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CONCEPTUAL/THEORETICAL PAPER

# Cooperative advertising, pricing strategy and firm performance in the e-marketing age

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**Abstract** Cooperative advertising plays a strategically important role in marketing programs. In this paper, we use a game theoretical model to study not only cooperative advertising but also pricing strategy in a manufacturer—e-retailer supply chain with the consideration of product categories. First, two cooperative advertising models (the leader-follower Stackelberg and the strategic alliance) are established and analyzed. We then compare the two models to develop some important theories and managerial insights. Furthermore, we utilize a bargaining model to implement profit sharing and determine the manufacturer's participation rate for cooperative advertising in the channel coordination of strategic alliance. Based on our results, we derive optimal market strategies and identify probable paths of future research.

**Keywords** E-marketing · Cooperative advertising · Product categories · Channel coordination · Pricing strategy · Marketing research

## Introduction

The surge in e-commerce over the past two decades has significantly reshaped supply chain management and given businesses an unprecedented marketing opportunity. According to ComScore Networks, online sales of U.S. products in 2007 reached $136.4 billion, marking a 20% increase over 2006's $102.1 billion, and will grow to $176.9 billion in 2010 (http://www.internetretailer.com/internet/marketing-conference/45281-online-retail-spending-rises-20-1227-billion-2007-comscore-says.html). According to MarketingVox, European online sales are to reach 323 billion euros in 2011 ($407 billion) (http://www.marketingvox.com/european-e-commerce-to-reach-323-billion-euros-in-2011-032147/). E-marketing has become an increasingly prevalent form of channel organization throughout the business world. As a result, channel coordination through cooperative advertising between the e-retailer and its manufacturer has significantly increased in importance.

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Cooperative advertising has been used by numerous industries for decades and continues to play a key promotional role for many manufacturers, retailers and retail customers (Huang and Li 2001; Li et al. 2002; Huang et al. 2002). In 1987, cooperative advertising expenditures of U.S companies were estimated at $10 billion (Somers et al. 1990). More recently, about $50 billion was spent on cooperative advertising (http://advertising.suite101.com/article.cfm/coop_ advertising programs). This increase in spending volume and the overall increase in the significance of cooperative advertising has motivated us to explore more research for the role and use of cooperative advertising in practice.

Advertising plays a strategically important role in stimulating consumer demand. A manufacturer's national advertising campaign is intended to create favorable product attitudes and to influence potential consumers to purchase its product. On the other hand, a retailer's advertising campaign usually is intended to increase retail sales (Houk 1995; Huang et al. 2002). Cooperative advertising is an arrangement whereby the retailer advertises the manufacturer's product while the manufacturer pays a percentage of the e-retailer's advertising expenditure, a payment known as the "participation rate" (Bergen and John 1997). Cooperative advertising helps retailers offer creative promotions that they normally wouldn't undertake without manufacturer support. In the absence of cooperative advertising, the retailer typically allocates less to its advertising budget than the amount that is optimal from the manufacturer's point of view (Bergen and John 1997). By assuming the cost of the retailer's advertising, the manufacturer can strengthen the image of its product and stimulate sales at the retail level to optimize its profit. Thus, cooperative advertising is strategically important in the channel coordination of the manufacturer and retailer.

The nature of cooperative advertising makes it a popular subject for game theoretical analysis. For example, Dant and Berger (1996), Bergen and John (1997), Kim and Staelin (1999), Huang and Li (2001), Li et al. (2002), Huang et al. (2002), and Karry and Zaccour (2006) have explored the role of cooperative advertising in channel coordination through the game theoretical model. However, in their studies, little discussion has been given to pricing strategy, even though pricing is a significant factor in the channel coordination of the manufacturer and retailer.

Various mechanisms for the channel coordination of the manufacturer and retailer through pricing have been proposed. For example, Jeuland and Shugan (1983) show that quantity discount is one effective mechanism to achieve channel coordination. Another early work, by McGuire and Staelin (1983), studies the strategic importance of product substitutability in a duopoly where each of two manufacturers sells its products through a single exclusive retailer. McGuire and Staelin (1983) recommend that if the degree of product substitutability is high, it is better to sell through competing retailers, otherwise selling through a company-owned store is recommended. Gerstner and Hess (1995) propose another coordinating mechanism, price discount, which improves total channel profit. On the other hand, coordination may not be in the interest of the manufacturer, especially when competition exits between retailers (Ingene and Parry 1995). Iyer (1998) examines how manufacturers should coordinate channel distribution when two retailers compete under price and non-price attributes. He concludes that neither quantity discounts nor a menu of two-part tariffs are sufficient to coordinate such a channel. Raju and Zhang (2005) show that a menu of two-part tariffs can coordinate a dominant retailer channel but a menu of two-part tariffs is not always profitable for the manufacturer; only when the dominant retailer is sufficiently dominant is a menu of two-part tariffs a better choice than a quantity discount. Koulamas (2006) conducts a theoretic study to show that manufacturers and retailers can implement a revenue-sharing policy to achieve channel coordination effectively. All of these studies, however, focused solely on the pricing factor, and did not address the strategic role that cooperative advertising plays in the channel coordination of the manufacturer and retailer.

