Two-echelon Price Competition with the Choice of Manufacturer’s Direct Channel and Retailer’s Store Brand

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Abstract—This paper considers a choice game that whether a manufacturer runs a direct channel (d-channel) and whether a retailer should respond by introducing a store brand (SB) in a two-echelon supply chain in which a dominant manufacturer sells his national brand product (NB) through a retailer. The results show that (i) the two channel competition and the brand competition can weaken the negative effects of double marginalization; (ii) when the operating costs for the d-channel and the SB are small, the optimal strategy is to introduce the d-channel and the SB, and a win-win outcome is achieved, and when they are relatively high, it is contrary; (iii) as the leader, the manufacturer has a first-mover advantage to maximize his profit when the operating costs are medium. The sensitivity analyses indicate that the manufacturer can benefit from the fierce channel competition, whereas the retailer prefers to the fierce brand competition.

Index Terms—supply chain, pricing, direct channel, store-brand, equilibrium

I. INTRODUCTION

A. Motivation

With the rapid development of e-commerce, many manufacturers such as IBM, Cisco and Nike have opened their own d-channels besides traditional r-channels (Kumar and Ruan 2006[1], Wang et al. 2016[2]). When a d-channel is established, opportunities and threats coexist (Choi 2003[3]). From manufacturers’ perspectives, running a d-channel may reduce the dependence on r-channels and enhance their bargaining power. However, the presence of the d-channel may intensify the competition between manufactures and retailers, sometimes deteriorating retailers (Chiang et al. 2003[4], Seifert et al. 2006[5]). This may result in retailers’ counterattack, including the improvement of service level and introduction of the SB product, etc.. Among these measures, introducing the SB product is a prevailing strategy. The latest available data show that the SB now account for at least 30% of all packaged food products sold in Europe (Nielsen/PLMA, 2014[6]). Many empirical researches have shown that introducing the SB tends to alleviate the retailer’s dependence on the NB product, increase the demand of the r-channel and improve customer loyalty to the retailer.

This paper will discuss a two-echelon supply chain, where one dominant manufacturer with the option of running a d-channel sells a NB through one retailer, who has the option of introducing a SB. We will investigate the two partners’ equilibrium options and their corresponding pricing policies.

B. Literature Review

The earlier works related to this paper mainly include two categories, which involves channel competition and brand competition.

With the emergence of e-commerce, the channel competition issues have gained increasing attention from academy. Rhee and Park (2000)[11] developed a hybrid channel model in which they divide consumers into two segments: a price sensitive segment and a service sensitive segment. They indicated that the hybrid channel is optimal when the segments are similar in their valuations of the retail service. Chiang et al. (2003)[4] considered the effect of the d-channel on the pricing strategies, the sales, the profits of a vertically integrated firms, and customer channel preference. They assumed that customer’s acceptance of d-channel is homogeneous, and showed that the d-channel could enhance the manufacturer’s negotiation power. Kumar and Ruan (2006)[1] considered a dual channel model in which consumers are divided into two segments: manufacturer loyal and retailer loyal. They also presented that the manufacturer can benefit from a d-channel. Using the same demand function as in [1], Cai et al. (2009)[12] evaluated the impact of price discount contracts and pricing schemes on the dual channel supply chain. Xu et al. (2013)[13] noted that customers preferred dual channels that offered them more shopping choices and experiences, and this trend forced the manufacturer to introduce a d-channel as a necessary strategy. Shang and Yang (2015)[14] applied the profit-sharing contract to coordinate a dual channel supply chain and examined the

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selection of profit-sharing parameters and the allocation of extra system profit. Matsui (2016)[15] studied an asymmetric product distribution strategy for a manufacturer that uses dual channel supply chain. More examples falling into this category can be found in the review article by Tsay and Agrawal (2004)[16].

Brand competition includes two streams. One stream is empirical studies on SB products. These empirical studies mainly focus on SB product introduction strategies for retailers, prevention strategies for NB manufacturers, and the role of SB product in channel relations[7]-[10]. The other stream discusses competitive pricing issues between NB and SB by mathematical modeling. Narasimhan and Wilcox (1998)[17] analyzed the impact of SB product on equilibrium pricing strategies and corresponding profits. Their research results showed that SB product introduction shifts some surplus from the manufacturer not only to the retailer but also to consumers. Groznik and Heese (2010)[18] and Choi and Fredj (2013)[19] studied pricing strategies between two r-channels with an endogenous manufacturer, where the manufacturer sells a NB product through two competing retailers, and each retailer has the option of introducing SB product. Ru et al. (2015)[20] showed that a SB may benefit the manufacturer when the manufacturer and the retailer play a retailer-Stackelberg game. Kurata et al. (2007)[21] analyzed channel pricing, where an NB is distributed through both a d-channel and a r-channel but SB is only distributed through a r-channel. In a Nash pricing game frame, they focused on channel competition and coordination issues. The results indicated that wholesale price failed to coordinate the supply chain, but an appropriate combination of markup and markdown prices can coordinate it and achieve a win-win outcome for each channel. Amrouche and Yan (2012)[22] proposed a model by implementing a d-channel for NB competing against SB. They discussed the impact of introducing the SB and implementing a d-channel on two the players’ profits in three cases: NB product was sold solely through a r-channel, the SB was introduced by the retailer, and the manufacturer opened a d-channel. Different from [21] and [22], this paper establishes a choice game model, that is, we focus on whether or under what conditions the manufacturer and the retailer should introduce d-channel and SB product, respectively. In addition, the paper discusses the effect of the operating cost difference between the NB at the d-channel and the SB. This paper also investigates pricing policies, and profits of the two players and the whole chain.

The main contributions of this paper include three aspects. First, while most related papers discussed pricing under either channel competition or brand competition, this paper considers a choice game of the manufacturer and the retailer, i.e., whether to introduce the d-channel and the SB. Second, differentiated from Nash pricing game frame in [21], we discuss pricing game under a manufacturer-Stackelberg framework. Finally, different from [22], this paper specifies the conditions under which the manufacturer and the retailer should introduce the d-channel and the SB.

II. PROBLEM FORMULATION AND BASIC MODEL

Consider a two-echelon supply chain consisting of a dominant manufacturer (he) and a retailer (she). The manufacturer produces a NB at $c_1$/unit and sells it at $w_1$/unit to the retailer, who sells it at $p_1$/unit to consumers. Now the manufacturer and the retailer may decide whether to run a d-channel and to introduce a SB respectively. Suppose that the manufacturer runs a d-channel, the NB’s unit cost in the d-channel, $c_0$, will be no less than its unit production cost, i.e., $c_0 \geq c_1$, because running the d-channel involves extra charge such as channel building and managing cost. For brevity, we also refer to $c_0$ as the unit operating cost in the d-channel. Likewise, $c_1$ is the unit operating cost of the SB, which includes its unit production cost. $p_0$ represents the NB’s price in the d-channel and $p_2$ is the SB’s retail price.

We now design the choice game between the manufacturer and the retailer unfolding in three stages. In the first stage, the manufacturer decides whether to or not to run the d-channel, and the retailer decides whether or not to complement the SB with the NB. Second, the manufacturer sets the wholesale price $w_1$ for the NB and the online price $p_0$ when he decides to sell direct. Finally, knowing the manufacturer’s decision, the retailer sets the NB’s price $p_1$ at the r-channel and the SB’s price $p_2$ if she offers the SB. There are four subgames in the model as follows: the r-channel providing only the NB (Case 1), and the r-channel providing the SB other than the NB (Case 2), introducing d-channel except the r-channel providing the NB (Case 3), r-channel introducing the SB by the retailer and d-channel being run by the NB manufacturer (Case 4). The choice game structure is illustrated in Fig. 1.

Comparing with [22], Case 3 discussed in this paper was not considered in [22]. They discussed the effect of the quality difference between NB and SB, whereas we consider the impact of the unit operating cost difference between the NB in the d-channel and the SB. Additionally, we will focus the game’s equilibrium outcome in Section 4,
which was not discussed in [22].

