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RESEARCH NOTE

Designing of Supply Chain Coordination Mechanism with Leadership Considering

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ABSTRACT

Vertical cooperative advertising is typically a cost sharing mechanism and coordinated effort by channel's members in order to increase demand and overall profits. In this marketing strategy, the manufacturer shares a fraction of the retailer's advertising investment. This paper studies the advertising and pricing decisions in a retailer-manufacturer supply chain in which the market demand is simultaneously affected by retail price and members' advertising efforts. We establish three non-cooperative game-theoretic models and one cooperative model. A particular non-cooperative game can be played based on the channel type which can be retailer-dominant, manufacturer-dominant, or the same-power. We investigate feasibility of the cooperative game with the aim of channel coordination, and, utilize bargaining model in order to discuss how both members should split the extra profit obtained by moving to cooperation case.

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1. INTRODUCTION

Today competitive markets in supply chains force members to become more efficient and cost-effective. Generally a supply chain is composed of independent members, who are concerned for optimizing their individual objectives. In the absence of cooperation, channel members choose their decisions independently and non-cooperatively. This uncoordinated strategy may lead to poor channel performance or channel inefficiency. In order to achieve win–win outcome and channel coordination, many mechanisms have been proposed such as vendor–buyer coordination, co-op advertising mechanism, return policy and etc. In this research we focus on co-op advertising mechanism.

Vertical cooperative (co-op) advertising is typically a cost sharing mechanism and coordinated effort by the channel's members in order to increase demand and overall profits. In the literature, advertising is divided into national and local advertising efforts. Both of them are budgeted with the ultimate goal of stimulating the customer purchases. The manufacturer's advertising or national advertising is planned for influencing potential consumers to consider the product's brand. However, the retailer's one is to motivate the customers' buying behavior. The co-op advertising is achieved when the manufacturer shares a fraction of the retailer's advertising investment (i.e. the manufacturer's participation rate).

In this paper, we consider co-op advertising in a two-echelon manufacturer-retailer supply chain where the market demand is determined by co-op advertising efforts and retail price. We discuss three non-cooperative game scenarios including: Nash game; two Stackelberg games in which the supplier is the leader in one game and is the follower in another game. Also, a cooperation game is considered in order to investigate channel coordination. Our objectives in this paper are described in the following.

The first objective is to investigate whether the more powerful member of the supply chain always chooses to be the leader of the Stackelberg game. We apply the Cobb-Douglas demand function as used by Yu et al. [1]. Depending more on the form of the demand function, sometimes, the leadership in Stackelberg game is not desirable for the more powerful member. Sometimes, being the follower can be more profitable for a member than being the leader.

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The second objective is to examine how the manufacturer can offer a contract in order to coordinate the supply chain. Here, the coordination mechanism depends on both the wholesale price and the manufacturer's participation rate on local advertising investment. The feasible region for cooperative game is investigated in all three scenarios. Our research is closely related to Xie and Neyret [2] and SeyedEsfahani et al. [3], but our coordination approach is different from those applied in their studies. They assume that "*a cooperative game is feasible if only if each member cannot achieve any higher profit in any other non-cooperative games*". For example, when the retailer and manufacturer reach their higher profit under Nash game, and Stackelberg-manufacturer game, respectively, they assume that a cooperative game should be designed in a way that the retailer gains higher profit than Nash game and, simultaneously the manufacturer gains higher profit than Stackelberg-manufacturer game. This approach seems to have an important flaw. Since, only one game (i.e. either Nash or Stackelberg-retailer or Stackelberg-manufacturer) can be played between the members in a time based on the members' decision power. In addition, only the more powerful member has an authority to select which game should be played. For instance, suppose a supply chain with a retailer and a powerful manufacturer as the market leader. In this manufacturer-dominant supply chain, the manufacturer certainly can be the leader of the game and impose his/her decisions to the retailer. But if the manufacturer notices that being the follower of the game is more profitable than being the leader of the game, he will choose to be the follower. But, the powerless retailer has no authority to select the game type. In this situation, when investigating the feasibility of a cooperative game for the retailer, the leadership of the manufacturer must be neglected, since, the manufacturer is willing to be the follower. Our approach is that "*cooperative game should result in a higher profit for the members when a particular game (i.e. the game i) is played*".

Finally, the third objective is to explore how the retailer and manufacturer can bargain over the values of the participation rate and wholesale price in order to split the extra profit achieved from moving to cooperation. We utilizeEliashberg'sbargaining model [4] for the problem.

The rest of the paper is organized as follows: Section 2 provides a brief review of related researches. Section 3 gives the assumptions, demand function and profit of the retailer, manufacturer and total channel. The four games model based on three non-cooperative games and a cooperative one are provided in section 4. Section 5 gives the analytical results and specifies which game should be played in different channel types. We discuss the feasibility of cooperation game with the aim of channel coordination in section 6. Section 7 gives the bargaining model. Finally, conclusion and managerial implications are given in Section 8.

2. LITERATURE REVIEW

Berger [5] is among the earliest works that proposed a primary co-op advertising model. In his model, the manufacture determines the cost sharing rate. The model was extended to an uncertainty demand in franchising systems by Dant and Berger [6]. Some other researchers extended the retailer-manufacturer co-op advertising model in a way that advertising effort divided into the local and national programs, for example see (Huang and Li [7]; Huang, et al. [8] and Li, et al. [9]). They investigated the problem as cooperative game and Stackelberg game. Li, et al.'s model [9] was extended to the case where the manufacturer's marginal profit is not large enough by Xie and Ai [10].