In general, there has been a scarcity of models that deal simultaneously with more than one aspect of channel coordination in the manufacturer—e-retailer supply chain. Our model deals with pricing and advertising strategies simultaneously in channel coordination, as both are significant factors of market demand and resultant profits for manufacturer and e-retailer. Furthermore, we also address the strategic role product category plays on cooperative advertising and pricing strategies.

In this study, we consider a simple supply chain, which consists of one manufacturer and one e-retailer. The manufacturer and e-retailer make mutually beneficial decisions by utilizing a cooperative advertising strategy. We examine the cooperative advertising schemes and the pricing strategies with the product web-fit factor incorporated into the following marketing models: the leader-follower Stackelberg model (Stackelberg 1934) and the strategic alliance. The product web-fit factor explores the compatibility of the product with e-marketing based on the characteristics of the product and the nature of e-marketing. Furthermore, we compare the two models to determine optimum strategies, discuss how to divide the increased profit gain, and determine the manufacturer's participation rate for cooperative advertising through a bargaining model. Then, based on our results, we develop optimal policies and derive significant marketing strategies for supply chain players.

The rest of the paper is organized as follows: a model framework is presented in the section "Model framework". In the section "The Stackelberg and strategic alliance models", two cooperative advertising models—the leader-follower Stackelberg and the strategic alliance—are established and analyzed, and then the main results are compared and the optimal marketing strategies are derived. Section "Profit sharing and bargaining results" addresses how to implement profit sharing and how to determine the manufacturer's participation rate for cooperative advertising. We present some numerical examples in the section "Numerical examples". Conclusions and managerial implications are presented in the section "Conlusions and managerial implications". All relevant proofs are given in the Appendices for clarity of exposition.

## Model framework

We consider a manufacturer—e-retailer supply chain in which the manufacturer's new product is sold through an e-retailer. The e-retailer's sales response volume is assumed to be affected mainly by the manufacturer's national advertising, e-retailer's cooperative advertising, and e-retailer's retail price.

As in Huang et al. (2002), we assume that both the manufacturer's national advertising and e-retailer's cooperative advertising influence sales in different ways. Thus we have

$$G = \lambda r\sqrt{A} + k\sqrt{Q} \quad (1)$$

where $G$ represents the consumer demand resulting from the manufacturer's national advertising expenditure and e-retailer's cooperative advertising expenditure. $A$ denotes the e-retailer's cooperative advertising expenditure. $Q$ denotes the manufacturer's national advertising expenditure. The parameters λ and $k$ measure the efficiencies of the e-retailer's cooperative advertising and manufacturer's national advertising in stimulating sales, respectively. The larger the value of λ ($k$), the more efficient the e-retailer's cooperative advertising (manufacturer's national advertising) is in stimulating sales. There is some substantial literature which examined the effectiveness of advertising on sales (see, for example, Little 1979; Dant and Berger 1996; Stewart and Pavlou 2002). $r$ ($0<r\leq 1$) represents the degree of the differentiation between the e-retailer's cooperative advertising and the manufacturer's national advertising. The larger the degree of the differentiation, the smaller the overlapping or interactive effect of the e-retailer's cooperative advertising and the manufacturer's national advertising, and the more efficient the e-retailer's cooperative advertising in stimulating sales. Note that when r=1, the overlapping or interactive effect of the e-retailer's cooperative advertising and the manufacturer's national advertising is a minimum. That means the e-retailer's cooperative advertising efficiency is maximized.

When a firm sells its product through e-marketing, the product category plays a strategic importance for online sales (Lal and Sarvay 1999; Kacen et al. 2002; Kwak et al. 2002; Korgaonkar et al. 2006; Kumar and Ruan 2006). This factor $\theta$ represents the product web-fit, which is the compatibility of the product with e-marketing based on the characteristics of the product and the nature of e-marketing. $\theta$ ranges from zero to one, where zero represents no compatibility with e-marketing and one represents complete compatibility with e-marketing. In a similar vein, Balasubramanian (1998) assumes that product web-fit varies across product categories. Kacen et al. 2002 (Table 1) further show that product web-fit, based on empirical analysis of data, turns out to be less than one for many product categories.

Consumer valuation of the product is $v$, when this product can be physically inspected and the customer can take possession straight away. Since the product purchased through an e-retailer at a price $p$ can only be virtually inspected and the possession and gratification of consumers is delayed, consumer valuation of the product is $\theta v (\theta v \leq v)$ in the e-market. Therefore, in this market, all consumers with valuations in the interval [p, $\theta v$] (i.e., $\theta v$ is greater than the price to be paid) will buy this product. As in Chiang et al. (2003), we have the consumer demand $d$ for this product at the e-market as the following:

$$d = \theta v - p,\ 0 < p < \theta v, 0 < \theta \leq 1 \quad (2)$$

By combining (1) with (2), we can characterize the one period expected demand $D$ as follows.

$$D = (\theta v - p)(\lambda r\sqrt{A} + k\sqrt{Q}), 0 < p < \theta v, 0 < \theta \leq 1 \quad (3)$$

For analytic simplicity, we assume that product value $v$ is uniformly distributed within the consumer population from 0 to 1, with a density of 1. Thus, the demand function can be rewritten as follows. All parameters in our model are positive.

$$D = (\theta - p)\left(\lambda r\sqrt{A} + k\sqrt{Q}\right), 0 < p < \theta, 0 < \theta \leq 1 \quad (4)$$