Consistent with [1], assume that consumers consist of two groups: brand loyal and store loyal. The brand loyal consumers only purchase the NB from either the d-channel or the r-channel, whereas the store loyal consumers buy either the NB or the SB only from the specific retailer. The brand loyal consumers have a strong preference for the NB and will never consider buying a different brand and the segment of size is $ε_M$. However, the store loyal consumers are not loyal to any specific brand and the segment of size is $ε_R$. Relative to the brand loyal consumers, the store loyal consumers maybe be viewed as those who are less informed about the products in the specific category. They have a need to touch and feel the product before purchasing. Consequently, consumers of this type will never consider buying the NB through the d-channel.

The demand for each product and profit of each player in the four cases are summarized as follows.

**Case 1:** only the NB is offered in the r-channel. The demand is linear in its retail price $p_1$, shown as follows:

$$D = (c_M + ε_M)(1 - βp_1).$$

(1)

where $β$ measures the effect of retail price on the demand.

The linear demand function is widely applied in price competition literature (e.g., [12], [22]) since it is tractable and enables closed-form solutions.

The profits in Case 1 are given as follows:

$$Π_d(w_1) = [c_M + ε_M](1 - βp_1)(w_1 - c_1),$$

(2)

$$Π_p(p_1) = [c_M + ε_M](1 - βp_1)(p_1 - w_1).$$

(3)

**Case 2:** the SB and the NB are offered through the r-channel. If the SB is offered, a fraction of store loyal consumers will shift from the NB’s ones. As noted earlier store loyal consumers fulfill all their purchasing needs only in the r-channel, the retailer could influence the purchasing decision of store loyal consumers. To capture this feature, we assume that the fraction of store loyal consumers that purchase the SB depends on the level of sales effort (e.g., advertisement and shelf space) that the retailer allocates to the SB. We assume that the total level of sales effort to SB and NB is normalized for simplicity to 1, and $δ_2$ represents the NB’s sales effort level. Correspondingly, the SB’s sales effort is $1 - δ_2$. The baseline demand for NB in the r-channel is equal to $c_M + ε_M$, and the baseline demand for SB is equal to $(1 - δ_2)ε_R$. The demand for NB through the r-channel (denoted by $D_1$) and for the SB (denoted by $D_2$) and the profits of the two partners are given as follows:

$$D_1 = (c_M + δ_2ε_R)(1 - βp_1) + η(p_1 - p_1).$$

(4)

$$D_2 = (1 - δ_2ε_R)(1 - βp_1) + η(p_1 - p_1).$$

(5)

$$Π_d(w_1) = [c_M + δ_2ε_R](1 - βp_1)(w_1 - c_1),$$

(6)

$$Π_p(p_1) = [1 - δ_2ε_R](1 - βp_1)(p_1 - w_1) + [(1 - δ_2)ε_R](1 - βp_1) + η(p_1 - p_1).$$

(7)

Where $η$ is the competition intensity between NB and SB.

**Case 3:** the manufacturer runs the d-channel and the retailer only sells the NB. If the manufacturer runs a d-channel, a fraction of brand loyal consumers switch from the r-channel to the d-channel due to the convenience that online shopping affords, and/or their expensive shopping (transportation) costs and/or their price sensitivities to the price. Let $λ_1$ represent the initial ratio of the brand loyal consumers who buy the NB from the retailer to all brand loyal consumers, i.e., the baseline demand for the NB in the d-channel is equal to $(1 - λ_1)c_M$, and the total demand for the NB in the r-channel is equal to $λ_1c_M + ε_R$. The demand for the NB through the d-channel (denoted by $D_0$) and the demand for the NB through the retail channel (denoted by $D_1$) are

$$D_0 = (1 - λ_1)c_M(1 - βp_0) + γ(p_1 - p_0),$$

(8)

$$D_1 = (λ_1c_M + ε_R)(1 - βp_1) + γ(p_1 - p_1).$$

(9)

Both members’ profits are

$$Π_d(w_1,p_0) = [(1 - λ_1)c_M(1 - βp_0) + γ(p_1 - p_0) + η(p_1 - p_1)](w_1 - c_1),$$

(10)

$$Π_p(p_1) = [(λ_1c_M + ε_R)(1 - βp_1) + γ(p_1 - p_1)](p_1 - w_1).$$

(11)

Where $γ$ is viewed as the channel competition intensity between the d-channel and the r-channel.

**Case 4:** the manufacturer runs the d-channel and the retailer offers the SB. According to Case 2 and Case 3, we assume that these demands are linearly dependent on the sales prices, which are given as follows:

(a) the brand loyal demand for NB in d-channel is

$$D_0 = (1 - λ_1)c_M(1 - βp_0) + γ(p_1 - p_0),$$

(b) the brand loyal demand for NB in r-channel is

$$D_1 = λ_1c_M(1 - βp_1) + γ(p_1 - p_1),$$

(c) the store loyal demand for NB in r-channel is

$$D_2 = (λ_1c_M + ε_R)(1 - βp_1) + η(p_1 - p_1),$$

(d) the store loyal demand for SB in r-channel is

$$D_3 = (1 - δ_2ε_R)(1 - βp_1) + η(p_1 - p_1).$$

The profits of the two sides are given as follows:

$$Π_d(w_1,p_0) = [D_0 + D_1 + D_2 + D_3 - (1 - λ_1)c_M(1 - βp_1) + (1 - δ_2ε_R)(1 - βp_1)](w_1 - c_1),$$

$$Π_p(p_1) = [(1 - λ_1)c_M + ε_R](1 - βp_1) + γ(p_1 - p_1),$$

where $c_M = a_1(1 - δ_2ε_R), b_M = b_1(1 - δ_2ε_R) + η(p_1 - p_1).$

Due to $D_0 + D_2 + D_1 + D_3 = (1 - λ_1)c_M + ε_R, (1 - δ_2ε_R)(1 - β)p_1$, the total demand is not affected by $γ$ and $η$. This implies that a change in intensities of both channel competition and brand competition do not lead to any variation in the aggregate demand.

### III. Two Members’ Decisions in Each Case

**Case 1:** only NB available through the r-channel

As a benchmark, we develop a basic model where neither the manufacturer runs the d-channel nor the retailer introduces SB (denoted by superscript “n”). As the leader, the manufacturer first declares $w_1$, the retailer then decides her retail price $p_1$. From (2) and (3), one can derive by backward induction that the prices and the profits are

$$w_1 = c_1 + 3(1 - βc_1)/(4β),$$

$$p_1 = c_1 + 3(1 - βc_1)/(4β),$$

$$Π_d = (c_M + ε_M)(1 - βc_1)^2/(8β),$$

$$Π_p = (c_M + ε_M)(1 - βc_1)^2/(16β).$$

(14)

**Case 2:** only introducing the SB

In this setting, only the retailer introduces the SB, and the profits for both sides are respectively given in (6) and (7). One can derive two members’ optimal pricing strategies (denoted by superscript “s”). Lemma 1 gives the optimal pricing strategies for both members.