Some recently published papers consider co-op advertising problem together with pricing decisions in a two echelon supply chain in which the market demand simultaneously is affected by price and advertising efforts of both firms. Each one evaluates different demand function. Yue, et al. [11] extended Huang et al.'s model [8] by investigating the price discount scheme in order to achieve coordinating the channel; Xie and Neyret [2] investigated this problem with different demand functions by applying four game-theoretic models including cooperative, Nash, Stackelberg-retailer and Stackelberg-manufacturer games; Xie and Neyret'smodel [2] was extended by Seyed Esfahani et al. [3] to relatively general demand function but with the same game models; Chen [12] studied the combined effect of the co-op advertising, the return policy and channel coordination to drive ordering decisions in addition to advertising-pricing decisions; Kunter [13] applied cost and revenue sharing mechanism to coordinate the channel; Zhang and Xie [14] considered multiple competing retailers in order to investigate the impact of the retailer's multiplicity on members' decision and total efficiency. Alaei et al. [15] considered a supply chain with one manufacturer and two competing retailers. In order to split the extra profit obtained by moving to the cooperation case, they utilized Nash bargaining model.Tofigh and Mahmoudi [16] studied dynamic pricing in a supply chain including one price leader and N followers. However, channel coordination was not considered in their research.

3. ASSUMPTIONS AND MODEL DESCRIPTION

A single-manufacturer-single-retailer channel is considered. The manufacturer sells the product to consumers through a retailer. The manufacturer has a fixed production cost c per unit product and the retailer has a fixed distribution cost d per unit. Also, the manufacturer sells the product with wholesale price w to the retailer who in turn sells it with the retail price p to the customers.

The manufacturer decides on the national advertising expenditures m, wholesale price w, and participation rate θ. On the other hand, the retailer decides on the local advertising investment r, and retail price p. The parameter θ is the fraction of the local advertising investment; and is the percentage the manufacturer agrees to share with the retailer (i.e., cost sharing rate). The demand is simultaneously affected by retail price, advertising investment of the retailer and manufacturer. In addition, the market demand is a decreasing and convex function of the price, but an increasing and concave function of the retailer's and manufacturer's advertising investment. We use a Cobb-Douglas demand function as used by Yu et al. [1] to demonstrate the relationship between the parameters. Assume that the demand function has the following form:

$$D(r,m,p) = kr^{\alpha}m^{\beta}/p^{\gamma} \quad (1)$$

where k is a positive constant characterizing the market scale, and p, r and m represent the price, retailer's and manufacturer's advertising investment. Besides, α, β and γ stand for the elasticity of r, m and p, respectively. It is necessary to assume $\gamma > 0$ in order to guarantee the convexity of $D(r, m, p)$ in p. In addition, $0 < \alpha < 1$ and $0 < \beta < 1$ to ensure the concavity of demand function in r and m. The manufacturer's, retailer's and total channel's profit can be expressed as follows, respectively:

$$\Pi_M = (w-c)\frac{kr^{\alpha}m^{\beta}}{p^{\gamma}} - m - \theta r \quad (2)$$

$$\Pi_R = (p-w-d)\frac{kr^{\alpha}m^{\beta}}{p^{\gamma}} - (1-\theta)r \quad (3)$$

$$\Pi_{M+R} = (p-c-d)\frac{kr^{\alpha}m^{\beta}}{p^{\gamma}} - m - r \quad (4)$$

To ensure the non-negative profit for the both members and total channel, we have $w \geq c$, $p \geq w + d$ and $p \geq c + d$. We discuss four game models including one cooperative game and three non-cooperative models. Note that as stated above, the manufacturer's decision variables are w, m and θ; while the retailer's ones are p and r.

4. GAME THEORETIC MODELS

4. 1. Nash Game When both members have the same decision power, they play a Nash game and choose their decisions non-cooperatively and simultaneously with the aim of maximizing their own profits. The solution to this model is called the Nash equilibrium. Here, the manufacturer's problem is:

$$\text{Max}_{\theta,w,m}\,\Pi_M = (w-c)\frac{kr^{\alpha}m^{\beta}}{p^{\gamma}} - m - \theta r$$
$$s.t.\ 0 \leq \theta \leq 1, c < w < p, 0 \leq m \quad (5)$$

and the retailer's one is:

$$\text{Max}_{p,r}\,\Pi_R = (p-w-d)\frac{kr^{\alpha}m^{\beta}}{p^{\gamma}} - (1-\theta)r$$
$$s.t.\ w+d < p, 0 \leq r \quad (6)$$

Consider that the optimal value of θ is zero, because it has a negative coefficient in the manufacturer's problem. Also, Π_M is increasing in w, so its optimal value is equal to p, but this cannot be a feasible strategy, since in this situation the retailer cannot choose p to satisfy $p > w + d$. In order to solve the problem, we use the same approach as applied by Xie and Neyret [2], and SeyedEsfahani, et al. [3]. We assume that both sides' margins are equal when they choose their decisions simultaneously. That is $w - c = p - w - d$ or

$$w = 0.5(p+c-d) \quad (7)$$

In addition, the retailer and manufacturer choose their decision variables so as to optimize their profit function:

$$\frac{\partial \Pi_M}{\partial m} = \frac{\beta}{m}D(w-c) - 1 = 0 \quad (8)$$

$$\frac{\partial \Pi_R}{\partial p} = D\left[1 - \frac{\gamma}{p}(p-w-d)\right] = 0 \quad (9)$$

$$\frac{\partial \Pi_R}{\partial r} = \frac{\alpha}{r}D(p-w-d) - (1-\theta) = 0 \quad (10)$$

By solving the above system of Equations (7-10) and by considering that $\theta = 0$, we get the unique Nash equilibrium as follows.

