Computers & Industrial Engineering 56 (2009) 1375–1385

Contents lists available at ScienceDirect

Computers & Industrial Engineering

journal homepage: www.elsevier.com/locate/caie

Co-op advertising and pricing models in manufacturer–retailer supply chains

Jinxing Xie*, Alexandre Neyret

Department of Mathematical Sciences, Tsinghua University, Beijing 100084, China

ARTICLE INFO

Article history:
Received 28 August 2007
Received in revised form 12 May 2008
Accepted 31 August 2008
Available online 12 September 2008

Keywords:
Co-op advertising
Pricing
Supply chain
Game theory

ABSTRACT

Cooperative (co-op) advertising plays a significant role in marketing programs in conventional supply chains and makes up the majority of promotional budgets in many product lines for both manufacturers and retailers. Nevertheless, most studies to date on co-op advertising have only assumed that the market demand is only influenced by the advertising level but not in any way by the retail price. That is why our work is concerned with co-op advertising and pricing strategies in distribution channels consisting of a manufacturer and a retailer. Four different models are discussed which are based on three non-cooperative games (i.e., Nash, Stackelberg retailer and Stackelberg manufacturer) and one cooperative game. We identify optimal co-op advertising and pricing strategies for both firms mostly analytically but we have to resort to numerical simulations in one case. Comparisons are then made about various outcomes, especially the profits, for all cases. This leads to consider more specifically the cooperation case in which profits are the highest for both the retailer and the manufacturer, and how they should share the extra joint profit achieved by moving to cooperation. We solve this bargain problem using the Nash bargaining model.

1. Introduction

Consider a distribution channel consisting of a manufacturer and a retailer. In the absence of cooperation, channel members determine their decision variables independently and non-cooperatively. It is well known, in the literature and in practice, that such uncoordinated decision making creates "channel ineffciency". In other words, channel members' marketing strategies are not at their joint profit maximization levels and their profits are inferior to what could be achieved with coordinated behavior. This creates an incentive for cooperation. If channel members agree to cooperate, they negotiate to make joint decisions that eliminate channel inefficiency. We suppose that although channel members cooperate, they remain independent.

Supply chain models have focused on almost all aspects related to pricing, purchasing, production, and inventories. However, models simultaneously dealing with at least two aspects above are complex and sparse. This paper is to identify optimal pricing and co-op advertising strategies for a manufacturer and a retailer in a distribution channel and concerned with their conflict and coordination.

A fundamental task for supply-chain managers is to determine wholesale prices (and/or retail prices). Such a decision is a core theme in the marketing science literature on distribution channels. For example, Jeuland and Shugan (1983, 1988) and Moorthy (1987) identified two commonly used price mechanisms (quantity-discount schemes and two-part tariffs) that can be used to achieve channel coordination. Ingene and Parry (1995a, 1995b, 1998, 2000) explored wholesale pricing behavior within a two-level vertical channel consisting of a manufacturer selling through multiple independent retailers.

Vertical cooperative (co-op) advertising is a coordinated effort by all members in a distribution channel to increase the customer demand and the overall profits. In a typical distribution channel, the upstream member can be a manufacturer of certain product, who often time promotes its product via the national level advertising to build the long-term image or "brand equity" for the company. Meanwhile, the downstream channel member can be a retailer, who usually advertises the product in its local market to induce short-term purchase. Traditionally, co-op advertising is achieved with the upstream manufacturer sharing a portion of the downstream retailer's advertising costs, commonly referred to as the manufacturer's participation rate (Bergen & John, 1997). It is often used in consumer goods industry and plays a significant role in market strategy for many companies. According to Nagler (2006), the total US expenditure of co-op advertising in 2000 was estimated at $15 billion, nearly a four-fold increase in real terms in comparison to $900 million in 1970. The growing importance of co-op advertising motivated us to pay more attention to this subject. Huang and Li (2001, 2002) are two recent papers on co-op advertising, where three one-period co-op advertising models are presented. They explored the role of vertical co-op advertising efficiency with respects to transactions between a manufacturer and a retailer through brand name investments, local advertising expenditures, and sharing rules of advertising expenses. Dynamic

* Corresponding author. Tel.: +86 10 62787812; fax: +86 10 62785847.
E-mail address: jxie@math.tsinghua.edu.cn (J. Xie).

0360-8352/$ - see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.cie.2008.08.017

co-op advertising problems have also discussed, e.g., in Chintagunta and Jain (1992); Jorgensen, Zaccour, and Sigue (2000); Jorgensen, Tiboubi, and Zaccour (2003), and among others.

The literature dealing with both pricing and co-op advertising at the same time is sparse, with some exceptions such as Jorgensen and Zaccour (1999, 2003); Jorgensen, Sigue, and Zaccour (2001). In these papers, the authors proposed a dynamic pricing and co-op advertising problem over time, compared coordinated strategies and profits with uncoordinated ones, and then discussed how a coordinated solution could be sustained over time. The difference between this paper and their work is that we consider pricing and co-op advertising models in one period as Huang and Li (2001) did.

The paper proceeds as follows. The next section presents the assumptions and the basic game-theoretic model. In Section 3, four specific models are discussed, which are based on three non-cooperative games (i.e., Nash, Stackelberg retailer and Stackelberg manufacturer), and one cooperative game. In Section 4, the numerical simulation and comparisons between the different scenarios are presented. A bargain problem is identified in Section 5. Section 6 summarizes the findings from the research and proposes future research directions.