## Profit functions

The manufacturer has a unit cost of production $c_1$ and the e-retailer has a unit of handling cost $c_2$. To simplify exposition, we assume $c_1 = c_2 = 0$ without affecting the basic results. Therefore, in a given period, when the manufacturer declares a participation rate $t$ for the e-retailer's cooperative advertising, the profit for the manufacturer can be expressed as follows:

$$\pi_m = wD - tA - Q \quad (5)$$

Similarly for the e-retailer, the profit can be expressed as follows:

$$\pi_r = (p - w)D - (1 - t)A \quad (6)$$

The total profit for the whole supply chain is as follows:

$$\pi_T = \pi_m + \pi_r = pD - A - Q \quad (7)$$

**Table 1** Product web-fit $\theta$ for web-based e-market

| Category | Book | Shoes | Toothpaste | DVD player | Flowers | Food items |
|---|---|---|---|---|---|---|
| Acceptance | 0.904 | 0.769 | 0.886 | 0.787 | 0.792 | 0.784 |

The above values come from Kacen et al.'s research in 2002

Where $0 < w < p < \theta$, $w$ is the manufacturer's wholesale price, $tA$ is the e-retailer's advertising cost shared by the manufacturer, and $0 \le t \le 1$.

## The Stackelberg and strategic alliance models

### The Stackelberg model (S)

The Stackelberg model is an economic strategic game in which the leader firm moves first and then the follower firm moves sequentially to maximize their respective profits. Industry examples of the Stackelberg model in the real world abound. For example, General Electric and its retailers, and appliance retailers and their manufacturers all behave according to the Stackelberg model (Bergen and John 1997). In this paper, our Stackelberg model leader is the manufacturer, who acts as the first mover by choosing its wholesale price $w$, its national advertising expenditure $Q$ and cooperative advertising's participation rate $t$ to maximize its own profit $\pi_m$. The e-retailer, acting as the follower, then chooses its optimal retail price $p$ and cooperative advertising expenditure $A$ to maximize its own profit $\pi_r$. Given the above structure, we can obtain the optimal results in Table 2.

From Table 2, we obtain the following proposition. Proofs are given in Appendix 2.

**Proposition 1**: *Under the leader-follower Stackelberg setting,*

(a) *the manufacturer's national advertising $Q^S$ always increases with its efficiency $k$ and the product web-fit $\theta$, respectively, but decreases with the e-retailer's cooperative advertising efficiency $\lambda$.*
(b) *the e-retailer's cooperative advertising $A^S$ increases with its efficiency $\lambda$, the degree of the differentiation $r$, the manufacturer's participation rate $t^S$, and the product web-fit $\theta$, respectively, but decreases with the manufacturer's national advertising efficiency $k$.*
(c) *both the wholesale price $w_s$ and the retail price $p^S$ increase with the manufacturer's national advertising efficiency* k *and the product web-fit $\theta$, respectively, but decrease with e-retailer's cooperative advertising efficiency $\lambda$.*
(d) *the manufacturer's participation rate $t^S$ increases with its national advertising efficiency $k$ and decreases with the e-retailer's cooperative advertising efficiency $\lambda$ but does nothing with product web-fit $\theta$.*

Proposition 1 reveals some important findings and managerial implications. Proposition 1(a) indicates that when the product is more compatible with e-marketing and the national advertising more efficiently promotes the product, the manufacturer would like to invest much more money into its national advertising expenditure to promote this product. Also, it is expected that the manufacturer will decrease its national advertising expenditure as the e-retailer's cooperative advertising is more efficient. The rationale is that the e-retailer is motivated to invest more money into its advertising to promote this product as its cooperative advertising is more efficient. Proposition 1(b) means that when the manufacturer is more willing to share the e-retailer's cooperative advertising costs and the product is more compatible with e-marketing, the e-retailer would like to invest more into its cooperative advertising expenditure. It is also reasonable to expect that when the e-retailer's cooperative advertising efficiency and the degree of the advertising differentiation increase, the e-retailer would like to increase its investment into cooperative advertising; on the other hand, when the national advertising efficiency increases, the e-retailer will decrease its cooperative advertising expenditure since the manufacturer will invest more in

**Table 2** Optimal results in the leader-follower Stackelberg model

| | |
|---|---|
| Wholesale price, $w_S$ | $\frac{4k^2\theta+\lambda^2r^2\theta\sqrt{9+\frac{16k^2(\lambda^2r^2+k^2)}{\lambda^4r^4}}}{9\lambda^2r^2+16k^2}$ |
| Manufacturer's national advertising, $Q^S$ | $\frac{k^2w_S^2(\theta-w_S)^2}{16}$ |
| Retail price, $p^S$ | $\frac{w_S+\theta}{2}$ |
| Manufacturer's participation rate, $t^S$ | $\frac{5w_S-\theta}{3w_S+\theta}$ |
| E-retailer's cooperative advertising, $A^S$ | $\frac{\lambda^2r^2(\theta-w_S)^2(3w_S+\theta)^2}{256}$ |
| Demand, $D^S$ | $\frac{(\theta-w_S)^2\left(\lambda^2r^2(3w_S+\theta)+4k^2w_S\right)}{32}$ |
| Manufacturer's profit, $\pi_m^S$ | $\frac{(\theta-w_S)^2\left(16k^2w_S^2+\lambda^2r^2(3w_S+\theta)^2\right)}{256}$ |
| E-retailer's profit, $\pi_r^S$ | $\frac{(\theta-w_S)^3\left(8k^2w_S+\lambda^2r^2(3w_S+\theta)\right)}{128}$ |
| Total profit, $\pi_r$ | $\frac{(\theta-w_S)^2\left(16k^2w_S\theta+\lambda^2r^2\left(3w_S^2+10w_S\theta+3\theta^2\right)\right)}{256}$ |