Proposition 1: Nash game solution:

$$\theta^N = 0, p^N = \frac{\gamma}{\gamma-2}(c+d), w^N = \frac{(\gamma-1)c+d}{\gamma-2}$$

$$r^N = \sqrt[1-\alpha-\beta]{k\frac{\alpha^{1-\beta}\beta^{\beta}}{\gamma^{\gamma}}\left[\frac{\gamma-2}{c+d}\right]^{\gamma-1}}, \quad m^N = \sqrt[1-\alpha-\beta]{k\frac{\alpha^{\alpha}\beta^{1-\alpha}}{\gamma^{\gamma}}\left[\frac{\gamma-2}{c+d}\right]^{\gamma-1}}$$

4. 2. Stackelberg-Retailer Game A Stackelberg game is used in a non-cooperative and sequential decision making process. In this game, one player acts as a leader and another plays as a follower. The leader first chooses his decision taking the follower's reaction into account, and then the follower sees this decision and selects his best decision. For more information on Stackelberg game, please refer to the work of Von Stackelberg [17]. Here, the relationship between both sides is modeled as a sequential non-cooperative game in which the retailer is the leader. The retailer acts as a leader by declaring retail price and his local advertising investment. Then, the manufacturer, as the follower, determines wholesale price and his own advertising investment. The solution is called the SR equilibrium. To determine the equilibrium, the first step is to find the best response of the manufacturer for any given values of r, and p. Similar to the Nash game model, we should use the same approach for θ, and w. In addition, Π_M is concave in m, and its optimal value will be obtained by solving the same equation as (8). So, the manufacturer's best response is:

$$\theta = 0, w = 0.5(p + c - d), m = \sqrt[1-\beta]{\frac{k\beta r^{\alpha}}{2p^{\gamma}}(p - c - d)} \tag{11}$$

The next step, is determining r, and p subject to satisfying the constraints in (11). So, by substituting the above values to (6), we get the following maximization problem for the retailer.

$$\text{Max}_{p,r}\, \Pi_R = \frac{m}{\beta} - r \; s.t.\; c + d < p, 0 \le r \tag{12}$$

so, the first-order conditions for the retailer are:

$$\frac{\partial \Pi_R}{\partial p} = \left[\frac{1}{p-c-d} - \frac{\gamma}{p}\right]\frac{m}{\beta(1-\beta)} = 0 \tag{13}$$

$$\frac{\partial \Pi_R}{\partial r} = \frac{\alpha m}{\beta(1-\beta) r} - 1 = 0 \tag{14}$$

In Equations (12-14), m is corresponding to (11). Therefore, by solving the system of Equations (11, 13, 14), we get the unique SR equilibrium as follows.

Proposition 2: SR game solution:

$$\theta^{SR} = 0, \quad p^{SR} = \frac{\gamma}{\gamma-1}(c + d), \quad w^{SR} = \frac{(2\gamma-1)c+d}{2\gamma-2}$$

$$r^{SR} = \sqrt[1-\alpha-\beta]{\frac{k}{2}\frac{\alpha^{1-\beta}\beta^{\beta}}{\gamma^{\gamma}(1-\beta)^{1-\beta}}\left[\frac{\gamma-1}{c+d}\right]^{\gamma-1}} \qquad m^{SR} = \sqrt[1-\alpha-\beta]{\frac{k}{2}\frac{\alpha^{\alpha}\beta^{1-\alpha}}{\gamma^{\gamma}(1-\beta)^{\alpha}}\left[\frac{\gamma-1}{c+d}\right]^{\gamma-1}}$$

4. 3. Stackelberg-Manufacturer Game In this subsection, the relationship between both sides is modelled as a sequential non-cooperative game similar to previous subsection but with the manufacturer being the leader. Here, the manufacturer acts as a leader by declaring w and m. Then, the retailer, as the follower, determines p and r. The solution is called the SM equilibrium. To determine the equilibrium, the first step is to find the best response of the retailer for any given values of w and m. Consider that Π_R is concave in p and r, so, by solving (9) and (10) we get the retailer's best response as follows:

$$p = \frac{\gamma}{\gamma-1}(w + d),\; r = \sqrt[1-\alpha]{k\frac{\alpha m^{\beta}}{\gamma^{\gamma}(1-\theta)}\left[\frac{\gamma-1}{w+d}\right]^{\gamma-1}} \tag{15}$$

The next step, is determining w, and m subject to satisfying the constraints in (15). So, by substituting the above values to (5), we get the following maximization problem for the manufacturer.