2. Assumptions and the basic model

Consider a single-manufacturer–single-retailer channel in which the manufacturer sells certain product only through the retailer, and the retailer sells only the manufacturer's brand within the product class. Decision variables for the channel members are their advertising efforts, their prices (manufacturer's wholesale price and retailer's retail price) and the co-op advertising reimbursement policy. Denote by a and q, respectively, the retailer's local advertising level and the manufacturer's national advertising investment. The consumer demand function $V(a,q,p_R)$ depends on the retail price p_R and the advertising levels a and q in a multiplicatively separable way like in Jorgensen and Zaccour (1999), i.e.,

$$V(a,q,p_R) = g(p_R)S(a,q),$$

where $g(p_R)$ is linearly decreasing with respect to p_R, and $S(a,q)$ is the function that Huang and Li (2001) proposed to model advertising effects on sales in a static way. That is,

$$V(a,q,p_R) = g(p_R)S(a,q) = (\alpha - \beta p_R)\left(A - \frac{B}{a^\gamma q^\delta}\right).$$

The parameters $\alpha, \beta, B, \gamma, \delta$ are positive constants, and $A > 0$ is the sales saturate asymptote. Please note that:

$$V(a,q,p_R) > 0 \Rightarrow p_R < \frac{\alpha}{\beta}.$$

Denote by t the fraction of the local advertising expenditure, which is the percentage the manufacturer agrees to share with the retailer (i.e., the manufacturer's co-op advertising reimbursement policy), and denote by p_M the manufacturer's transfer price to the retailer. Furthermore, denote by c (a positive constant) the manufacturer's unit production cost and by d (a positive constant) the retailer's unit cost incurred in addition to the purchasing cost.

Under these assumptions, the profits of the manufacturer, the retailer and the whole channel can be expressed as follows, respectively:

$$\Pi_M = (p_M - c)(\alpha - \beta p_R)\left(A - \frac{B}{a^\gamma q^\delta}\right) - ta - q, \tag{1}$$

$$\Pi_R = (p_R - p_M - d)(\alpha - \beta p_R)\left(A - \frac{B}{a^\gamma q^\delta}\right) - (1-t)a, \tag{2}$$

$$\Pi_{M+R} = (p_R - c - d)(\alpha - \beta p_R)\left(A - \frac{B}{a^\gamma q^\delta}\right) - a - q. \tag{3}$$

Remark 1. Throughout this paper, the subscript 'M', 'R' and 'M + R' means the parameters corresponding to the manufacturer, the retailer, and the whole system.

Please note that the non-negativity of the retailer's profit implies $p_R > p_M + d > p_M$, the non-negativity of the manufacturer's profit implies $p_M > c$ and the non-negativity of the system profit implies $p_R > c + d$. The last inequality and $p_R < \alpha/\beta$ lead to $\alpha - \beta(c+d) > 0$.

In order to handle the problem in an equivalent but more convenient way, we apply an appropriate (and legitimate according the above inequalities) change of variables as shown below:

$$\alpha' = \alpha - \beta(c+d) > 0,$$

$$p'_R = \frac{\beta}{\alpha'}(p_R - (c+d)) > 0,$$

$$p'_M = \frac{\beta}{\alpha'}(p_M - c) > 0,$$

$$B' = \frac{\alpha'^2}{\beta}B,$$

$$A' = \frac{\alpha'^2}{\beta}A.$$

It is easy to see that

$$p_R < \alpha/\beta \Longleftrightarrow \beta(p_R - (c+d)) < \alpha - \beta(c+d) \Longleftrightarrow \frac{\beta(p_R - (c+d))}{\alpha - \beta(c+d)} < 1 \Longleftrightarrow p'_R < 1.$$

Besides, the condition $p_R > p_M + d$ also implies that $p'_R > p'_M$.

Under these redefinitions for variables, the profit functions in (1)–(3) can be rewritten as:

$$\Pi_M = p'_M(1-p'_R)\left(A' - \frac{B'}{a^\gamma q^\delta}\right) - ta - q,$$

$$\Pi_R = (p'_R - p'_M)(1-p'_R)\left(A' - \frac{B'}{a^\gamma q^\delta}\right) - (1-t)a,$$

$$\Pi_{M+R} = p'_R(1-p'_R)\left(A' - \frac{B'}{a^\gamma q^\delta}\right) - a - q.$$

A final change of variables $q' = q/B'^{\frac{1}{\gamma+\delta+1}}, a' = a/B'^{\frac{1}{\gamma+\delta+1}}, \Pi' = \Pi/B'^{\frac{1}{\gamma+\delta+1}}$ leads to the following expressions for the manufacturer's, the retailer's and the whole channel's profits:

$$\Pi'_M = p'_M(1-p'_R)\left(\frac{A'}{B'^{\frac{1}{\gamma+\delta+1}}} - \frac{1}{a'^\gamma q'^\delta}\right) - ta' - q', \tag{4}$$

$$\Pi'_R = (p'_R - p'_M)(1-p'_R)\left(\frac{A'}{B'^{\frac{1}{\gamma+\delta+1}}} - \frac{1}{a'^\gamma q'^\delta}\right) - (1-t)a', \tag{5}$$

$$\Pi'_{M+R} = p'_R(1-p'_R)\left(\frac{A'}{B'^{\frac{1}{\gamma+\delta+1}}} - \frac{1}{a'^\gamma q'^\delta}\right) - a' - q'. \tag{6}$$

For simplicity, hereafter we remove the superscript (') from the above expressions throughout the paper (the only exception is in Section 4.1 where we will discuss how to set these parameters approximately).

3. The four game scenarios

3.1. Nash game

When the manufacturer and the retailer have the same decision power, they simultaneously and non-cooperatively maximize their own profits. This situation is called an Nash game and the solution provided by this structure is called the Nash equilibrium.

Specifically, the manufacturer's decision problem is