct channel online; *the difference between the value before the sales effort and after the sales effort in percentage

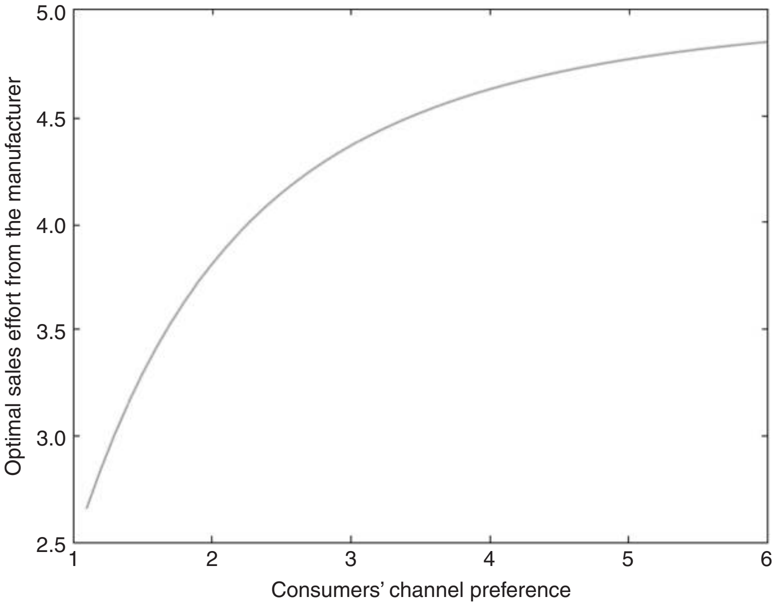

Figure 3.
The optimal sales effort respects to consumers' channel preference

increasing with channel preference in a high ratio. In this scenario, the manufacturer can increase their profit by enhancing the consumer's channel preference.

If the consumer have a channel preference of 0.95, it would be a win-win situation for the manufacturer and the retailer. For the retailer, the demand of the retail channel increased 36 percent with sales effort of 0.29. At the same time, the retailer's overall profit reached US$1,548, an increase of 32 percent. Surprisingly, the demands of the direct channel and manufacturer's profit have increased 36 percent with only a sales effort of 0.1. The manufacturer has benefited from the sales activities of the retailer. However, based on *P2*, the threshold cost of the sales effort of the direct channel is 0.353

which is larger than the current direct channel's cost of the sales effort. At the same time, the threshold cost of the sales effort of the retail channel is 0.117 which is larger than the current cost of the retail channel. This guarantees both channels can make sales efforts on the market in the optimal situation (Figure 4).

Furthermore, we analyze the optimal sales efforts and profits of the retailer and the manufacturer while the retailer's cost of the sales effort is raising. It indicates that once the retailer's cost of the sales effort exceeds the threshold rate $\widehat{\eta_r}$, the optimal sales effort of the direct channel will reduce to zero. Meanwhile, the corresponding sales effort of the retailer and overall sales effort will drop to a low level. It also illustrates that the profits of the manufacturer and the retailer decrease with the retailer's cost of the sales effort. Once the retailer's cost of the sales effort reach the threshold value $\widehat{\eta_r}$, both the retailer and the manufacturer suffer profit losses where the manufacturer loses more. Therefore, it is important for manufacturer and the retailer to ensure the each other has a cost of sales effort which is lower than the threshold. Otherwise, both the manufacturer and the retailer will suffer profit lose.

In the condition of consumers having a low preference of direct channel such as 0.8 (i.e. customers prefer direct channel), compared with the profit of both channels without sales efforts, the profit of the retailer increased by US$2,090. In the view of manufacturer, although the sales activities in direct channel only lead to costs of US $838 in the direct channel. It finally increase the profit of the manufacturer by US$3,543 due to sales rise in the retailer channel. It indicates that the direct channel can be a useful marketing channel while all consumers purchase from the retailer channel. According to *P3*, if we adjust the costs of the sales effort based on Equations (35) and (36), then $\eta_r = \eta_d = 0.226$. Correspondingly, the optimal sales efforts from the manufacturer and the retailer are same with a value of 0.5. In that case, the optimal profit of manufacturer and the retailer will increase to US$5,003. In this case, the increased cost of sales efforts of the manufacturer and the retailer leads to a profit rise of both parties. It demonstrates the fact that it is important for the manufacturer and retailer to maintain their efficiencies of the sales effort.