$$\text{Max}_{\theta,w,m}\, \Pi_M = kr^{\alpha}m^{\beta}(w - c)\left[\frac{\gamma-1}{\gamma(w+d)}\right]^{\gamma} - m - \theta r$$
$$s.t. 0 \le \theta \le 1, c < w < p, 0 \le m \tag{16}$$

Then, the manufacturer optimizes his profit with respect to m, θ and w:

$$\frac{\partial \Pi_M}{\partial m} = \frac{D\beta(w-c)}{m(1-\alpha)} - 1 - \frac{\theta\beta r}{m(1-\alpha)} = 0 \tag{17}$$

$$\frac{\partial \Pi_M}{\partial \theta} = -\frac{D\alpha(w-c)}{(1-\alpha)(1-\theta)} - r\left[1 - \frac{\theta}{(1-\alpha)(1-\theta)}\right] = 0 \tag{18}$$

$$\frac{\partial \Pi_M}{\partial w} = D\left[1 - \frac{\gamma\alpha(w-c)}{(1-\alpha)p} - \frac{\gamma(w-c)}{w+d}\right] + \frac{\gamma\theta r}{(1-\alpha)p} = 0 \tag{19}$$

In Equations (17-19), D is corresponding to (1); p and r are corresponding to (15). Therefore, by solving the system of Equations (15, 17-19), we get the unique SM equilibrium as follows.

Proposition 3: SM game solution:

$$\theta^{SM} = \frac{2\gamma-\alpha-1}{3\gamma-\alpha-1}, \quad p^{SM} = \frac{\gamma^2}{(\gamma-1)(\gamma-\alpha-1)}(c + d), \quad w^{SM} = \frac{\gamma c+(1+\alpha)d}{\gamma-\alpha-1}$$

$$r^{SM} = \sqrt[1-\alpha-\beta]{\frac{k\alpha^{1-\beta}\beta^{\beta}}{\gamma^{\gamma}(c+d)^{\gamma-1}}\frac{(\gamma-1)^{\gamma-1}(\gamma-\alpha-1)^{\gamma+\beta-1}}{\gamma^{\gamma}(3\gamma-\alpha-1)^{\beta-1}}}$$

$$m^{SM} = \sqrt[1-\alpha-\beta]{\frac{k\alpha^{\alpha}\beta^{1-\alpha}}{\gamma^{\gamma}(c+d)^{\gamma-1}}\frac{(\gamma-1)^{\gamma-1}(\gamma-\alpha-1)^{\gamma-\alpha}}{\gamma^{\gamma}(3\gamma-\alpha-1)^{-\alpha}}}$$

4. 4. Cooperative Game In this subsection, we focus on a cooperative game model. Here, both the retailer and manufacturer agree to choose their decisions in order to maximize the whole supply chain's profit. The total channel's profit is as (4), so we have the following maximization problem which is a function of p, m, and r.

$$\text{Max}_{p,r,m}\, \Pi_{M+R} = (p - c - d)\frac{kr^{\alpha}m^{\beta}}{p^{\gamma}} - m - r$$
$$s.t. c + d < p, 0 \le m, 0 \le r \tag{20}$$

The above maximization problem should be optimized as below:

$$\frac{\partial \Pi_{M+R}}{\partial p} = D\left[1 - \frac{\gamma}{p}(p - c_M - c_R)\right] = 0 \tag{21}$$

$$\frac{\partial \Pi_{M+R}}{\partial r} = \frac{\alpha}{r}D(p - c - d) - 1 = 0 \tag{22}$$

$$\frac{\partial \Pi_{M+R}}{\partial m} = \frac{\beta}{m}D(p - c - d) - 1 = 0 \tag{23}$$

where D is corresponding to (1). Therefore, by solving the system of Equations (21-23), we get the unique solution as follows.

Proposition 4: Cooperative game solution:

$$p^{CO} = \frac{\gamma}{\gamma-1}(c + d), r^{CO} = \sqrt[1-\alpha-\beta]{k\frac{\alpha^{1-\beta}\beta^{\beta}}{\gamma^{\gamma}}\left[\frac{\gamma-1}{c+d}\right]^{\gamma-1}},$$

$$m^{CO} = \sqrt[1-\alpha-\beta]{k\frac{\alpha^{\alpha}\beta^{1-\alpha}}{\gamma^{\gamma}}\left[\frac{\gamma-1}{c+d}\right]^{\gamma-1}}$$

5. ANALYTICAL RESULTS

Table 1 shows the summary of different models' results. The last three rows correspond to the retailer's, manufacturer's and channel's profit, respectively. At cooperative model, the participation rate and wholesale price are open to take any value subject to $0 \leq \theta \leq 1$ and $c < w < (c + d)\, \gamma / (\gamma - 1)$. So, Π_R and Π_M at cooperation case are calculated based on the decision variables w and θ. Consider that it is necessary for γ to be greater than one in order to have feasible SR and cooperative games. Similarly, SM and Nash games are defined if we have $\gamma \geq \alpha + 1$ and $\gamma \geq 2$, respectively.