**Lemma 1.** Define $m = b_M + b_2 - 2γ$, if only the retailer sells the SB, then the optimal pricing strategies are given by

$$p_1 = c_1 + 3(1 - βc_1)/(4β) - (1 - δ_2ε_R)/(4βm),$$

$$p_2 = c_2 + (1 - λ_1c_M)/(2β),$$

$$w_1 = c_1 + (1 - βc_1)/(2β) - (1 - δ_2ε_R)/(2βm).$$

All proofs are provided in Appendix. From Lemma 1, one

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can easily derive that the market demands of the two products and the profits of two sides are given as follows: 
\[ D_1^d = \max\{m(1-\beta c)-\eta(1-\beta c)/d\}, \]
\[ D_2^d = \max\{(2b_m-\eta^2)(1-\beta c)/(4\beta^2)-\eta(1-\beta c)/d\}, \]
\[ \Pi^d = m(1-\beta c)/(4\beta^2)(8\beta^2), \]
\[ \Pi^d = (4b_m-3\eta\beta(1-\beta c)(16/\beta^d m)-\eta(1-\beta c)(1-\beta c)/(8\beta^2) + m(1-\beta c)^2(16\beta^d)), \]

The differences of the wholesale prices and the retail prices between Case 1 and Case 2 are as follows: 
\[ w_1^d - w_1^s = -\eta(1-\beta c)(2/\beta^d m), \]
\[ p_1^d - p_1^s = -\eta(1-\beta c)(2/\beta^d m). \]

The wholesale price and the retail price of the NB in Case 2 are lower than that in Case 1. This implies that introducing the SB induces the decreasing of the wholesale price and the retail price for NB. As a result, the manufacturer’s profit margin for the NB is reducing. However, an interesting phenomenon is that the retailer’s profit margin for NB is increasing due to \( p_1^d / w_1^d - p_1^s / w_1^s = \eta(1-\beta c)/(4\beta^d m) > 0 \).

Table 1 Sensitivity of pricing strategies to the parameters in Case 2

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The sensitivity of the pricing strategies to the parameters is listed in Table 1. When \( c_2 \) increases, the SB’s price increases. The higher the SB’s cost, the weaker the SB’s competition with the NB will be. Correspondingly, the manufacturer increases the wholesale price and the retailer increases the retail price. The higher the competition intensity (\( \eta \)) between the NB and the SB, the lower the wholesale price and the retail price is. When the brand loyal consumers (\( \epsilon_0 \)) or the store loyal consumers (\( \epsilon_0 \)) or the initial ratio of the store loyal consumers who prefer to buy the NB (\( \lambda_0 \)) increase, the NB’s baseline demand increases and, hence, the manufacturer increases the wholesale price and the retailer will increase the NB’s retail price.

Theorem 1 gives the condition under which the retailer is willing to introduce the SB, and the impact of introducing the SB on the profits for the manufacture, the retailer and the whole supply chain.

**Theorem 1.** (1) if \( c_2 < c_2^{\text{min}}, c_2^{\text{max}} \), the retailer is willing to introduce the SB;
(2) if \( c_2 \in [c_2^{\text{min}}, c_2^{\text{max}}] \), then \( \Pi^d > \Pi^s > \Pi^d \);
(3) if \( c_2 \in [c_2^{\text{min}}, c_2^{\text{max}}] \), then \( \Pi^d > \Pi^s > \Pi^d \), and if \( c_2 \in [c_2^{\text{min}}, c_2^{\text{max}}] \), then \( \Pi^d > \Pi^s > \Pi^d \), where 
\[ c_2^{\text{min}} = \max\{\eta - m(1-\beta c), \beta \gamma m\}, \]
\[ c_2^{\text{max}} = \min\{\beta - m(1-\beta c), \beta \gamma m\}. \]

From Theorem 1, we obtain that the retailer can benefit from the introduction of the SB, whereas the manufacturer will be worse off in the presence of the SB. Besides, the brand competition between the two partners benefits to the supply chain only if the unit cost of SB is low, i.e., \( c_2 < c_2^{\text{max}} \), correspondingly, Pareto improving is achieved, whereas the brand competition harms the supply chain if \( c_2 > c_2^{\text{max}} \).

**Case 3: only running the d-channel.**

In this case, only the manufacturer runs the d-channel, and the profits of both sides are given in (10) and (11). Two members’ optimal pricing strategies are shown in Lemma 2 (denoted by superscript “d”).

**Lemma 2.** Define \( k = b_1 - b_2 - 2\eta \), if the manufacturer runs the d-channel, then the optimal pricing strategies are given by 
\[ p_1^d = c_1 + 3(1-\beta c)/(4\beta^d)(1-\beta c)/(4\beta^d), \]
\[ w_1^d = c_1/(1-\beta c)/2\beta, \]
\[ p_0^d = c_0/(1-\beta c)/(2\beta). \]

It is easy to have \( p_0^d > w_1^d > w_0^d > c_1 \). This means that when the manufacturer runs the d-channel, the manufacturer’s online price is no less than the his wholesale price offered to the retailer, which means that the retailer will not purchase the NB from the d-channel.

From Lemma 2, one easily derives that the demands and the profits of two members are respectively given by 
\[ D_1^d = (2b_c - \gamma^2)(1-\beta c)/(4\beta^d)(1-\beta c)/(4\beta^d), \]
\[ D_1^d = k((1-\beta c)/(4\beta^d)(1-\beta c)/(4\beta^d), \]
\[ \Pi^d = (2b_c - \gamma^2)(1-\beta c)/(4\beta^d)(1-\beta c)/(4\beta^d), \]
\[ \Pi^d = k((1-\beta c)/(4\beta^d)(1-\beta c)/(4\beta^d), \]
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\[ \Pi^d = k((1-\beta c)/(4\beta^d)(1-\beta c)/(4\beta^d). \]

Comparing the wholesale price and the retail price between Case 1 and Case 3 leads to:
\[ w_1^d - w_1^s = 0, \]
\[ p_1^d - p_1^s > 0. \]

Note that the wholesale price for the NB in Case 1 and Case 3 is equal, whereas the retail price in the r-channel in Case 3 is lower than the one in Case 1. This implies that running the d-channel forces the retailer to decrease the retail price. Correspondingly, her profit margin is decreasing. This indicates that the channel competition harms the retailer, benefits consumers, and weakens the negative effects of double marginalization caused by high retail price.

Table 2 lies in the sensitivity of the pricing strategies in Case 3 with respect to the parameters. The direct price and the retail price for the NB increase with the operating cost of the d-channel (\( c_0 \)). If the channel competition intensity (\( \gamma \)) between the d-channel and the r-channel increases, the retailer has to decrease the NB’s price. When the brand loyal consumers (\( \epsilon_0 \)), or the store loyal consumers (\( \epsilon_0 \)) or the initial ratio of the brand loyal consumers who prefer to buy the NB from the retailer (\( \lambda_0 \)) increase, the baseline demand for the NB at the r-channel increase and, hence, the retailer will increase the NB’s retail price.

**Theorem 2.** (1) if \( c_0 \in [c_1, c_0^{\text{max}}] \), the manufacturer is willing to run a d-channel;
(2) if \( c_0 > c_1 \), then \( \Pi^d < \Pi^s \) and \( \Pi^d < \Pi^d \);
(3) if \( c_0 \in [c_1, c_0^{\text{max}}] \), then \( \Pi^d < \Pi^s \), and if \( c_0 \in [c_0^{\text{min}}, c_0^{\text{max}}] \), then \( \Pi^d < \Pi^d \), where 
\[ c_0^{\text{max}} = \min\{1-\beta - k\gamma(1-\beta c)/(4\beta^d)(1-\beta c)/(4\beta^d), \beta - k\gamma(1-\beta c)/(4\beta^d)(1-\beta c)/(4\beta^d), \]
\[ c_0^{\text{min}} = \max\{1-\beta - k\gamma(1-\beta c)/(4\beta^d)(1-\beta c)/(4\beta^d), \beta - k\gamma(1-\beta c)/(4\beta^d)(1-\beta c)/(4\beta^d), \]
\[ c_0^{\text{min}} = \max\{1-\beta - k\gamma(1-\beta c)/(4\beta^d)(1-\beta c)/(4\beta^d), \beta - k\gamma(1-\beta c)/(4\beta^d)(1-\beta c)/(4\beta^d). \]

The specified condition under which the manufacturer is willing to run the d-channel is discussed as follows.