6. Conclusions

Once a decentralized dual-channel distribution is constructed, how much sales effort should be made from each channel for marketing? This research determined the optimal

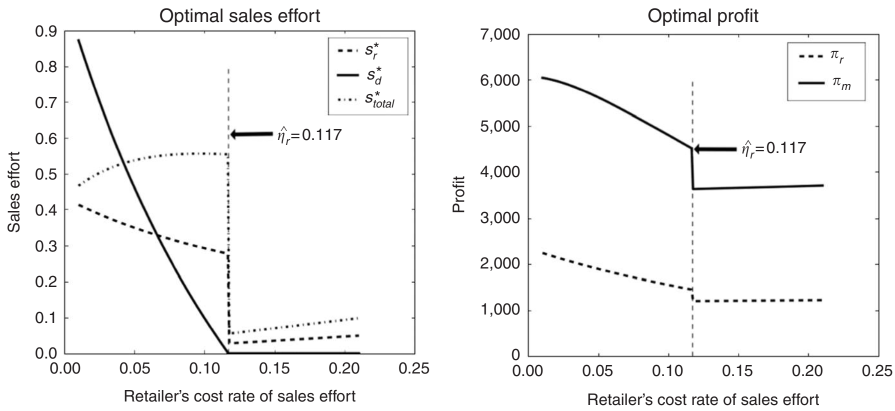

Figure 4.
Optimal sales effort and profits respect to retailer's cost of sales effort

sales effort of the direct channel and the retail channel based on the demand forecasting by the expected utility of the consumers. It shows that the channel preference of the consumers is the key parameter for the demand distribution in dual-channel situation. There will be demand in both channels even though consumers may slightly prefer the retail channel rather than the direct channel. Otherwise, all consumers will purchase through direct channel if consumers prefer direct channel than retail channel.

We found that the sales effort of the direct channel increases with consumer's channel preference of the direct channel when more customers buy the product online (direct channel). Because customer preference to the direct channel increases, it gives a higher valuation of the product through the online shopping. Therefore, more profit can be earned by sales effort on the direct channel due to the increased demand. It encourages the manufacturer to put more and more sales effort into the direct channel. However, while the manufacturer's profit approaches the limit, the marginal profit of the sales effort decreases to zero. If the return rate of the sales effort is considered, we can determine the manufacturer's desired channel preference rate (θ). The desired channel preference rate (θ), can be a guideline for a manufacturer to maintain customer preference in order to reach the optimal profit in the long term.

Moreover, we discussed the situation where both the direct channel and the retail channel have demand, and showed that the low efficiency of the sales effort of one channel will reduce the profit of the other channel. For example, if the direct channel has a low-marketing efficiency, which means more money is required for the same sales effort, the profit of the retailer will be affected and decrease correspondingly. To avoid such situations, the marketing department of the direct and the retail channel are suggested to support the sales activities of the other channel by offering some technical assistance or marketing information to enhance the efficiency of the other channel.

Additionally, we analyzed the case that all consumers have strong preference to the retail channel. It should be noted that the direct channel could be an effective marketing channel even if no consumer purchased through it. We also found that in order to reach the potential maximum profit, the sales efforts from the retailer and the manufacturer should be the same.

According to the discussion, dual-channel distribution is favorable for manufacturer. No matter the consumer's channel preference is, the manufacturer can always benefit from the sales effort through the direct channel even if direct channel has no sales. The retailer will only suffer no sales or low sales while consumers prefer direct channel than the retailer channel. To handle the dilemma for the retailer due to consumer's high preference to the direct channel, the retailer may try to open online by its own to compete with the direct channel of the manufacturer. It can be an interesting topic for further discussion.

Besides, future work should be done to analyze the optimal sales effort and profit of the manufacturer and the retailer in a dynamic manner. Since demand in each time period may reflect consumer channel preference, we could maximize the overall profits of the manufacturer and the retailer by deploying sales effort correspondingly. Additionally, different product price strategy can be assumed in retail channel and direct channel for further study.

Note

1. When $\theta < 1$, there is $v^d < v^r$. If $v^d < v^r$, then $v^d - v^r < 0$, which implies $\theta > \big((p + c_d)/(p + c_r)\big)$. The product of $v^{rd} - v^r$ is $\big((c_r + c_d)/(1-\theta)\big) - (p + c_r) > (c_r + c_d)/1 - \big((p + c_d)/(p + c_r)\big) - (p + c_r) = p + c_r - (p + c_r) = 0$. Therefore, $v^d < v^r < v^{rd}$.