Proofs are given in Appendix 1

national advertising to promote this product. These results in Proposition 1(c) show that when national advertising more efficiently promotes the product, the manufacturer would like to invest more into national advertising, which leads to higher costs for the manufacturer. Then the manufacturer has to charge a higher wholesale price to the e-retailer, so the retail price increases too. Additionally, Chiang et al. (2003) show that both wholesale price and retail price increase with increased product web-fit when the product is sold through e-market. On the other hand, when the e-retailer's cooperative advertising is more efficient, the manufacturer will decrease its investment in national advertising, which leads to lower costs for the manufacturer, resulting in a lower wholesale price and a lower retail price. Proposition 1(d) reveals that when the national advertising more efficiently promotes the product, the manufacturer would like to share more of the e-retailer's cooperative advertising cost. It is also intuitive that the manufacturer has a lower participation rate for the e-retailer's cooperative advertising as the e-retailer has a larger share of sales resulting from the e-retailer's higher advertising efficiency.

### The strategic alliance (A)

In this section, we analyze the strategic alliance case, where two supply chain players maximize their joint profits. This case is of particular interest currently because we see more and more instances (e.g., Lenovo Group Ltd. with Best Buy Co., Coca-Cola Inc. with Wal-Mart Stores Inc. (Rosenbloom 2003; Yan and Pei 2009)) where two supply chain players are entering into a strategic alliance for the purpose of benefiting from each other's resources, capabilities, and core competencies.

In recent marketing and economics literature, it has become a norm to include the case of the strategic alliance for two important reasons. One is that strategic alliances are used as a base case to show the profit reduction when supply chain players act independently. The second reason is that in the real business world, supply chain players treat strategic alliances as one of their major trusts in setting their operation strategies. When the manufacturer and the e-retailer are in a strategic alliance, the manufacturer and the e-retailer effectively act like a single firm. Thus, they maximize a single objective function, which is the sum of the two profit functions, as follows:

$$\pi_A = w_A D - tA - Q + (p - w_A)D - (1-t)A$$
$$= pD - A - Q \quad (8)$$

Subject to $0 \leq t \leq 1, A \geq 0, Q \geq 0$, where $\pi_A$ is the total supply chain profit in the strategic alliance. Given the above structure, we obtain the optimal results summarized in Table 3.

**Table 3** Optimal results in the strategic alliance

| | |
|---|---|
| Manufacturer's national advertising, $Q^A$ | $\frac{k^2\theta^4}{64}$ |
| Retail price, $p^A$ | $\frac{\theta}{2}$ |
| E-retailer's cooperative advertising, $A^A$ | $\frac{\lambda^2 r^2\theta^4}{64}$ |
| Demand, $D^A$ | $\frac{\theta^3(\lambda^2r^2+k^2)}{16}$ |
| Total profit, $\pi_A$ | $\frac{\theta^4(\lambda^2r^2+k^2)}{64}$ |

Proofs are given in Appendix 3.

We have seen in Proposition 1 that under the leader-follower Stackelberg setting, the manufacturer's national advertising expenditure always increases with its efficiency $k$ and the product web-fit $\theta$, and the e-retailer's cooperative advertising expenditure always increases with its efficiency λ, the degree of the advertising differentiation $r$ and the product web-fit θ. We also see that the retail price always increases with the product web-fit $\theta$. It turns out that these results hold for the strategic alliance as well.

### Analysis of the two models

In this subsection, we will derive the differences between the optimum strategies in the two cases and develop some managerial guidelines. Table 4 shows the expressions for advertising, prices and profits for the two cases.

In the following proposition, we derive some important results regarding the whole supply chain profit and optimum strategies for the manufacturer and e-retailer under the two different models considered above. Proofs are given in Appendix 4.

**Proposition 2**:

(a) *When the manufacturer and the e-retailer form a strategic alliance, the profit for the whole supply chain is higher than when they act independently in a leader-follower Stackelberg setting. Thus,* $\pi_A > \pi_T$.

(b) *The e-retailer's cooperative advertising expenditure in the strategic alliance is higher than the e-retailer's cooperative advertising expenditure in the leader-follower Stackelberg setting. Thus,* $A^A > A^S$.

(c) *The retail price in the strategic alliance is lower than the retail price in the leader-follower Stackelberg setting. Thus,* $p^A < p^S$.

