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Decision Support

Vertical cooperative advertising and pricing decisions in a manufacturer–retailer supply chain: A game-theoretic approach

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A B S T R A C T

Manufacturers can increase the advertising expenditures of their retailers by bearing a fraction of the occurring costs within the framework of a vertical cooperative advertising program. We expand the existing research which deals with advertising and pricing decisions in a manufacturer–retailer supply chain contemporaneously. By means of game theory, four different relationships between the channel members are considered: Firstly, three non-cooperative games with either symmetrical distribution of power or asymmetrical distribution with one player being the leader in each case, and one cooperative game where both players tend to maximize the total profit. The latter is complemented by a bargaining model, which proposes a fair split of profit on the basis of the players' risk attitude and bargaining power. Our main findings are as follows: (a) In contrast to previous analyses, we do not limit the ratio between manufacturer's and retailer's margin, which provides more general insights into the effects of the underlying distribution of power within the channel. (b) The highest total profit is gained when both players cooperate. This behavior puts also the customers in a better position, as it produces the lowest retail price as well as the highest advertising expenditures compared to the other configurations.

1. Introduction

In the recent years, several papers dealt with vertical cooperative advertising in a manufacturer–retailer channel (for the sake of simplicity, we refer to cooperative advertising in the following). This type of collaboration can be defined as an financial agreement, in which the manufacturer offers to bear either a certain part or the entire advertising expenditures of his retailer (Bergen and John, 1997). Thereby, he intends to increase the retailer's advertising, which has the task to stimulate the immediate demand of the customers. With this financial assistance, the retailer can increase his level of advertising, which leads to higher sales for both, the retailer and the manufacturer (Somers et al., 1990). Though being a significant part of many manufacturers' advertising budgets (for example, a total sum of $15 billion was invested in such programs in the United States in 2000), most firms seem to determine the participation rate arbitrarily and without detailed analysis on 50% or 100% (Nagler, 2006).

The research on cooperative advertising can be roughly divided into two groups. Authors belonging to the first group concentrate their analysis solely on advertising. The first mathematical modeling of cooperative advertising was the work of Berger (1972), who proposed a financing of the retailer's advertising expenditures by a discount on the wholesale price. Dant and Berger (1996) adopted this approach to the context of franchising. Karray and Zaccour (2006) considered a bilateral duopoly and demonstrated, that cooperative advertising can also have harmful impacts on the retailers. In contrast to the latter examples, which are based on static models, Jørgensen et al. (2000, 2003), and Jørgensen and Zaccour (2003) studied the effects of cooperative advertising in a dynamic environment by using a goodwill function, on which the retailer's advertising has either positive or negative effects. The first one comparing different types of manufacturer–retailer relationships by game theory was the work of Huang and Li (2001), who used a demand function which depends both on the local advertising expenditures of the retailer and on the global advertising expenditures of the manufacturer. Though emphasizing the changed power structure in favor of the retailers, they considered equal power distribution (Nash equilibrium), manufacturer-leadership (Stackelberg manufacturer equilibrium) and the case were manufacturer and retailer act in cooperation and bargain for the division of profits. Similar approaches with slightly modified demand functions can be found in Li et al. (2002), Huang et al. (2002), and Huang and Li (2005).

Representatives of the second group, to which the present paper belongs to, also include other decision variables like pricing, as it can be found in Bergen and John (1997), Kim and Staelin (1999), and Karray and Zaccour (2007). For instance, Yue et al. (2006)

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extended the model of Huang and Li (2001) by a price-sensitive component within the demand function in order to deliver the optimal advertising expenditures of both channel members as well as the optimal price discount offered to the costumers by the manufacturer. They compared the results of the Stackelberg manufacturer equilibrium to the cooperation. In lieu of the price discount, Szmerekovsky and Zhang (2009) included the resulting retail price in their demand function and calculated the Stackelberg manufacturer equilibrium. In contrast to the latter, the retailer fully determines the price demand, which previously was influenced only by the manufacturer. The model proposed by Xie and Wei (2009) is based upon a different demand function, which enabled the authors to handle the (cooperative) advertising and pricing decisions of both channel members contemporaneously. In this context, closed-form solutions of the Stackelberg manufacturer equilibrium and the cooperation were derived. Yan (2010) customized this model in order to fit to the e-marketing environment. The assumption of a dominant manufacturer is indeed very common in marketing literature, but the development of large retailers like Wal-Mart and, according to that, the shift of market power necessitates additional analyses. The first paper, which considered not only a leadership of the manufacturer, but also a dominant retailer, was written by Xie and Neyret (2009). Besides this Stackelberg retailer equilibrium, they calculated also the Nash equilibrium, the Stackelberg manufacturer equilibrium and the cooperation. The work of SeyedEsfahani et al. (2011) applied these four games on the model proposed by Xie and Wei (2009), but relaxed the assumption of a linear price demand function by introducing a new parameter ν which can cause either a convex ($\nu < 1$), or a linear ($\nu = 1$) or a concave ($\nu > 1$) curve. Lastly, a recent paper of Kunter (2012) follows a different approach and concentrates on establishing channel coordination by means of a royalty payment contract.