**Theorem 2.** (1) if \( c_0 \in [c_1, c_0^{\text{max}}] \), the manufacturer is willing to run a d-channel;
(2) if \( c_0 > c_1 \), then \( \Pi^d < \Pi^s \) and \( \Pi^d < \Pi^d \);
(3) if \( c_0 \in [c_1, c_0^{\text{max}}] \), then \( \Pi^d < \Pi^s \), and if \( c_0 \in [c_0^{\text{min}}, c_0^{\text{max}}] \), then \( \Pi^d < \Pi^d \), where 
\[ c_0^{\text{max}} = \min\{1-\beta - k\gamma(1-\beta c)/(4\beta^d)(1-\beta c)/(4\beta^d), \beta - k\gamma(1-\beta c)/(4\beta^d)(1-\beta c)/(4\beta^d), \]
\[ c_0^{\text{min}} = \max\{1-\beta - k\gamma(1-\beta c)/(4\beta^d)(1-\beta c)/(4\beta^d), \beta - k\gamma(1-\beta c)/(4\beta^d)(1-\beta c)/(4\beta^d), \]
\[ c_0^{\text{min}} = \max\{1-\beta - k\gamma(1-\beta c)/(4\beta^d)(1-\beta c)/(4\beta^d), \beta - k\gamma(1-\beta c)/(4\beta^d)(1-\beta c)/(4\beta^d). \]
Lemma 4. Purchase the NB product from the $d$-channel competition between the two partners benefits to the total demand and, hence, weakens the negative effects of channel competition induce the decreasing of retail prices. This Lemma 4 indicates that the channel and the brand means that the competition benefits consumers, increases competition benefits to the $d$-channel. Besides, the channel competition between the two partners benefits to the supply chain only if the unit cost in the $d$-channel is lower than $c_o$, i.e., $c_o < c_o^*$, correspondingly, Pareto improving is achieved.

Case 4: running the $d$-channel and introducing the SB

If the manufacturer runs the $d$-channel and the retailer introduces the SB, the profits are given in (12) and (13). One can derive two members’ optimal pricing strategies (denoted by the superscript “$ds$”). Lemma 3 gives the optimal pricing strategies for both sides.

Lemma 3. Define $n=\{2b(b, b, \gamma_1^2)h(b, b, \gamma_2^2)\}^{-1}$. If the $d$-channel and the SB occur simultaneously, the optimal pricing strategies for both members are given by $p_{1}^{ds} = c_1 + 3(1-\beta c_1)(2\beta c_2)(1-\beta c_2)(2\beta n) - n b_2 (b, b, \gamma_1^2)(1-\beta c_2)(2\beta n)$, $p_{2}^{ds} = c_2 + (1-\beta c_2)(2\beta n) - n b_2 (b, b, \gamma_2^2)(1-\beta c_2)(2\beta n)$, $w_{1}^{ds} = c_1 + (1-\beta c_1)(2\beta n) - n b_2 (b, b, \gamma_1^2)(1-\beta c_1)(2\beta n)$, $p_0^{ds} = c_0 + (1-\beta c_1)(2\beta n) - n b_2 (b, b, \gamma_1^2)(1-\beta c_1)(2\beta n)$.

The optimal pricing policies will lead to the demands of two products in the two channels below:

$D_{1}^{ds} = \{2b(b, b, \gamma_1^2)h(b, b, \gamma_2^2)\}^{-1}(1-\beta c_1)(4\beta n)2b(b, b, \gamma_2^2)h(b, b, \gamma_2^2)$;
$D_{1}^{ds} = \{2b(b, b, \gamma_1^2)h(b, b, \gamma_2^2)\}^{-1}(1-\beta c_1)(4\beta n)2b(b, b, \gamma_2^2)h(b, b, \gamma_2^2)$;
$D_{2}^{ds} = \{2b(b, b, \gamma_1^2)h(b, b, \gamma_2^2)\}^{-1}(1-\beta c_1)(4\beta n)2b(b, b, \gamma_2^2)h(b, b, \gamma_2^2)$.

Since $c_o < c_o^*$, it is obvious to have $p_{1}^{ds} > w_{1}^{ds} \geq 0$. That is to say, when the manufacturer runs the $d$-channel and the retail introduces the SB as well, the manufacturer’s online price in the $d$-channel is no less than his wholesale price offered to the retailer and, hence, the retailer will not purchase the NB product from the $d$-channel.

From the above analyses, we can derive Lemma 4.

Lemma 4. (1) $p_{1}^{ds} \leq p_{1}^n < p_{1}^d < p_{1}^d = p_{1}^n < p_{1}^d < p_{1}^d < p_{1}^d$ and $p_{2}^{ds} \leq p_{2}^d$;

(2) $\frac{\partial \Pi_{MD}^{ds}}{\partial c_o^{ds}} < 0, \frac{\partial \Pi_{MD}^{ds}}{\partial c_o^{ds}} < 0, \frac{\partial \Pi_{MD}^{ds}}{\partial c_o^{ds}} < 0, \frac{\partial \Pi_{MD}^{ds}}{\partial c_o^{ds}} > 0$;

(3) $\frac{\partial \Pi_{MD}^{ds}}{\partial c_o^{ds}} < 0, \frac{\partial \Pi_{MD}^{ds}}{\partial c_o^{ds}} < 0, \frac{\partial \Pi_{MD}^{ds}}{\partial c_o^{ds}} < 0, \frac{\partial \Pi_{MD}^{ds}}{\partial c_o^{ds}} > 0$.

Lemma 4 indicates that the channel and the brand competition induce the decreasing of retail prices. This means that the competition benefits consumers, increases the total demand and, hence, weakens the negative effects of double marginalization. From Lemma 4, one can also observe that if the manufacturer runs the $d$-channel, his profit will decrease but the retailer’s will increase as the unit operating cost in the $d$-channel increases. Likewise, if the retailer introduces the SB, her profit will decrease but the manufacturer’s profit will increase as the unit purchasing cost of the SB increases.

We will discuss under what condition the manufacturer will run the $d$-channel given that the retailer has introduced the SB, and under what condition the retailer will introduce the SB given that the manufacturer has run the $d$-channel.

Suppose that the retailer has introduced the SB (i.e., the parameter $c_2$ is given). In that case, if the manufacturer wants to run a $d$-channel, a fundamental condition is to assure $D_{2}^{ds} \geq 0$, which is equivalent to

$c_o \leq \frac{1}{\beta} - \frac{\gamma(b, b, \gamma_1^2)(1-\beta c_1)}{beta(2b_2(b, b, \gamma_2^2) - \gamma_2^2b_2)} = c_o^{ds} - \gamma_2^2b_2 \gamma_2^2 b_2$.

Besides, it is also necessary to pledge the manufacturer’s profit increment incurred by running the $d$-channel no less than zero. Denote this increment by $\Delta \Pi_{M}^{ds}(c_o^{ds}, c_2)$, then

$\Delta \Pi_{M}^{ds} \equiv c_o^{ds} - c_o \equiv (2b_2(b, b, \gamma_1^2) - b_2)\frac{1}{\beta} - \frac{\gamma(b, b, \gamma_1^2)(1-\beta c_1)}{beta(2b_2(b, b, \gamma_2^2) - \gamma_2^2b_2)} = c_o^{ds} - \gamma_2^2b_2 \gamma_2^2 b_2$.

$\Delta \Pi_{M}^{ds}$ is constant with respect to $c_0$, and $\Delta \Pi_{M}^{ds}$ decreases with $c_0$ according to Lemma 4. Thus, $\Delta \Pi_{M}^{ds}(c_o^{ds}, c_2)$ decreases with $c_o$. Hence, if $\Delta \Pi_{M}^{ds}(c_o^{ds}, c_2) \geq 0$ is given. In that case, if the manufacturer runs the $d$-channel, the equation $\Delta \Pi_{M}^{ds}(c_o^{ds}, c_2) \geq 0$ will be a unique root (denoted by $c_o^{ds}$) in the interval $(c_1, c_o^{max})$, whereas $\Delta \Pi_{M}^{ds}(c_o^{ds}, c_2) \leq 0$ is more beneficial for the manufacturer not to run the $d$-channel. To sum up, given that the retailer has introduced the SB, the condition that the manufacturer should run the $d$-channel is that his unit operating cost in the $d$-channel does not exceed $c_o^{ds}$, where

$c_o^{ds} \equiv \left\{ c_o^{ds}, \frac{\partial \Pi_{M}^{ds}}{\partial c_o^{ds}}(c_o^{ds}, c_2) \geq 0, \frac{\partial \Pi_{M}^{ds}}{\partial c_o^{ds}}(c_o^{ds}, c_2) > 0 \right\}$.