Proposition 2 indicates that a strategic alliance provides a higher profit to the whole supply chain compared to the case of the leader-follower Stackelberg setting. This is to be expected as the strategic alliance coordinates the supply chain better. Also, under the strategic alliance, the retail price is lower than the retail price under the Stackelberg setting, and the e-retailer's cooperative advertising expen-

**Table 4** The equilibrium advertising, price and profit for two models

| | Leader-follower Stackelberg | Strategic alliance |
|---|---|---|
| Manufacturer's national advertising | $\frac{k^2 w_S^2(\theta-w_S)^2}{16}$ | $\frac{k^2\theta^4}{64}$ |
| Retail price | $\frac{w_S+\theta}{2}$ | $\frac{\theta}{2}$ |
| E-retailer's cooperative advertising | $\frac{\lambda^2 r^2(\theta-w_S)^2(3w_S+\theta)^2}{256}$ | $\frac{\lambda^2 r^2\theta^4}{64}$ |
| Total profit | $\frac{(\theta-w_S)^2\left(16k^2 w_S\theta+\lambda^2 r^2\left(3w_S^2+10w_S\theta+3\theta^2\right)\right)}{256}$ | $\frac{\theta^4\left(\lambda^2 r^2+k^2\right)}{64}$ |

Where, $w_S = \frac{4k^2\theta+\lambda^2 r^2\theta\sqrt{9+\frac{16k^2(\lambda^2 r^2+k^2)}{\lambda^4 r^4}}}{9\lambda^2 r^2+16k^2}$

diture is higher than the e-retailer's cooperative advertising expenditure in the Stackelberg setting. The lower retail price and higher cooperative advertising expenditure all increase product demand. Increased revenue due to increased demand will more than offset the decrease in revenue due to lower retail price and increased advertising expenditure. Lower retail price and higher advertising expenditure will have quite a salutary effect on the market performance of the supply chain players. These beneficial effects also create powerful incentives to the supply chain players to form a strategic alliance.

In the next proposition, we examine the effect of product web-fit on the value of the strategic alliance in the channel coordination between the manufacturer and the e-retailer. Based on the analytical results, we obtain the proposition as follows. Proofs are given in Appendix 5.

**Proposition 3:** *The value of the strategic alliance in the manufacturer—e-retailer channel coordination increases with product web-fit θ.*

The result in Proposition 3 is intuitive. The rationale is that the strategic alliance is a more coordinated model than the leader-follower Stackelberg model. Thus, when the product is more compatible with e-marketing, a more coordinated model will return a higher profit to the manufacturer—e-retailer supply chain. Proposition 3 reveals an important managerial guideline. When the product category is strongly compatible with e-marketing, the manufacturer and the e-retailer should actively cooperate with each other to form a strategic alliance under any circumstance. Then the channel coordination will run more efficiently, which leads to higher supply chain profits.

The strategic alliance effectively improves the overall profit of the supply chain of the manufacturer and the e-retailer. However, under the Stackelberg setting, each player determines its profit by making decisions without regard to the impact on the other player. Therefore, neither the manufacturer nor the e-retailer would be willing to accept lower profits in a strategic alliance. Thus, in order to ensure the success of the strategic alliance, an optimal profit scheme is acceptable to both the manufacturer and the e-retailer only if

$$\Delta\pi_m = \pi_m^P - \pi_m^S \geq 0 \quad (9)$$

$$\Delta\pi_r = \pi_r^P - \pi_r^S \geq 0 \quad (10)$$

where $\pi_A = \pi_m^P + \pi_r^P, \pi_m^P$ is the manufacturer's profit in the strategic alliance with an optimal profit scheme and $\pi_r^P$ is the e-retailer's profit in the strategic alliance with an optimal profit scheme.

Thus, we have the proposition as follows. Proofs are given in Appendix 6.

**Proposition 4**: *There exist optimal profit schemes, which can effectively improve the overall profits for both the manufacturer and the e-retailer through a strategic alliance.*

Proposition 4 suggests that there exists at least one optimal profit scheme such that both the manufacturer and the e-retailer will realize more profits through a strategic alliance than they would realize using a leader-follower Stackelberg model. According to (9) and (10), for any optimal profit scheme, $\Delta\pi_m + \Delta\pi_r = \Delta\pi$, where $\Delta\pi = \pi_A - \pi_T$ is defined as the increased profit gain from the strategic alliance. Thus, an advanced coordination mechanism is needed to coordinate the manufacturer and the e-retailer in order to improve the profits of both supply chain players in the strategic alliance. We thus propose an advanced coordination mechanism—profit sharing—to optimize the profit for each supply chain player.

In the next section, we study the profit sharing mechanism that will implement the channel coordination for the manufacturer and the e-retailer.

## Profit sharing and bargaining results

Channel coordination and profit improvement of supply chain players can be achieved by a profit sharing mechanism. In this profit sharing mechanism, the manufacturer receives the amount of $\Delta\pi_m$ of the increased profit gain while the e-retailer receives the remainder $\Delta\pi_r$. Thus, the manufacturer's expected profit and the e-retailer's expected profit are as follows:

$$\pi_m^P = \pi_m^S + \Delta\pi_m \quad (11)$$

$$\pi_r^P = \pi_r^S + \Delta\pi_r \quad (12)$$

$$\Delta\pi = \Delta\pi_m + \Delta\pi_r \qquad (13)$$

Equations (11), (12) and (13) imply that the more increased profit the manufacturer gains, the less increased profit the e-retailer gains, and vice versa. When profit sharing does achieve the desirable incentive structure for channel coordination for a strategic alliance, we need to find a tool to divide the increased profit gain between the manufacturer and the e-retailer. Consequently, the topic in the next section deals with profit bargaining in order to achieve optimal profit for each of supply chain players.