Table 1 summarizes the cooperative advertising models, which are most related to our approach, as well as the corresponding demand functions and games being used. Please note that both Xie and Neyret (2009) and SeyedEsfahani et al. (2011) only initially used the parameters α and β within their price demand function and normalized them to one during further calculus.

It is clearly visible, that only the latter two really take into account the changed market structure, i.e. the shift of power from manufacturers to retailers, by including Nash and Stackelberg retailer equilibrium. However, both had to deal with some mathematical difficulties during the calculation of the manufacturer's decision problem for these new games: Following the notation explained in Table 2, the profit functions of both articles can be written as

$$\Pi_m = wg(p)h(a,A) - A - ta \quad (1)$$
$$\Pi_r = (p - w)g(p)h(a,A) - (1 - t)a, \quad (2)$$

where $g(p)$ and $h(a, A)$ denominate the respective price and advertising demand function. As the price demand depends only on the retail price p, the manufacturer will choose the highest possible wholesale price $w < p$ in order to maximize his profit. Given that this behavior would result in $\Pi_r = 0$, Xie and Neyret (2009) assumed identical margins (i.e. $w = p/2$) for both players both in the Nash and the Stackelberg retailer equilibrium. This ratio between wholesale price and retail price was also adopted by SeyedEsfahani et al. (2011).

Table 2
Table of symbols.

Variables		Parameters	
p	Retail price	α	Price demand potential
w	Wholesale price	β	Price sensitivity
m	Retailer margin	ν	Shape parameter
a	Local advertising expenditures	k_r	Effectiveness of local advertising
A	Global advertising expenditures	k_m	Effectiveness of global advertising
t	Advertising participation rate	k	Advertising ratio
Π	Profit		

In this paper, we intend to relax this restrictive assumption of identical margins to get better insights into the effects of market power on the distribution of channel profits. Through a modification of the profit functions, we are able to extend the existing research by unrestrained Nash and Stackelberg retailer equilibria. Thereby, we follow the modified price demand function introduced by SeyedEsfahani et al. (2011), as we expect more insights as from the linear function of Xie and Wei (2009). Contrary to the authors, we will not normalize the parameters α and β to one in order to be able to adapt the function to the real price demand. The remainder is organized as follows: In Section 2, we propose our modification of the profit functions and calculate the Nash (2.1), the Stackelberg manufacturer (2.2), the Stackelberg retailer equilibrium (2.3) and the cooperation (2.4). The latter game has to be complemented by a bargaining model, which is used to determine the profit split between manufacturer and retailer. Therefore, we introduce the asymmetric Nash bargaining model of Harsanyi and Selten (1972) and Kalai (1977) in Section 2.5. The results of these four games are compared in Section 3 via numerical examples. Section 4 summarizes our main findings and indicates possible directions of further research.

2. Four forms of retailer–manufacturer relationship

We consider a supply chain consisting of one manufacturer and one retailer, which is illustrated in Fig. 1.

According to Choi (1991, 1996), we introduce the retailer margin m as a new decision variable, with

$$m = p - w. \quad (3)$$

Hence, we derive the following modified price and advertising demand functions of SeyedEsfahani et al. (2011):

$$g(w,m) = [\alpha - \beta(w + m)]^{1/\nu} \quad (4)$$
$$h(a,A) = k_r\sqrt{a} + k_m\sqrt{A}, \quad (5)$$

The downward-sloping price demand function $g(w, m)$ in Eq. (4) is an advancement of the widely used linear demand function

Table 1
Related cooperative advertising models.

	Price demand	Advertising demand	Games			
Huang and Li (2001)	–	$\alpha - \beta a^{-\gamma} A^{-\delta}$	N	SM	–	C
Yue et al. (2006)	$(p/p_0)^{-e}$	$\alpha - \beta a^{-\gamma} A^{-\delta}$	–	SM	–	C
Szmerekovsky and Zhang (2009)	p^{-e}	$\alpha - \beta a^{-\gamma} A^{-\delta}$	–	SM	–	–
Xie and Wei (2009)	$1 - \beta p$	$k_r\sqrt{a} + k_m\sqrt{A}$	–	SM	–	C
Xie and Neyret (2009)	$\alpha - \beta p$	$A - B\,a^{-\gamma} A^{-\delta}$	N	SM	SR	C
SeyedEsfahani et al. (2011)	$(\alpha - \beta p)^{1/\nu}$	$k_r\sqrt{a} + k_m\sqrt{A}$	N	SM	SR	C

N – Nash, SM – Stackelberg manufacturer, SR – Stackelberg retailer, C – Cooperation.