Given that the manufacturer has run the $d$-channel, a fundamental condition for the retailer selling the SB is to have $D_{2}^{ds} \geq 0$, which is equivalent to

$c_o \leq \frac{1}{\beta} - \frac{\gamma(b, b, \gamma_1^2)(1-\beta c_1)}{beta(2b_2(b, b, \gamma_2^2) - \gamma_2^2b_2)} = c_o^{ds}$.

Additionally, it is also natural to have the retailer’s profit increment incurred by selling the SB product no less than zero. Denote this profit increment of the retailer by $\Delta \Pi_{R}^{ds}(c_o^{ds}, c_2)$, then

$\Delta \Pi_{R}^{ds} \equiv c_o^{ds} - c_o \equiv \frac{n b_2 + (b, b, \gamma_1^2)(1-\beta c_1)}{16\beta^2 b_2} = \frac{\gamma(b, b, \gamma_1^2)(1-\beta c_1)}{beta(2b_2(b, b, \gamma_2^2) - \gamma_2^2b_2)} = \frac{\gamma(b, b, \gamma_1^2)(1-\beta c_1)}{beta(2b_2(b, b, \gamma_2^2) - \gamma_2^2b_2)}$.

Noting that $\Delta \Pi_{R}^{ds}$ is constant with respect to $c_2$ and $\Delta \Pi_{R}^{ds}$ is a decreasing function of $c_2$. Therefore, if $\Delta \Pi_{R}^{ds}(c_o^{ds}, c_2) \geq 0$, then $c_o^{ds}$ will be the maximal unit operating cost that the retailer can introduce the SB, otherwise, the equation $\Delta \Pi_{R}^{ds}(c_o^{ds}, c_2) = 0$ is the condition of $c_o^{ds}$, which will be derived in Appendix. Summing up the above analysis, we have, that given that the manufacturer has run the $d$-channel, the condition that the retailer introduce the SB is that her unit operating cost for the SB does not exceed $c_o^{ds}$, where

$c_o^{ds} \equiv \left\{ c_o^{ds}, \Delta \Pi_{R}^{ds}(c_o^{ds}, c_2) \geq 0, \frac{\partial \Pi_{R}^{ds}}{\partial c_o^{ds}}(c_o^{ds}, c_2) < 0 \right\}$.

However, it is difficult to discuss theoretically the impact of the SB and running the $d$-channel on the whole supply chain’s profit. We use a numerical example to illustrate how the parameters $c_0$ and $c_2$ affect the supply chain’s profit.

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From Table 3 and the analyses in Sections 3, we can derive the Nash equilibrium outcomes according to the parameters $c_0$ and $c_2$, which are shown as follows.

1. If $c_2 \leq \min\{c_s^{a-d}, c_s^{d-d}\}$, then the retailer’s strategy is \{Y, Y\}. In such a case, if the manufacturer introduces the d-channel, his profit is $\Pi_s^{a-d}$; otherwise, his profit is $\Pi_s^{d-d}$.

Thus, the manufacturer chooses the d-channel if and only if $\Pi_M^{d-d} > \Pi_M^{a-d}$, i.e., $c_0 < c_0^{d-d}$. From the above analysis, the Nash equilibrium is (Y, Y) if $c_0 < c_0^{d-d}$ and $c_2 < \min\{c_s^{a-d}, c_s^{d-d}\}$, and (N, Y) for $c_0 \geq c_0^{d-d}$ and $c_2 < \min\{c_s^{a-d}, c_s^{d-d}\}$.

(2) If $c_2^{a-d} < c_2^{d-d}$, the retailer’s strategy is \{Y, N\}. This means that she will introduce the SB if the manufacturer runs the d-channel, but she will not introduce the SB if the manufacturer does not sell online. In such a case, if the manufacturer introduces the d-channel, his profit is $\Pi_s^{a-d}$; otherwise, his profit is $\Pi_s^{d-d}$. Thus, the manufacturer introduces the d-channel only if $\Pi_M^{d-d} > \Pi_M^{a-d}$. Obviously, $\Pi_s^{a-d}$ is consistent with respect to $c_0$, and $\Pi_s^{d-d}$ is a decreasing function of $c_0$ according to Lemma 4. We have that $\Delta \Pi_M^{d-d}(c_0)_{|c_2^{d-d}|} = \Pi_M^{a-d} - \Pi_M^{d-d}$ is a decreasing function of $c_0$. Thus, if $\Delta \Pi_M^{d-d}(c_0)_{|c_2^{d-d}|} < 0$, then $c_0^{d-d}$ will be the maximal unit operating cost that the manufacturer runs the d-channel, otherwise, the equation $\Delta \Pi_M^{d-d}(c_0)_{|c_2^{d-d}|} = 0$ will be a unique root (denoted by $c_0^{(2)}$). To sum up, the Nash equilibrium is (Y, Y) for $c_0 < c_0^{(2)}$ and $c_2 < c_2^{d-d}$, and (N, N) for $c_0 \geq c_0^{(2)}$ and $c_2 < c_2^{d-d}$, where

$c_0^{d-d} = \begin{cases} c_0^{d-d}(c_2), & \Delta \Pi_M^{d-d}(c_2) > 0 > \Delta \Pi_M^{a-d}(c_2), \\ c_0^{(2)}, & \text{otherwise}. \end{cases}$

(3) If $c_2^{d-d} < c_2^{a-d}$, the retailer’s strategy is \{N, Y\}. In such a case, if the manufacturer introduces the d-channel, his profit is $\Pi_M^{d-d}$, otherwise, his profit is $\Pi_M^{a-d}$. Thus, the manufacturer is willing to introduce the d-channel only if $\Pi_M^{a-d} > \Pi_M^{d-d}$. Obviously, $\Pi_M^{a-d}$ is a decreasing function of $c_0$. To sum up, the Nash equilibrium is $\Pi_M^{d-d} = \Pi_M^{a-d} - \Delta \Pi_M^{d-d}$ is a decreasing function of $c_0$. Therefore, if $\Delta \Pi_M^{d-d}(c_0)_{|c_2^{d-d}|} \geq 0$, then $c_0^{d-d}$ will be the maximal unit operating cost that the manufacturer can introduce the d-channel, otherwise, the equation $\Delta \Pi_M^{d-d}(c_0)_{|c_2^{d-d}|} = 0$ will be a unique root (denoted by $c_0^{(2)}$). To sum up, the Nash equilibrium is (Y, Y) for $c_0 < c_0^{(2)}$ and $c_2 < c_2^{a-d}$, and (N, N) for $c_0 \geq c_0^{(2)}$ and $c_2 < c_2^{a-d}$, where

$c_0^{a-d} = \begin{cases} c_0^{a-d}(c_2), & \Delta \Pi_M^{d-d}(c_2) > 0 > \Delta \Pi_M^{a-d}(c_2), \\ c_0^{(2)}, & \text{otherwise}. \end{cases}$

(4) If $c_2^{a-d} > \max\{c_2^{a-d}, c_2^{d-d}\}$, the retailer’s strategy is \{N, Y\}. This means that if the manufacturer introduces the d-channel, his profit is $\Pi_M^{d-d}$, otherwise, his profit is $\Pi_M^{a-d}$. Thus, the manufacturer chooses the d-channel if and only if $\Pi_M^{d-d} > \Pi_M^{a-d}$, i.e., $c_0 < c_0^{d-d}$. Consequently, the Nash equilibrium is (Y, N) for $c_0 < c_0^{d-d}$ and $c_2 > \max\{c_2^{a-d}, c_2^{d-d}\}$, and (N, N) for $c_0 \geq c_0^{d-d}$ and $c_2 > \max\{c_2^{a-d}, c_2^{d-d}\}$.

