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A game theoretic approach to coordinate pricing and vertical co-op advertising in manufacturer–retailer supply chains

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ABSTRACT

Vertical cooperative (co-op) advertising is a marketing strategy in which the retailer runs local advertising and the manufacturer pays for a portion of its entire costs. This paper considers vertical co-op advertising along with pricing decisions in a supply chain; this consists of one manufacturer and one retailer where demand is influenced by both price and advertisement. Four game-theoretic models are established in order to study the effect of supply chain power balance on the optimal decisions of supply chain members. Comparisons and insights are developed. These embrace three non-cooperative games including Nash, Stackelberg-manufacturer and Stackelberg-retailer, and one cooperative game. In the latter case, both the manufacturer and the retailer reach the highest profit level; subsequently, the feasibility of bargaining game is discussed in a bid to determine a scheme to share the extra joint profit.

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1. Introduction

Supply chain coordination has been the focus of many research studies without which channel members tend to maximize their own profit. A prime example associated with such an uncoordinated system is "double marginalization", in which the retailer makes arbitrary decisions without considering supplier's profit margin (Spengler, 1950). Another example is the "bullwhip effect" which occurs when supply chain members make decision ignoring the others; this, in return, will lead to the spread of distorted demand information moving upstream (Lee et al., 1997).

Sahin and Robinson (2002) proposed two key drivers of supply chain performance involving information sharing and coordination. Fugate et al. (2006) classified supply chain coordination mechanisms into three categories: (1) price coordination, (2) non-price coordination and (3) flow coordination. Based on this classification, pricing and vertical cooperative advertising, two business decisions discussed in this paper, are placed in the first and second category, respectively.

A considerable amount of research has been conducted in recent years on different aspects of supply chain coordination including pricing, production, purchasing, inventory, etc. In this paper, optimal pricing and vertical co-op advertising decision is discussed in a single-manufacturer–single-retailer supply chain in which consumer demand is influenced by both price and advertising efforts.

Manufacturers and retailers use advertising programs to convince customers to purchase their products. Their efforts are different in the sense that, the aim of manufacturer's national advertising is to influence potential customers and raise brand awareness, while the Retailer's local advertising is intended to bring potential customers to the point of desire and action (Huang and Li, 2001). Vertical co-op advertising is an arrangement whereby a manufacturer agrees to pay for a portion or the entire costs of local advertising undertaken by a retailer. The percentage of local advertising cost that the manufacturer agrees to pay is called "participation rate" (Bergen and John, 1997). The main reason for the manufacturer to use co-op advertising is to strengthen the brand image and promote immediate sales at the retail level (Hutchins, 1953).

The vertical co-op advertising plays an important role in firms' marketing programs. Total expenditures on co-op advertising in the United States in 2000 were estimated at $15 billion; an approximately fourfold increase in real terms compared with $900 million in 1970 (Nagler, 2006). Berger (1972) was the first to address the vertical co-op advertising problem mathematically. Using a real world application, he showed the proposed quantitative analysis can be applied in determining the optimal decisions appropriately.

A common approach in the literature to analyze the role of co-op advertising in supply chain coordination is to use game theoretical models; these exist in two categories: static and dynamic. In static models, interactions among supply chain members are discussed in a single period. Examples in this category are Dant and

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Berger (1996), Bergen and John (1997), Kim and Staelin (1999), Karray and Zaccour (2006, 2007), Huang and Li (2001), Huang et al. (2002) and Li et al. (2002). In dynamic models, a goodwill function is introduced to express the carry-over effect of advertising. Most of the studies in this category ignore the participation rate despite its fundamental role. Reader is referred to Jørgensen et al. (2001, 2000) and Jørgensen and Zaccour (2003b) for more examples. On the other hand, when the retailer has perfect knowledge about manufacturer's decision in advertising policy or in the case it has already been announced, the required assumptions of game-theoretic model do not hold. Berger et al. (2006) considered such issue in co-op advertising problem. Determining retail/wholesale price has been the focus of many studies, as a fundamental task in the supply chain management literature. Jeuland and Shugan (1983, 1988), McGuire and Staelin (1983), Moorthy (1988), Ingene and Parry (1995a,b, 1998, 2000) and Choi (1991, 1996) discuss channel coordination in the context of two-level supply chain; they do this by adopting two common pricing mechanisms as well as two-part tariffs and quantity discounts. There are a number of studies that consider pricing and advertising decisions simultaneously in supply chain coordination. Jørgensen and Zaccour (1999) proposed a differential game model in which they consider pricing and advertising decisions in a two-level supply chain under channel conflict and coordination. In their study, consumer demand is influenced by retail price and advertising goodwill. Jørgensen et al. (2001), considered the leadership role in a single-manufacturer–single-retailer marketing channel; each player controls her advertising and margin. In their model, consumer demand is influenced by both advertising goodwill and retail price. They proposed four game-theoretic models and compared the results. Jørgensen and Zaccour (2003a) also modeled consumer demand as the multiplicative product of retail price and advertising goodwill in dynamic setting, and then compared results in coordinated strategies with all those of uncoordinated.