Figure 1 illustrates the maximum profits of both firms. The figure is obtained based on values of parameters α and γ. Also, we set $\beta = 0.9\ \alpha$. The parameters space is divided to two regions. In both regions, the SR game result in the highest profit for the manufacturer. On the other hand, the retailer's profit has its maximum value at SR game in region (I); while it ismaximized under SM game in region (II). Now, three conditions might occur: a) the retailer is more powerful than the manufacturer(the retailer-dominant channel); b) the manufacturer is more powerful than the retailer(the manufacturer-dominant channel); and, c) both members have the same decision power. In a retailer-dominant channel, retailer decides to be the leader in region (I), and, to be the follower inregion (II). However, in a manufacturer-dominant channel, the manufacturer always chooses to be the follower. Table 2 specifies which game should be played in different channel types. Note that, in a same-power channel, although, both members prefer to play Stackelberggame (SR or SM), they will play a Nash game. However, in region (I) they can move to SR game scenario due to its win-win outcome.

TABLE 2. Games with respect to the channel type

Region	Channel type		
	Retailer-dominant	**Manufacturer-dominant**	**Same-power**
(I)	SR	SR	Nash
(II)	SM	SR	Nash

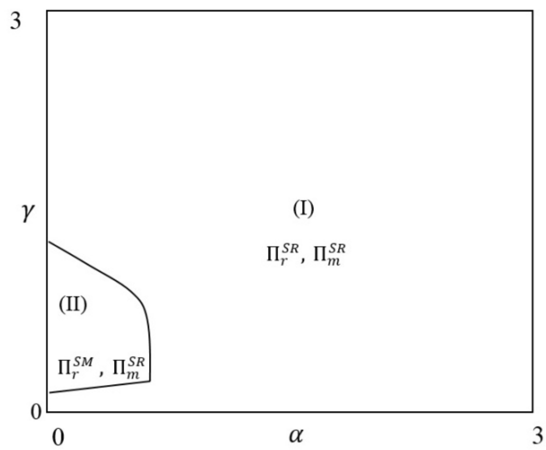

Figure 1. Maximum profits of the retailer and manufacturer

TABLE 1. Solution of four game models

	Nash game	**SR game**	**Cooperative**	**SM game**
θ	0	0	-	$\frac{2\gamma-\alpha-1}{3\gamma-\alpha-1}$
w	$\frac{(\gamma-1)c+d}{\gamma-2}$	$\frac{(2\gamma-1)c+d}{2\gamma-2}$	-	$\frac{\gamma c+(1+\alpha)d}{\gamma-\alpha-1}$
p	$\frac{\gamma(c+d)}{\gamma-2}$	$\frac{\gamma(c+d)}{\gamma-1}$	$\frac{\gamma(c+d)}{\gamma-1}$	$\frac{\gamma^2(c+d)}{(\gamma-1)(\gamma-\alpha-1)}$
$m^{1-\alpha-\beta}$	$K_m(\gamma-2)^{\gamma-1}$	$\frac{K_m}{2}\frac{(\gamma-1)}{(1-\beta)^{\alpha}}^{\gamma-1}$	$K_m(\gamma-1)^{\gamma-1}$	$K_m\frac{(\gamma-1)^{\gamma-1}(\gamma-\alpha-1)^{\gamma-\alpha}}{\gamma^{\gamma}(3\gamma-\alpha-1)^{-\alpha}}$
$r^{1-\alpha-\beta}$	$K_r(\gamma-2)^{\gamma-1}$	$\frac{K_r}{2}\frac{(\gamma-1)}{(1-\beta)^{1-\beta}}^{\gamma-1}$	$K_r(\gamma-1)^{\gamma-1}$	$K_r\frac{(\gamma-1)^{\gamma-1}(\gamma-\alpha-1)^{\gamma+\beta-1}}{\gamma^{\gamma}(3\gamma-\alpha-1)^{\beta-1}}$
Π_R	$\frac{1-\alpha}{\alpha}r^{N}$	$\frac{1-\alpha-\beta}{\alpha}r^{SR}$	$\left[\frac{w-c}{c+d}(\gamma-1)-\beta-\alpha\theta\right]\frac{r^{CO}}{\alpha}$	$\frac{\gamma}{3\gamma-\alpha-1}\frac{1-\alpha}{\alpha}r^{SM}$
Π_M	$\frac{1-\beta}{\alpha}r^{N}$	$\frac{(1-\beta)^2}{\alpha}r^{SR}$	$\left[\frac{\gamma c+d}{c+d}-\frac{w}{c+d}(\gamma-1)-\alpha+\alpha\theta\right]\frac{r^{CO}}{\alpha}$	$\frac{\gamma-\alpha-1}{3\gamma-\alpha-1}\frac{1-\alpha-\beta}{\alpha}r^{SM}$
$\Pi_R+\Pi_M$	$\frac{2-\alpha-\beta}{\alpha}r^{N}$	$\frac{(1-\beta)(2-\beta)-\alpha}{\alpha}r^{SR}$	$\frac{1-\alpha-\beta}{\alpha}r^{CO}$	$\frac{r^{SM}}{3\gamma-\alpha-1}\left[\frac{\gamma(2-2\alpha-\beta)-(1+\alpha)(1-\alpha-\beta)}{\alpha}\right]$

$K_m=\frac{k\alpha^{\alpha}\beta^{1-\alpha}}{\gamma^{\gamma}(c+d)^{\gamma-1}}$, $K_r=\frac{k\alpha^{1-\beta}\beta^{\beta}}{\gamma^{\gamma}(c+d)^{\gamma-1}}$