The above analyses show that the equilibrium options are dependent on the unit operating cost ($c_0$) of the d-channel and the SB’s unit operating cost ($c_2$). We can conclude that the retailer’s optimal option is to introduce the SB if $c_2$ is relatively low, whereas she does not introduce the SB if it is relatively high. If $c_2$ is medium, the retailer’s optimal policy depends on the manufacturer’s decision. Thus the manufacturer has the advantage of making the first move, and it is possible that he can choose the policy which
maximizes his profit, but may be harmful to the retailer. Besides, if \( c_0 \) and \( c_2 \) are very low (i.e., \( c_0 < c_0^{d,s} \) and \( c_2 \leq \min(c_2^{s-a}, c_2^{d,d}) \)), the optimal choice is \((Y, Y)\), whereas if \( c_0 \) and \( c_2 \) are very high (i.e., \( c_0 > c_0^{d,n} \) and \( c_2 > \max(c_2^{s-s}, c_2^{d,n}) \)), the choice game’s outcome is \((N, N)\). This is consistent with our intuition.

\[
\begin{align*}
&\text{Fig. 3.1 Variation of } c_2^{d,n} \text{ and } c_2^{d-d} \text{ with } c_0 \\
&\text{Fig. 3.2 Variation of } c_0^{d-n} \text{ and } c_0^{d-s} \text{ with } c_2 \\
&\text{Fig. 3.3 Variation of } c_2^{d,s} \text{ and } c_2^{d-n} \text{ with } c_2
\end{align*}
\]

We use numerical examples to further illustrate how the two players determine their equilibrium options. The value of these parameters is also consistent with that in the above example in Case 4, Section 3.

Fig. 3.1 shows how \( c_2^{s-a} \) and \( c_2^{d-d} \) change with the parameter \( c_0 \), and the horizontal axis represents \( c_0 \). From Fig. 3.1, we see that \( c_2^{s-a} < c_2^{d-d} \). Fig. 3.2 and Fig. 3.3 indicate how \( c_0^{d-s} \), \( c_0^{d-n} \), \( c_0^{d-s} \) and \( c_0^{d-n} \) change with parameter \( c_2 \), respectively, and the horizontal axis represents parameter \( c_2 \). If the manufacturer runs the \( d \)-channel, the retailer introduces the SB only if \( c_2 > c_2^{d-d} \); otherwise, the retailer introduces the SB only if \( c_2 < c_2^{s-a} \). This means that running the \( d \)-channel may decrease the possibility of introducing SB.

According to the above analyses and Figs. 3.1-3.3, we can induce the equilibrium outcome for the two players, which is shown in Fig. 4. From Fig. 4, we can observe that the optimal equilibrium outcome is \((Y, Y)\) if \( c_0 < c_0^{d,s} \) and \( c_2 < c_2^{d-d} < c_2^{s-a} \), and \((N, Y)\) if \( c_0 > c_0^{d,s} \) and \( c_2 < c_2^{d-d} < c_2^{s-a} \). This is because that \( c_2 < c_2^{d-d} < c_2^{s-a} \) induces the retailer’s optimal choice \((Y, Y)\), which means that the manufacturer’s choice does not affect the retailer’s strategy. Given the retailer’s optimal strategy, the manufacturer should choose to run the \( d \)-channel if \( c_0 < c_0^{d,s} \), and not to run the \( d \)-channel if \( c_0 > c_0^{d,s} \). Similarly, the equilibrium outcome is \((Y, N)\) if \( c_0 < c_0^{d,s} \) and \( c_2 < c_2^{d-d} < c_2^{s-a} \), and \((N, Y)\) if \( c_0 > c_0^{d,s} \) and \( c_2 < c_2^{d-d} < c_2^{s-a} \). The outcome is \((Y, N)\) if \( c_0 < c_0^{d,s} \) and \( c_2 < c_2^{d-d} < c_2^{s-a} \) and \((N, N)\) if \( c_0 > c_0^{d,s} \) and \( c_2 > c_2^{d-d} > c_2^{s-a} \). From Fig. 4, we maybe conclude that the equilibrium outcome is \((Y, Y)\) for low \( c_0 \) and low \( c_2 \), and \((N, N)\) for high \( c_0 \) and high \( c_2 \), and \((N, Y)\) for high \( c_0 \) and low \( c_2 \), and \((Y, N)\) for low \( c_0 \) and high \( c_2 \). However, for medium \( c_0 \) and medium \( c_2 \), the equilibrium outcome is \((Y, N)\). In such a case, the retailer’s choice will depend on the manufacturer’s strategy. As the choice game’s leader, the manufacturer has the advantage of the first move, and he prefers to run the \( d \)-channel.

\[
\begin{align*}
&\text{Fig. 4 The choice game’s equilibrium outcome}
\end{align*}
\]

We will discuss how the parameters \( c_0 \) and \( c_2 \) influence the players’ profit increments derived from their optimal options. Let \( \Pi_R^{*}, \Pi_M^{*} \) and \( \Pi_L(-=\Pi_R^{*} + \Pi_M^{*}) \) be the retailer’s profit, the manufacturer’s profit and the supply chain profit under the optimal strategies, respectively. For example, from Fig. 4, the optimal equilibrium outcome is \((Y, Y)\) if \( c_0^{d,s} = 7 \) and \( c_2^{d-d} = 5 \). In such a case, we have that \( \Pi_R^{*} = \Pi_R^{d,s} \), \( \Pi_M^{*} = \Pi_M^{d-d} \) and \( \Pi_L^{*} = \Pi_L^{d-d} = \Pi_R^{d-s} + \Pi_M^{d-d} \).

Fig. 5 shows how the profit increments vary with \( c_0 \) given \( c_2^{d-s} = 5 \), \( c_2^{d-n} = 13.7 \) and \( c_2^{d-s} = 15 \), respectively, and the horizontal axis represents parameter \( c_0 \). From Fig. 5, we can observe that the increase of \( c_0 \) is always adverse to the manufacturer but beneficial to the retailer, whereas the increase of \( c_2 \) is always harmful to the retailer but profitable to the manufacturer. This means that the manufacturer (the retailer) should lower the unit operating cost \( c_0 \) (\( c_2 \)) to enhance competitive power in introducing the \( d \)-channel (the SB). From supply chain perspective, the increase of \( c_0 \) (\( c_2 \)) is always adverse to the whole chain. Another observation from Fig. 5 is that when both \( c_0 \) and \( c_2 \) are relatively smaller (say, \( c_2^{d-d} = 6 \) and \( c_2^{d-n} = 5 \) in the leftmost part of Fig. 5), the three profit increments \( \Pi_R^{d-s} - \Pi_R^{d-n}, \Pi_R^{d-s} - \Pi_R^{d-d} \) and \( \Pi_R^{d-s} - \Pi_R^{d-d} \) all remain non-negative. This indicates that when the operating costs of both the \( d \)-channel and the SB are not very high, the two parties’ game of introducing the \( d \)-channel and the SB product leads to an increase of both players’ profits and the whole channel profit as well. This also implies that the two parties’ competition on introducing the \( d \)-channel and the SB can eliminate the negative effects of double marginalization, which is further verified by the fact that the competition induces lower pricing of both the manufacturer and the retailer (shown in Lemma 4).