In the static framework, Yue et al. (2006) extended the model of Huang et al. (2002); they did this by considering a price-sensitive demand and studied the impact direct discount from manufacturer to the costumer may have on the channel coordination. In his paper, Zaccour (2008) attempted to study the conditions that may lead the manufacturer to achieve the integrate channel solution by means of a two-part tariff wholesale price. He further compared static and dynamic models in which demand function is affected by price and advertising. He et al. (2009) modeled a single-manufacturer–single-retailer supply chain as a stochastic Stackelberg differential game; in this game the demand is a function of both retailer's price and advertising. Szmerekovsky and Zhang (2009) considered pricing and advertising in a two-member supply chain; where costumer demand depends on both retail price and advertisement. They obtained both the manufacturer and the retailer's optimal decisions by solving the Stackelberg-manufacturer. Xie and Neyret (2009) and Xie and Wei (2009) followed a similar approach; they compared the cooperative game optimal results with those of non-cooperative. Xie and Neyret (2009) investigated four game models, three of which were non-cooperative and one was cooperative; whereas, Xie and Wei (2009) only considered two game models including Stackelberg-manufacturer and cooperative game.

This paper is closely related to the last three studies just mentioned. According to Choi (1991), different demand-price functions lead to considerably different results. Following Choi's results, in this paper, a relatively general demand function is proposed, compared to what Xie and Wei (2009) did in their model. In addition, we investigate one cooperative and three non-cooperative game-theoretic models; in contrast to only two models discussed by Xie and Wei. Major differences between this paper and three most related studies mentioned above are summarized in Table 1.

To our best knowledge, most of the studies in the subject of power balance have assumed a dominant manufacturer. This considers the manufacturer as leader and the retailer as follower (Berger, 1972; Somers et al., 1990). Nowadays, this issue is the focus of many research studies (e.g. see Kumar, 1996; Kadiyali et al., 2000; Geylani et al., 2007). There exist some different approaches in the supply chain coordination; for instance, consider a powerful manufacturer, such as P&G, who is able to order certain shelves in her retailer's stores, whereas a powerful retailer, such as Wal-Mart, is able to limit manufacturer's margin or demand extra requirements including RFID attachment, inventory management, quality control, etc.

Keeping in mind both approaches, we propose four scenarios including (1) equal power as in Nash game, (2) powerful manufacturer or Stackelberg-manufacturer game, (3) powerful retailer or Stackelberg-retailer game and (4) the state of integration or cooperation game.

The remainder of the paper is organized as follows: in Section 2, the model framework is presented. Four game-theoretic models based on one cooperative and three non-cooperative games are discussed in Section 3. Section 4 is dedicated to illustrate the results of four proposed models. The feasibility of cooperation and solution of bargaining game is discussed in Section 5. Finally, the conclusion including summary of the main results and some directions for future research is given in Section 6. Proofs of all propositions appear in the Appendix.

2. Model framework

Consider a supply chain that consists of a single manufacturer, selling her products through a single retailer that, in turn, sells the manufacturer's product only. The manufacturer decides on the wholesale price w, National advertising expenditures A, and participation rate t. The retailer, on the other hand, decides on the retail price p and local advertising costs a. Bearing in mind the prevalent assumption in the literature (Jørgensen and Zaccour, 1999, 2003a; Yue et al., 2006; Szmerekovsky and Zhang, 2009; Xie and Wei, 2009; Xie and Neyret, 2009), it can be assumed that the consumer demand $D(p,a,A)$ to have the following form:

$$D(p,a,A) = D_0 \cdot g(p) \cdot h(a,A), \quad (1)$$

Table 1
Comparing the current paper with three most related studies.

Demand function	Szmerekovsky and Zhang (2009)	Xie and Neyret (2009)	Xie and Wei (2009)	Proposed model
Price effect	p^{-e} $(e > 1)$	$\alpha_1 - \beta_1 p$ $(\alpha_1, \beta_1 > 0)$	$\alpha_1 - \beta_1 p$ $(\alpha_1, \beta_1 > 0)$	$(\alpha_1 - \beta_1 p)^{\frac{1}{\nu}}$ $(\alpha_1, \beta_1 > 0)$
Advertising effect	$\alpha_2 - \beta_2 a^{-\gamma} A^{\delta}$ $(\alpha_2, \beta_2, \gamma, \delta > 0)$	$\alpha_2 - \beta_2 a^{-\gamma} A^{\delta}$ $(\alpha_2, \beta_2, \gamma, \delta > 0)$	$k_1\sqrt{a} + k_2\sqrt{A}$ $(k_1, k_2 > 0)$	$k_1\sqrt{a} + k_2\sqrt{A}$ $(k_1, k_2 > 0)$
Game structures	–	N	–	N
	SM	SM	SM	SM
	–	SR	–	SR
	–	Co	Co	Co

p, retail price; a, local advertising expenditures; A, national advertising expenditures; N, Nash game; SM, Stackelberg-manufacturer game; SR, Stackelberg-retailer game; Co, cooperation game.

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