6. COORDINATION

In this section, we investigate the feasibility of the cooperation game. The cooperative solution will be feasible if and only if both the retailer and manufacturer gain higher profit in the cooperation case comparedwith the non-cooperative game which is played. In the other words, the manufacturer should offer *(w, θ)* in a way that he and his retailer can benefit from the cooperative case compared with the non-cooperative one. Consider that the whole channel's gain in the cooperation case comparing to the non-cooperation one is $\Delta\Pi^i = \Delta\Pi^i_R + \Delta\Pi^i_M$, where $\Delta\Pi^i_R$ and $\Delta\Pi^i_M$ are the retailer's and manufacturer's gain, respectively, where the subscript "i" denotes the game which is played between the members and, belongs to {N, SR, SM}. Xie and Neyret [2] and SeyedEsfahani et al. [3] assume that a cooperative game is feasible if and only if each member cannot achieve any higher profit in any other non-cooperative games. So, they examine $\Pi^{co}_M \geq Max\ (\Pi^N_M, \Pi^{SM}_M, \Pi^{SR}_M)$ and $\Pi^{co}_R \geq Max\ (\Pi^N_R, \Pi^{SM}_R, \Pi^{SR}_R)$. This approach seems to have an important flaw. It is true that a cooperative game should be designed in a way that none of the members has a temptation to deviate from the agreement. But, in this case, one game can be played between the members at a time. In addition, some*(w, θ)*are ignored for bargaining in their approach.For example, when each member prefers to be the follower of another member, only the more powerful member has an authority of being either the leader or the follower of the game. If they have the same decision power, they will play a Nash game. Otherwise, the dominant player will decide to be the follower, and, another player obliged to be the leader. Consequently, to have a feasible cooperative game when a particular game (i.e. the game i) is played, we should have $\Pi^{co}_M \geq \Pi^i_M$ and $\Pi^{co}_R \geq \Pi^i_R$. From Table 1:

$$\Delta\Pi^i_r = \Pi^{co}_r - \Pi^i_r = \frac{r^{co}}{\alpha}\left[\frac{\gamma-1}{c+d}w - \alpha\theta - I^i\right], \tag{24}$$

$$\Delta\Pi^i_m = \Pi^{co}_m - \Pi^i_m = \frac{r^{co}}{\alpha}\left[-\frac{\gamma-1}{c+d}w + \alpha\theta + J^i\right], \tag{25}$$

$$\Delta\Pi^i = \Delta\Pi^i_r + \Delta\Pi^i_m = \frac{r^{co}}{\alpha}\left[J^i - I^i\right] \tag{26}$$

where:

$$I^N = \frac{\gamma c-c}{c+d} + \beta + (1-\alpha)\left(\frac{\gamma-2}{\gamma-1}\right)^{\frac{\gamma-1}{1-\alpha-\beta}}; \tag{27}$$

$$J^N = \frac{\gamma c+d}{c+d} - \alpha - (1-\beta)\left(\frac{\gamma-2}{\gamma-1}\right)^{\frac{\gamma-1}{1-\alpha-\beta}}; \tag{28}$$

$$I^{SR} = \frac{\gamma c-c}{c+d} + \beta + (1-\alpha-\beta)\left(\frac{1}{2(1-\beta)^{1-\beta}}\right)^{\frac{1}{1-\alpha-\beta}}; \tag{29}$$

$$J^{SR} = \frac{\gamma c+d}{c+d} - \alpha - (1-\beta)^2\left(\frac{1}{2(1-\beta)^{1-\beta}}\right)^{\frac{1}{1-\alpha-\beta}}; \tag{30}$$

$$I^{SM} = \frac{\gamma c-c}{c+d} + \beta + \frac{\gamma(1-\alpha)}{3\gamma-\alpha-1}\left(\frac{(\gamma-\alpha-1)^{\gamma+\beta-1}}{\gamma^\gamma(3\gamma-\alpha-1)^{\beta-1}}\right)^{\frac{1}{1-\alpha-\beta}}; \tag{31}$$

$$J^{SM} = \frac{\gamma c+d}{c+d} - \alpha - \frac{\gamma-\alpha-1}{3\gamma-\alpha-1}(1-\alpha-\beta)\left(\frac{(\gamma-\alpha-1)^{\gamma+\beta-1}}{\gamma^\gamma(3\gamma-\alpha-1)^{\beta-1}}\right)^{\frac{1}{1-\alpha-\beta}} \tag{32}$$

In order to have a feasible cooperation case, the right-hand-side of both Equations (24) and (25) should be positive. That is characterized by following proposition.

Proposition 5: (Feasible region for bargaining): both the manufacturer and his retailer are willing to cooperate if the couple(w, θ)satisfies the constraint as follows in which I^i andJ^i are corresponding to (27-32):

$$I^i < \frac{\gamma-1}{c+d}w - \alpha\theta < J^i$$

Proposition 5 characterizes the region in which the cooperation is feasible.In order to quantifying the results of Proposition 5, first consider a case*[α, β, γ, c, d]=[0.4, 0.36, 2.3, 1, 0.3]*, Figure 2 illustrates the feasible region for bargaining under this case. It can be implied from the figure that both the retailer and manufacturer prefer to play Stackelberg game with the retailer being the leader (SR game). Since, from (24), the greater values ofI^i represents the greater profit of the retailer(Π^i_R), while, the lower values ofJ^irepresent the greater profit of the manufacturer (Π^i_M). It is shown that all three regions are feasible for Nash and SM games, however, only region (II) is feasible for SR game.