In order to illustrate how parameters \( \varepsilon_M, \varepsilon_R, \lambda_1, \lambda_2, \gamma \) and \( \eta \) influence the two parties’ profits, respectively, we present the sensitivity analysis of the two parties’ profits with respect to these parameters. The initial parameter values are those assumed in Example except for \( c_2^{d-s} = 7 \) and \( c_2^{d-d} = 5 \). We carry out the analysis by increasing the value of one single parameter by -50% up to 50% while holding all the other parameters constant. Fig. 6 shows that how the changes of \( \varepsilon_M, \varepsilon_R, \lambda_1, \lambda_2, \gamma \) and \( \eta \) influence two parties’ profits.
The prior literature mainly focused on dual-channel supply chains (Kumar and Ruan, 2006[1], Wang et al. 2016[2], Chiang et al. (2003)[4]), ignoring the introduction of the SB, whereas, most of the literature on the SB ignored the channel competition between the r-channel and the d-channel. This study has concentrated on a choice game in which whether a manufacturer runs a d-channel and whether a retailer should respond by introducing the SB, thereby enriching literature in this area. The theoretical contributions of this paper are shown as follows.

Corroborating the studies (Amrouche and Yan (2012)[22]; Shang and Yang (2015)[14]; Kurata et al. (2007)[21]), running the d-channel and introducing the SB has been found to cause the competition between the manufacturer and the retailer, and to exert significant influence on pricing strategies for the two partners as well. It reaffirms the argument that the competition forces the firms to reduce pricing. It is therefore not surprising to see that the competition between the firms can weaken the negative effects of double marginalization on the overall supply chain profit, and increase more consumer surpluses.

With the absence of the SB, running a d-channel benefits the manufacturer (Kumar and Ruan, 2006[1], Cai et al. (2009)[12]). Similarly, Without running a d-channel, the retailer can be better off through introducing SBS (Pauwels and Srinivasan, 2004[8]; Narasimhan and Wilcox (1998)[17]). Our study suggests that the operating cost in the d-channel and the SB operating cost have been found to exert a significant influence on the strategies and the profits for the manufacturer and the retailer. Specifically, when the d-channel’s operating costs and the SB’s operating costs are small, running a d-channel and introducing a SB can benefit the manufacturer and the retailer, whereas when the costs are high, it is contrary.

**V. DISCUSSION AND IMPLICATIONS**

*A. Theoretical contributions*

The prior literature mainly focused on dual-channel supply chains (Kumar and Ruan, 2006[1], Wang et al. 2016[2], Chiang et al. (2003)[4]), ignoring the introduction of the SB, whereas, most of the literature on the SB ignored the channel competition between the r-channel and the d-channel. This study has concentrated on a choice game in which whether a manufacturer runs a d-channel and whether a retailer should respond by introducing the SB, thereby enriching literature in this area. The theoretical contributions of this paper are shown as follows.

Corroborating the studies (Amrouche and Yan (2012)[22]; Shang and Yang (2015)[14]; Kurata et al. (2007)[21]), running the d-channel and introducing the SB has been found to cause the competition between the manufacturer and the retailer, and to exert significant influence on pricing strategies for the two partners as well. It reaffirms the argument that the competition forces the firms to reduce pricing. It is therefore not surprising to see that the competition between the firms can weaken the negative effects of double marginalization on the overall supply chain profit, and increase more consumer surpluses.

With the absence of the SB, running a d-channel benefits the manufacturer (Kumar and Ruan, 2006[1], Cai et al. (2009)[12]). Similarly, Without running a d-channel, the retailer can be better off through introducing SBS (Pauwels and Srinivasan, 2004[8]; Narasimhan and Wilcox (1998)[17]). Our study suggests that the operating cost in the d-channel and the SB operating cost have been found to exert a significant influence on the strategies and the profits for the manufacturer and the retailer. Specifically, when the d-channel’s operating costs and the SB’s operating costs are small, running a d-channel and introducing a SB can benefit the manufacturer and the retailer, whereas when the costs are high, it is contrary.

**B. Implications for practice**

With economic globalization and rapid development of
Internet, interest in establishing a d-channel has grown explosively among manufacturers in recent years. However, opportunities and threats exist when the d-channel is established in addition to existing r-channels. Meanwhile, in consumer goods retailing, the SB is threatening the NB. This study has focused on channel selection and brand choice between the manufacturer and the retailer. The findings provide recommendations to the two partners in decision-making.

Both of the manufacturer and the retailer should strive to expand the market and increase the market size. For the manufacturer, he should strive to expand d-channel loyalty to increases brand loyal customers, and strengthen the channel competition between d-channel and r-channel. However, for the retailer, our finding suggests that the retailer should strive to expand store loyalty to increases r-channel loyal customers, and strengthen the brand competition between the NB and the SB.

VI. CONCLUSIONS

This paper discusses both channel competition and brand competition issues in a two-echelon supply chain, where a dominant manufacturer sells a NB through a retailer. Besides the r-channel, the manufacturer may select a d-channel. Likewise, the retailer may choose a SB. We study the two partners’ optimal strategies. The results show that (i) the competition between channels or brands can weaken the negative effects of double marginalization, and (ii) when the operating costs for the d-channel and the SB are relatively low, a win-win equilibrium outcome can be achieved, which is not the case when the operating costs are relatively high. The sensitivity analyses reveal that the retailer should build up the product loyalty for the SB and increase the substitutability between the SB and the NB, whereas the manufacturer should build up the loyalty for d-channel and decrease the substitutability between the SB and the NB, which can be achieved by increasing product differentiation.

Future research may include two aspects. First, this paper only investigated the aspect of price. It would be interesting to introduce other marketing elements in the model, such as advertising, and shelf-space allocation. Second, this model considers deterministic demand and symmetric information. Stochastic demand and information asymmetry are challenging and interesting.

APPENDIX

Proof of Lemma 1. From (6), we have \( \Pi_s \) is a concave function with respect to \((p_1, p_d)\). Solving the first-order conditions gives

\[
p_1^* = \frac{1 + \beta_c}{2\beta}, \quad p_d^* = \frac{1 + \beta_c}{2\beta}.
\]

(4.1)

Substituting (4.1) to (7) gives the manufacturer’s profit as:

\[
\Pi_m(w_s) = \frac{m(1 - \beta_c) - \eta(1 - \beta_c)}{2\beta} (w_s - c_s).
\]

From (4.2), one easily derives that \(d\Pi_m(w_1)/dw_1 = -m < 0 \). Thus

\[
w_1^* = c_1 + (1 - \beta_c)(2\beta - \eta)(1 - \beta_c)/(2\beta m).
\]

(4.3)

Substituting (4.3) to (4.1) gives \( p_1^* \) and \( p_d^* \).

Proof of Theorem 1. (1) One easily derives that \( D_1 \geq 0 \) and \( D_2 \geq 0 \) are equivalent to \( \max\{0, m(1 - \beta_c)/\beta h - d_0 \} \leq c_{s_{\min}} \leq c_s \leq c_{s_{\max}} \leq 1/[\beta \cdot m(1 - \beta_c)/(2\beta m - \eta)] \). It implies that the retailer or the manufacturer will exit when \( c_s \notin [c_{s_{\min}}, c_{s_{\max}}] \). We do not consider the situation where any of the two members exists. Hence, we restrict \( c_s \in [c_{s_{\min}}, c_{s_{\max}}] \). For \( c_s \in [c_{s_{\min}}, c_{s_{\max}}] \), the retailer’s profit increment is given by

\[
\Delta \Pi_s^* (c_s) = \{(4b_2 m - 3)\eta(1 - \beta_c) - 2m(1 - \beta_c)(1 - \beta_c) - m b_d(2 - \beta)(1 - \beta_c)/(16\beta m^3).
\]

The retailer will introduce the SB as long as \( \Delta \Pi_s^* (c_s) > 0 \).