We assume that there is no supply chain player with more bargaining power than the other in the strategic alliance. Therefore, we use the Nash bargaining model (1950) to implement profit sharing and to determine optimal profit schemes. Both supply chain players also are assumed to be uncertain about the increased profit gain, $\Delta\pi$, from the strategic alliance since there always exists an environment of uncertainty in the sales response volume. Suppose both the manufacturer and the e-retailer have preferences for the amount of the increased profit gain, and these preferences are represented by each player's utility function. The manufacturer's utility function of $\Delta\pi_m$ is $\mu_m$ and the e-retailer's utility function of $\Delta\pi_r$ is $\mu_r$. According to the Nash bargaining model (1950), the optimal bargaining profit scheme is obtained by solving the following problem.

$$\text{Max}\, u_m(\Delta\pi_m)u_r(\Delta\pi_r) \qquad (14)$$

We assume that both the manufacturer and the e-retailer are risk averse with the following utility functions:

$$u_i(\Delta\pi_i) = (\Delta\pi_i)^{\frac{1}{b_i}}, i = m, r \qquad (15)$$

Where $0 < b_i < 1, b_m$ is the constant risk aversion function for the manufacturer, and $b_r$ is the constant risk aversion function for the e-retailer.

We substitute Eq. (15) into Eq. (14); the system utility function is as follows:

$$u_m u_r = (\Delta\pi_m)^{\frac{1}{b_m}}(\Delta\pi_r)^{\frac{1}{b_r}} \qquad (16)$$

Thus, profit bargaining is determined by maximizing the system utility function on the set of the acceptable profit scheme. Maximizing $u_m u_r$ subject to the constraint $\Delta\pi_m + \Delta\pi_r = \Delta\pi$ yields

$$\Delta\pi_m = \frac{b_r}{b_m + b_r}\Delta\pi \qquad (17)$$

$$\Delta\pi_r = \frac{b_m}{b_m + b_r}\Delta\pi \qquad (18)$$

Here $\frac{b_r}{b_m+b_r}\Delta\pi$ represents the amount of the increased profit gain that the manufacturer receives and $\frac{b_m}{b_m+b_r}\Delta\pi$ represents the amount of the increased profit gain that the e-retailer receives.

From Eqs. (17) and (18), we can see (a) if the manufacturer has zero risky decision (the manufacturer would not take any risk), then the e-retailer will have all of the increased profit gain and vice versa; and (b) if both the manufacturer and the e-retailer have the same degree of risk aversion or both are risk neutral ($b_m = b_r$), then the manufacturer and the e-retailer will equally divide the increased profit gain. That is, $u_m = \Delta\pi_m = \frac{1}{2}\Delta\pi$. Note that $\Delta\pi_m + \Delta\pi_r = \Delta\pi$, thus $u_r = \Delta\pi_r = \frac{1}{2}\Delta\pi$. Additionally we find (c) if the manufacturer has a higher risk aversion than the e-retailer, the manufacturer will receive less of the increased profit gain, and vice versa. For example, if $b_m > b_r$, then $\Delta\pi_m < \Delta\pi_r$.

Furthermore, because $\Delta\pi_m = \pi_m^P - \pi_m^S$ and $\Delta\pi_m = \frac{b_r}{b_m+b_r}\Delta\pi$.

Thus, the manufacturer's participation rate for cooperative advertising in the strategic alliance is

$$t^A = \frac{(w_A - w_S)(D^A - D^S) + t^S A^S - Q^A + Q^S - \frac{b_r}{b_m+b_r}\Delta\pi}{A^A} \qquad (19)$$

There are several implications about the manufacturer's participation rate in the e-retailer's cooperative advertising. First, $t^A$ is an increasing function of $b^m$, thus a manufacturer with a larger risk version will have a higher participation rate for the e-retailer's cooperative advertising. Second, $t^A$ is an increasing function of $w_A$, thus if the manufacturer charges a higher wholesale price in the strategic alliance, then the manufacturer will share more of the e-retailer's cooperative advertising.

## Numerical examples

While our findings can be derived analytically, the analytical expressions are too complex to provide meaningful insights. Thus we now present some numerical examples to illustrate the effect of changes in product web-fit, $\theta$, on cooperative advertising as well as on the value of the strategic alliance in a manufacturer—e-retailer supply chain. For our numerical examples, the values we used for the various parameters are shown in Table 5. All of values in Table 5 come from simulated firm data.

Figure 1 shows that the cooperative advertising expenditure is positively related to the product web-fit. In other words, the cooperative advertising expenditure always increases with the product web-fit. Also, we observed that the cooperative advertising expenditure under the strategic alliance is higher than the cooperative advertising expendi-

**Table 5** Parameters values and range of values used in our numerical examples

| Parameters | Base values and range of values |
|---|---|
| $k$ | 1.5 |
| $\lambda$ | 1.2 |
| $r$ | 0.8 |
| $b_m$ | 1 |
| $b_r$ | 2 |
| $\theta$ | 0–1 |

ture under the Stackelberg setting. This is exactly matching with what we analytically found in Propositions 1 and 2.

Figure 2 shows that the supply chain players' profits always increase when the product web-fit is stronger. The difference in profit between the cases of the Stackelberg and the strategic alliance reflects the value of the strategic alliance. This profit difference shows that as product web-fit increases (increasing $\theta$), the value of the strategic alliance increases for both the manufacturer and the e-retailer. This result confirms our analytical observations from Propositions 3 and 4.