Now consider another case with*[α, β, γ, c, d]=[0.08, 0.072, 1.5, 0.3, 0.2]*, Figure 3 illustrates the feasible region for bargaining under SM and SR games. Here, we have no feasible Nash game, since$\gamma < 2$. Here, the retailer prefers to play SM game, while the manufacturer prefers to play SR game. In other words, both the retailer and manufacturer prefer to be the follower of other player when Stackelberg game is played between the members. In this case, when SR game is played, the bargaining can be made on regions (I) and (II); and,when SM game is played, the bargaining can be made on regions (II) and (III).

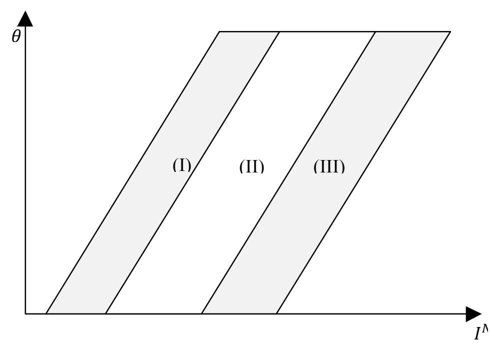

Figure 2. Feasible region of bargaining for case 1

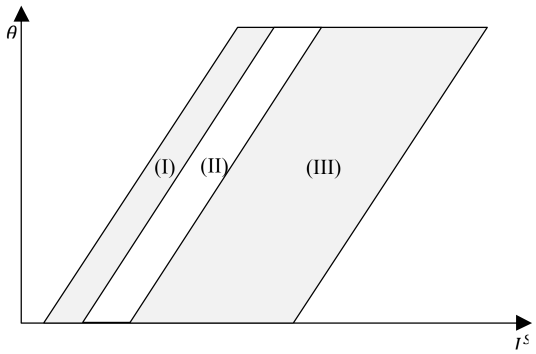

Figure 3. Feasible region of bargaining for case 2

Consider that it is impossible to determine precisely the values of wholesale price, participation rate, and each member's share of the channel profit gain without any further information (see, for example, Nash [18]; Huang and Li [7]; Xie and Neyret [2]; SeyedEsfahani et al. [3]; Kunter [13]). One possible approach is applying the bargaining model. In these models, the channel members bargain on(w,θ) in order to share the extra profit obtained from cooperation. Their profit share can be determined by their bargaining power and risk attitude. There are many cooperative bargaining models in the literature. In this paper, we utilize bargaining model as used in Eliashberg [4].

7. BARGAINING MODEL

Here, we use the bargaining model which is used in Eliashberg [4]. We assume that both the manufacturer and retailer are risk-averse, and, their utility functions are specified by$u_m(\Delta\Pi_m) = 1 - e^{-b_m\Delta\Pi_m}$and $u_r(\Delta\Pi_r) = 1 - e^{-b_r\Delta\Pi_r}$, respectively, where b_m and b_r are positive constants; and representing the risk aversion factor of the manufacturer and retailer, respectively. The whole channel utility function is:

$$u_s(\Delta\Pi_m, \Delta\Pi_r) = \lambda_m u_m(\Delta\Pi_m) + \lambda_r u_r(\Delta\Pi_r) = 1 - \lambda_m e^{-b_m\Delta\Pi_m} - \lambda_r e^{-b_r\Delta\Pi_r} \tag{33}$$

where$\lambda_m > 0$ and $\lambda_r > 0$ are the aggregation weights $(\lambda_m + \lambda_r = 1)$ reflecting the bargaining power or importance of the manufacturer and retailer, respectively. In order to achieve the optimal solution, we should maximize $u_s(\Delta\Pi_m, \Delta\Pi_r)$ by considering the constraint $\Delta\Pi_r = \Delta\Pi - \Delta\Pi_m$. So we have:

$$\Delta\Pi_m^* = \frac{b_r}{b_m+b_r}\Delta\Pi + \frac{1}{b_m+b_r}\ln\frac{\lambda_m b_m}{\lambda_r b_r} = b\Delta\Pi + \delta \tag{34}$$

$$\Delta\Pi_r^* = \frac{b_m}{b_m+b_r}\Delta\Pi - \frac{1}{b_m+b_r}\ln\frac{\lambda_m b_m}{\lambda_r b_r} = (1-b)\Delta\Pi - \delta \tag{35}$$

where$b = b_r/(b_m + b_r)$ is the manufacturer's quota of the channel's gain, $1 - b = b_m/(b_m + b_r)$ is the retailer's one, and $\delta = ln(\lambda_m b_m/\lambda_r b_r)/(b_m + b_r)$ is the compensation fee paid from one member to another one depending on the sign of δ. In the other words, if $\lambda_m b_m > \lambda_r b_r$, the compensation fee will be paid from the retailer to the manufacturer; if $\lambda_m b_m < \lambda_r b_r$, the compensation fee will be paid from the manufacturer to the retailer; and if $\lambda_m b_m = \lambda_r b_r$, the compensation fee will be equal to zero. Also, it can be inferred from (34) and (35) that if the risk aversion has the same value for both members, they equally share the channel gain and the member who has a higher bargaining power, receives the compensation fee. Moreover, if the members have the same bargaining power, their share of the channel profit will depend only on their risk aversion value. In the other words, the more risk-seeking member will receive a positive compensation fee. By combining Equations (34-35) with Equations (24-26), the Eliashberg [4]'s bargaining solution can be achieved as in proposition 6.