Since \( d\Delta \Pi_s^*(c)/dc = -D_2 < 0 \) for \( c_s \in [c_{s_{\min}}, c_{s_{\max}}] \), \( \Delta \Pi_s^* (c_s) \) is decreasing with \( c_s \). (2b - m - \eta \sqrt{2})(2 - b_d)m^2 \eta < 0 \) derives \( \Delta \Pi_s^* (c_{s_{\min}}) > 0 \). Hence, the monotonicity of \( \Delta \Pi_s^* (c_s) \) means that \( \Delta \Pi_s^* (c_s) > 0 \) keeps in \( c_s \in [c_{s_{\min}}, c_{s_{\max}}] \). If (2b - m - \eta \sqrt{2})(2 - b_d)m^2 \eta \leq 0 \), it is clear to have \( \Delta \Pi_s^* (c_{s_{\max}}) > 0 \). In that case, due to \( c_{s_{\min}} \leq c_s \), \( \Delta \Pi_s^* (c_{s_{\max}}) > 0 \) has a unique zero-point in \( c_s \in [c_{s_{\min}}, c_{s_{\max}}] \). Solving \( \Delta \Pi_s^* (c_s) = 0 \) will give \( c_{s_{\min}} \) as the unique zero-point in the interval \([c_{s_{\min}}, c_{s_{\max}}]\). Therefore, \( \Delta \Pi_s^* (c_s) > 0 \) will hold in the interval \([c_{s_{\min}}, c_{s_{\max}}]\), where

\[
c_s^* = 1/\beta [m \eta^2 + m^2 \eta (b_d - 2p_b)/(4b_2 m - 3)](1 - \beta_c)/(2b_d m - \eta^2).
\]

Proof of Lemma 2. For any \( w_1 \) and \( p_{b_0} \), one easily derives from (11) that the second-order derivatives of the retailer’s profit are given by

\[
d\Pi_s / d\beta_s^2 = -2(b_1 + b_2 - 2\eta) < 0.
\]

Thus, the optimal price is

\[
p_1^* = \frac{1}{\beta} \gamma(1 - \beta p_b) - (h + b_1 + b_2 - 2)b/2b_d (1 - \beta w_1).
\]

(4.4)

Second, substituting (4.4) into (10) gives

\[
\Pi_s(w_1, p_{b_1}) = \frac{1}{2b_d} \left( 2h_1k - \gamma(1 - \beta p_b) - \gamma(1 - \beta w_1) \right) + \frac{k}{2b_d} (1 - \beta p_b) \right) (w_1 - c_s).
\]

(4.5)

Where \( k = b_1 + b_2 - 2\eta \). From (4.5), it is easy to obtain \( \Pi_s \) is a concave function with respect to \((w_1, p_{b_1})\). Hence, solving equations \( \partial \Pi_s / \partial w_1 = 0 \) and \( \partial \Pi_s / \partial p_{b_1} = 0 \) gives

\[
p_1^* = \frac{1 + \beta_c}{2\beta}, \quad w_1^* = \frac{1 + \beta_c}{2\beta}.
\]

(4.6)

Substituting (4.6) into (4.4) will yield Lemma 2.

Proof of Theorem 2. (1) \( c_{s_{\min}} \), \( p_{b_{10}} \), \( p_{b_{20}} \), and \( D_2^{*_{b_{10}}} \) are independent. To assure \( D_2^{*_{b_{10}}} > 0 \), it is necessary to have \( c_{s_{\min}} - c_{s_{\max}} = 1/\beta \cdot \gamma(1 - \beta p_b)/(2b_2 m - \eta^2) \). Thus, we restrict \( c_0 \) in the interval \([c_{s_{\min}}, c_{s_{\max}}]\).

The manufacturer’s profit increment is given as

\[
\Delta \Pi_s^* (c_0) = \{(2b_2 \eta - 2)(1 - \beta_c) - 2 \eta (1 - \beta_c) (1 - \beta_c) - k(b_2 - 2p_b)(1 - \beta_c) / (2b_2 m - \eta^2) - k(2b_d m - 3) (1 - \beta_c)/2b_2 m - \eta^2).
\]

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\[
d \Delta \Pi_\alpha^{d,c}_\mu(e_0) = \begin{cases} D\Pi_\mu^{d,c}(e_0) & \text{if } D \Pi_\mu^{d,c}(e_0) > 0; \\
-D\Pi_\mu^{d,c}(e_0) & \text{if } D \Pi_\mu^{d,c}(e_0) < 0; \\
0 & \text{if } D \Pi_\mu^{d,c}(e_0) = 0.
\end{cases}
\]

Equations (2), (3), and (4) are derived from the derivatives of \( \Pi_\mu^{d,c}(e_0) \) with respect to \( e_0 \). Noticing that \( c_0 \leq c_{0,\text{max}} \), we have:

\[
\Delta \Pi_\alpha^{d,c}(e_0) = \begin{cases} \Delta \Pi_\mu^{d,c}(e_0) & \text{if } \Delta \Pi_\mu^{d,c}(e_0) > 0; \\
0 & \text{if } \Delta \Pi_\mu^{d,c}(e_0) \leq 0.
\end{cases}
\]

The derivative of \( \Delta \Pi_\alpha^{d,c}(e_0) \) is given by:

\[
\Delta \Pi_\alpha^{d,c}(e_0) = \frac{\partial}{\partial e_0} \left( \Pi_\alpha^{d,c}(e_0) - \Pi_\mu^{d,c}(e_0) \right).
\]

\[\text{Proof of Lemma 3.}\] For any given \( w_b \) and \( p_b \), it derives from (10) that \( \Pi_\alpha^{d,c} \) is a concave function with respect to \( p_1 \) and \( p_2 \), through the sign of the second-order partial derivatives. Thus:

\[
p_1 - \frac{1}{\beta} \hat{b}_2 = \frac{1}{\beta} (1 - \beta_1) p_1 + \frac{1}{\beta} (1 - \beta_2) p_2.
\]

(4.7) Substituting (4.7) to (11) gives the retailer’s profit as:

\[
\Pi_\mu = \frac{2(2b_2 - \eta_2)h_2 - \eta_2 h_2}{2b(2b_2 - \eta_2)} - \frac{1}{\beta} (1 - \beta_1) p_1 + \frac{1}{\beta} (1 - \beta_2) p_2.
\]

(4.8) From (4.8), one derives \( \Pi_\mu \) is a concave function with \( w_b \) and \( p_{10} \). Define:

\[
\mathfrak{M}(h_2, \beta_1, \beta_2, \eta_2) = \frac{2h_2 - \eta_2}{2b(2b_2 - \eta_2)},
\]

then:

\[
\mathfrak{M}(h_2, \beta_1, \beta_2, \eta_2) = \frac{2\eta_2 h_2 - \eta_2 h_2}{2\beta_2 - \eta_2}.
\]

(4.9) Thus, solving the equation:

\[
\mathfrak{M}(h_2, \beta_1, \beta_2, \eta_2) = \mathfrak{M}(h_2, \beta_1, \beta_2, \eta_2) = 0,
\]

we have:

\[
p_{1,0} = \frac{1}{\beta} (1 - \beta_1) - \frac{1}{\beta} (1 - \beta_2).
\]

Substituting (4.9) to (4.7) gives:

\[
p_{1,0} = \frac{1}{\beta} (1 - \beta_1), \quad \frac{1}{\beta} (1 - \beta_2), \quad \frac{1}{\beta} (1 - \beta_3), \quad \frac{1}{\beta} (1 - \beta_4).
\]

(4.10) The above results are derived from Lemma 1 and 2, and 3, and we have:

\[
\begin{align*}
(1) p_1 - p_2 & = \frac{1}{\beta} (1 - \beta_1), \\
p_1 - p_2 & = \frac{1}{\beta} (1 - \beta_2), \\
p_1 - p_2 & = \frac{1}{\beta} (1 - \beta_3), \\
p_1 - p_2 & = \frac{1}{\beta} (1 - \beta_4),
\end{align*}
\]

(4.11) The above results are derived from Lemma 1 and 2, and 3, and we have:

\[
\Pi_\mu^{d,c}(e_0) = \begin{cases} D\Pi_\mu^{d,c}(e_0) & \text{if } D\Pi_\mu^{d,c}(e_0) > 0; \\
-D\Pi_\mu^{d,c}(e_0) & \text{if } D\Pi_\mu^{d,c}(e_0) < 0; \\
0 & \text{if } D\Pi_\mu^{d,c}(e_0) = 0.
\end{cases}
\]

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**References**


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