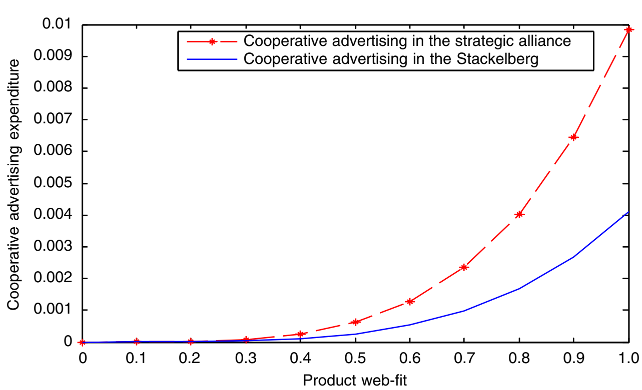


**Figure 1** Cooperative advertising expenditure under different strategies.

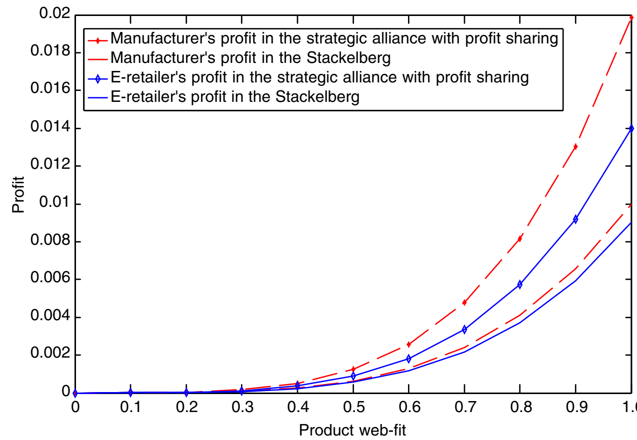


**Figure 2** Supply chain players' profits under different strategies.

## Conclusions and managerial implications

The contributions of this study are both theoretical and substantive in nature. In this paper, we provide a framework for studying the optimal equilibrium pricing policies and cooperative advertising strategies simultaneously in a manufacturer—e-retailer supply chain considering different marketing structures. We derive optimal pricing and cooperative advertising strategies for the supply chain players under the leader-follower Stackelberg model and under the strategic alliance model, then we compare the two models to develop some important theories and managerial insights. Our results indicate that the strategic alliance model achieves higher channel coordination than the leader-follower Stackelberg model: the retail price in the leader-follower Stackelberg model will decrease in the strategic alliance, and the cooperative advertising effort and the whole supply chain profit in the leader-follower Stackelberg model will increase in the strategic alliance. The value of the strategic alliance always increases as the product web-fit increases. Our results further show that equitable profit sharing can ensure the success of a strategic alliance and can effectively improve the profits for each supply chain player. Utilizing the Nash bargaining model (1950), we determine the manufacturer's participation rate for cooperative advertising and determine the equitable division of the increased profit to ensure channel coordination for the strategic alliance. Our numerical examples further illustrate and verify our analytical findings and provide more managerial interpretations and insights.

The findings in our research provide managerial implications for business managers. If the manufacturer and the e-retailer know that their respective profits could be increased by employing these cooperative strategies (i.e., cooperative advertising, profit sharing), both would feel the urge to cooperate with each other to improve channel coordination. Our findings also can be useful for supply chain players by helping them identify the value of a cooperative advertising strategy and a strategic alliance model in their business. These businesses may be able to use the insights from our research to improve their marketing decisions to improve profit.

In today's business environment, supply chain players are increasingly improving their channel coordination (e.g., Berger 1972; Jeuland and Shugan 1983; Weng 1995; Raju and Zhang 2005). Since e-marketing is becoming increasingly common in business today, it is managerially important to develop a coordination mechanism between the e-retailer and its manufacturer. This is an intuition-based conclusion. In our paper, we use mathematical models to show that this intuition can be made objective by employing a cooperative advertising strategy and strategic alliance model. In the business market, Amazon, Overstock, and firms with e-channels (i.e., Kohl's, K-Mart, Wal-Mart, and Barnes & Noble) and their manufacturers can actively apply these strategies to their business and effectively profit from these strategies.

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## Appendix 1

$$D = (\theta - p)\left(\lambda r\sqrt{A} + k\sqrt{Q}\right) \tag{A1}$$

The profit for the manufacturer is as follows:

$$\pi_m = wD - tA - Q \tag{A2}$$

Similarly, for the e-retailer, the profit is as follows:

$$\pi_r = (p - w)D - (1 - t)A \tag{A3}$$

The total profit for the whole supply chain is as follows:

$$\pi_T = \pi_m + \pi_r = pD - A - Q \tag{A4}$$

Taking the derivative of (A3) with respect to $p$ and $A$, respectively, and letting $(\partial\pi_r/\partial p) = 0$ and $(\partial\pi_r/\partial A) = 0$ yields:

$$p^S = \frac{1}{2}(w + \theta) \tag{A5}$$

$$A^S = \frac{\lambda^2 r^2 (\theta - w)^4}{64(1 - t)^2} \tag{A6}$$

Substituting (A5) and (A6) into (A2), then by the differential of $\pi_m$ on w, Q and t, respectively, and letting $(\partial\pi_m/\partial w) = 0$, $(\partial\pi_m/\partial Q) = 0$ and $(\partial\pi_m/\partial t) = 0$, we obtain:

$$w_S = \frac{4k^2\theta + \lambda^2 r^2\theta\sqrt{9 + \frac{16k^2\left(k^2+\lambda^2 r^2\right)}{\lambda^4 r^4}}}{9\lambda^2 r^2 + 16k^2} \tag{A7}$$

$$t^S = \frac{5w_S - \theta}{3w_S + \theta} \tag{A8}$$

$$Q^S = \frac{k^2 w_S^2 (\theta - w_S)^2}{16} \tag{A9}$$

Substituting (A7), (A8) and (A9) into all of the functions, we then obtain all of results listed in Table 2.