Proposition 6: when the game i is played between the members, $i \in \{N, SR, SM\}$, the channel will be coordinated if the manufacturer offers a contract (w,θ) with:

$$\theta = \frac{1}{\alpha}\left[\frac{\gamma-1}{c+d}w - \frac{J^i b_m + I^i b_r}{b_m+b_r} + \frac{\alpha}{r^{co}}\frac{1}{b_m+b_r}ln\frac{\lambda_m b_m}{\lambda_r b_r}\right]$$

with any $w$that satisfies the following constraint:

$$\frac{c+d}{\gamma-1}\zeta_1 < w < \frac{c+d}{\gamma-1}\zeta_2$$

where:

$$\zeta_1 = \left[\frac{J^i b_m + I^i b_r}{b_m+b_r} + \frac{\alpha}{r^{co}}\frac{1}{b_m+b_r}ln\frac{\lambda_r b_r}{\lambda_m b_m}\right]$$

$$\zeta_2 = \left[\alpha + \frac{J^i b_m + I^i b_r}{b_m+b_r} + \frac{\alpha}{r^{co}}\frac{1}{b_m+b_r}ln\frac{\lambda_r b_r}{\lambda_m b_m}\right]$$

Note that the constraint associated to wholesale price in proposition 6 can be obtainedby assuming that the value of participation rate should satisfy $0 < \theta < 1$.

8. CONCLUSIONS

The paper investigated optimal pricing and co-op advertising decisions between a manufacturer and a single retailer under four game-theoretic models. We obtained close-form optimal solution and unique equilibrium for each game model.We established the feasible region for cooperation where both the retailer and manufacturer can bargain over the values of the participation rate and wholesale price in order to split the extra profit achieved from moving to cooperation. For objective (1) of the paper, we compared the members' profit in the non-cooperative games. It is shown that the manufacturer always prefers to be the follower of the retailer. However, the retailer prefers to be the leader except for a small fraction of the region in which we have almost $\alpha < 0.1$. So, in a manufacturer-dominant channel where the manufacturer is the more powerful member, he prefers to be the follower of the game. However, in a retailer-dominant channel, the retailer often decides to be the leader, and, to be the follower in a small fraction of the (α, γ) space. Then, we conclude that the leadership in Stackelberg game is not always desirable for the members.In the decentralized setting, the more powerful member (if any) has an authority to select which game should be played, otherwise, the Nash game will be played. So, only one game (i.e. either Nash or Stackelberg-retailer or Stackelberg-manufacturer) can be played between the members in a time based on the channel type. In order to reach objective (2), the feasible ranges of wholesale price and participation rate are investigated for cooperative game based on the type of the channel. The manufacturer can offer a contract (w, θ) such that the cooperative game will result in a higher profit than other game for both members, and the highest profit for the whole channel. For objective (3), the bargaining model and the members' utility function are assumed to be similar to the one used in Eliashberg [4]. The members bargain over the values of (w, θ) to split the extra profit. It is shown that the members will equally share the channel gain if they have the same value for risk attitude. Also, the member will receive more share of the channel gain if he has a lower degree of risk attitude.

Our study can be extended as involving more decision makers such as competing retailers or competing manufacturers.Moreover, assuming competition between channels may lead to interesting results (Hafezalkotob et al. [19]). In addition, one can apply Shapely value rather than bargaining games for fair allocation of gains as used by Abbasi et al. [20].

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Designing of Supply Chain Coordination Mechanism with Leadership Considering

RESEARCH NOTE

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چکیده

تبلیغات همکارانه عمودی به نوعی یک مکانیزم تقسیم هزینه‌ها بوده و تلاشی است از طرف اعضا یرای هماهنگ کردن زنجیره که باعث افزایش تقاضا و سود کلی می‌شود. در این استراتژی، تولیدکننده بخشی از هزینه‌های تبلیغات خرده‌فروش را متحمل می‌شود. در این مقاله، تصمیمات مربوط به تبلیغات و قیمت گذاری در یک زنجیره خرده‌فروش–تولیدکننده مطالعه می‌شود که در آن تقاضای بازار همزمان متاثر از قیمت خرده فروشی و تبلیغات اعضا است. سه مدل غیرهمکارانه و یک مدل همکارانه با بکارگیری تئوری بازی‌ها برای مسئله ارائه شدهاست. هر یک از بازی‌های غیرهمکارانه بر اساس نوع کانال انجام‌پذیر است که می‌تواند بصورت خرده‌فروش–غالب، تولیدکننده–غالب یا با قدرت برابر باشد. شدنی بودن بازی همکارانه به منظور هماهنگ کردن زنجیره مورد بررسی قرار گرفته است. همچنین یک مدل چانه‌زنی برای تعیین سهم هر یک از اعضا از سود حاصل شده از هماهنگی بکار برده شده است.

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