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Appendix

Considering the scenario that the consumers prefer the direct channel to the retail channel, the profit of the retailer is zero as there is no demand in the retail channel according to the demand analysis above. The profit of the manufacturer can be set as follows:

$$\pi_m = (p-c)\left(1-N\left(\frac{p+c_d}{\theta}\right)\right)(1+s_d)-\frac{\eta_d s_d^2}{2} \tag{A1}$$

The maximum profit can be obtained by the first-order condition where the first-order derivative of the profit with respect to the sales effort is zero $\left(\partial\pi_m/\partial s_d\right) = 0$:

$$(p-c)\left(1-N\left(\frac{p+c_d}{\theta}\right)\right)-\eta_d s_d = 0 \tag{A2}$$

Furthermore, the uniqueness of the optimal sales effort can be proved by the second-order condition where the second-order derivative should always less than zero. For the manufacturer, $\left(\partial^2\pi_m/\partial s_d^2\right) = -\eta_d \leqslant 0$, the uniqueness can be guaranteed since the cost of the sales effort always has a positive value.

When consumers prefer the retail channel and the preference is larger than $(p+c_d)/(p+c_r)$, there is demand in both the retail and direct channels. The profits for the retailer and the profit of manufacturer are listed as follows:

$$\pi_r = (p-\omega)\left(1-N\left(\frac{c_r-c_d}{1-\theta}\right)\right)(1+s_r+s_d-s_d s_r)-\frac{\eta_r s_r^2}{2} \tag{A3}$$

$$\begin{aligned}\pi_m = {} & (p-c)\left(N\left(\frac{c_r-c_d}{1-\theta}\right)-N\left(\frac{p+c_d}{\theta}\right)\right)(1+s_r+s_d-s_d s_r) \\ & +(\omega-c)\left(1-N\left(\frac{c_r-c_d}{1-\theta}\right)\right)(1+s_r+s_d-s_d s_r)-\frac{\eta_d s_d^2}{2}\end{aligned} \tag{A4}$$

Determination of the optimal sales effort follows the same approach mentioned above. The first-order condition of equilibrium is shown as follows:

$$\frac{\partial \pi_r}{\partial s_r} = (p-\omega)\left(1-N\left(\frac{c_r-c_d}{1-\theta}\right)\right)(1-s_d)-\eta_r s_r = 0 \tag{A5}$$

$$\frac{\partial \pi_m}{\partial S_d} = (p-c)\left(N\left(\frac{c_r-c_d}{1-\theta}\right)-N\left(\frac{p+c_d}{\theta}\right)\right)(1-s_r) + (\omega-c)\left(1-N\left(\frac{c_r-c_d}{1-\theta}\right)\right)(1-s_r)-\eta_d s_d = 0 \tag{A6}$$

The second-order condition of the profits of the manufacturer and the retailer is $\left(\partial^2 \pi_m/\partial s_d^2\right) = -\eta_d \leqslant 0$ and $\left(\partial^2 \pi_r/\partial s_r^2\right) = -\eta_r \leqslant 0$, which ensures the uniqueness of the optimal sales effort.

Eventually, when customers prefer the retail channel rather than the direct channel (online sale), with channel preference lower than $(p+c_d)/(p+c_r)$, consumers only choose the retail channel. Although there is no demand in the direct channel, sales effort from the direct channel could benefit the manufacturer by increasing demand in the retail channel. The profit functions of the retailer and the manufacturer are shown as following:

$$\pi_r = (p-\omega)(1-N(p+c_r))(1+s_r+s_d-s_d s_r)-\frac{\eta_r s_r^2}{2} \tag{A7}$$

$$\pi_m = (\omega-c)(1-N(p+c_r))(1+s_r+s_d-s_d s_r)-\frac{\eta_d s_d^2}{2} \tag{A8}$$

The first-order condition for equilibrium is:

$$\frac{\partial \pi_r}{\partial s_r} = (p-\omega)(D-N(p+c_r))(1-s_d)-\eta_r s_r = 0 \tag{A9}$$

$$\frac{\partial \pi_m}{\partial s_d} = (p-\omega)(F-N(p+c_r))(1-s_r)-\eta_d s_d = 0 \tag{10}$$

Following the same proof above, the uniqueness of optimal sales effort is guaranteed, with the positive cost of the sales effort $\left(\left(\partial^2 \pi_m/\partial s_d^2\right) = -\eta_d \leqslant 0, \quad \left(\partial^2 \pi_r/\partial s_r^2\right) = -\eta_r \leqslant 0\right)$.

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