## Appendix 2

Because $w_S = \frac{4k^2\theta+\lambda^2 r^2\theta\sqrt{9+\frac{16k^2\left(k^2+\lambda^2 r^2\right)}{\lambda^4 r^4}}}{9\lambda^2 r^2+16k^2}$ and $Q^S = \frac{k^2 w_S^2(\theta-w_S)^2}{16}$, thus it is easy to prove that $\partial Q^S/\partial k > 0$, $\partial Q^S/\partial\theta > 0$ and $\partial Q^S/\partial\lambda < 0$. Similarly, we can easily prove that $\partial A^S/\partial k < 0$, $\partial A^S/\partial\lambda > 0$, $\partial A^S/\partial r > 0$, $\partial A^S/\partial t^S > 0$, $\partial A^S/\partial\theta > 0$; $\partial p^S/\partial\theta > 0$, $\partial w_S/\partial\theta > 0$, $\partial p^S/\partial k > 0$, $\partial p^S/\partial\lambda < 0$, $\partial w_S/\partial k > 0$, $\partial w^S/\partial\lambda < 0$, $\partial w_S/\partial\theta > 0$, $\partial t^S/\partial k > 0$, $\partial t^S/\partial\lambda > 0$ and $\partial t^S/\partial\theta = 0$.

## Appendix 3

$$\text{Because } \pi_A = pD - A - Q \tag{A10}$$

Thus taking the derivative of $\pi_A$ on $p$, $Q$ and $A$, respectively, and letting $(\partial\pi_A/\partial p) = 0$, $(\partial\pi_A/\partial Q) = 0$ and $(\partial\pi_A/\partial A) = 0$, we then obtain:

$$Q^A = \frac{k^2\theta^4}{64}, p^A = \frac{\theta}{2}, A^A = \frac{\lambda^2 r^2\theta^4}{64} \tag{A11}$$

Substituting (A11) into all of the functions, then we obtain all of results listed in Table 3.

## Appendix 4

Because $w_S = \frac{4k^2\theta+\lambda^2 r^2\theta\sqrt{9+\frac{16k^2\left(k^2+\lambda^2 r^2\right)}{\lambda^4 r^4}}}{9\lambda^2 r^2+16k^2}$, we let $g = \frac{k}{\lambda r}$, then we have $w_S = \frac{4g^2\theta+\theta\sqrt{9+16g^2(1+g^2)}}{9+16g^2}$, $\partial w_S/\partial g > 0$ and g > 0, thus we obtain $\frac{\theta}{3}|_{g=0} \le w_S \le \frac{\theta}{2}|_{g\to\infty}$. Also, $\pi_T = \frac{(\theta-w_S)^2\left(2\left(5+8g^2\right)w_S\theta+3w_S^2+3\theta^2\right)}{256}$, thus we obtain $\partial\pi_T/\partial w_S < 0$. $\pi_T < \pi_T|_{w_S=\theta/3} = \frac{\theta^4\left(5+4g^2\right)}{1296}$. Furthermore, $\pi_A = \frac{\theta^4\left(1+g^2\right)}{64}$.

Thus, it is easy to prove that $\pi_A > \pi_T|_{w_S=\theta/3}$. Thus, we have $\pi_A > \pi_T$.

By the same way, we can prove that $A^A > A^S$, $p^A < p^S$ and $D^A > D^S$.

Thus, Proposition 2 is proved.

## Appendix 5

Let $f = \frac{4g^2+\sqrt{9+16g^2(1+g^2)}}{9+16g^2}$, thus $w_S = f\theta$.

Thus, $\pi_T = \frac{\theta^4(1-f)^2\left(2f\left(5+8g^2\right)+3f^2+3\right)}{256}$ and $\pi_A = \frac{\theta^4\left(1+g^2\right)}{64}$,

So $\partial(\pi_A - \pi_T)/\partial\theta = \frac{\theta^3\left(4\left(1+g^2\right)(1-f)^2\left(2f\left(5+8g^2\right)+3f^2+3\right)\right)}{64} > 0$.

Thus, Proposition 3 is proved.

## Appendix 6

If the profit sharing is successful, the acceptable schemes to the manufacturer and the e-retailer respectively are:

$$\Delta\pi_m = \pi_m^P - \pi_m \geq 0$$

$$\Delta\pi_r = \pi_r^P - \pi_r \geq 0$$

From Appendix 4, we know $\pi_A > \pi_T = \pi_m^S + \pi_r^S$.

Thus, we have $\pi_m^P + \pi_r^P = \pi_A > \pi_m^S + \pi_r^S$.

Therefore, Proposition 4 is proved.

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