Automatica 45 (2009) 601–610

Contents lists available at ScienceDirect

Automatica

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

Integrated marketing communications in markets with uncertainty and competition☆

Ashutosh Prasad, Suresh P. Sethi *

The University of Texas at Dallas, Richardson, TX 75080, USA

ARTICLE INFO

Article history:
Received 27 November 2007
Received in revised form
30 April 2008
Accepted 12 September 2008
Available online 19 December 2008

Keywords:
Advertising
Dynamics
Budgeting
Integrated Marketing Communications
Uncertainty
Optimization

ABSTRACT

Firms frequently utilize multiple communications instruments as part of their marketing campaign. Interactions between these instruments suggest that firms should apply Integrated Marketing Communications (IMC) to benefit from the synergies. We review different IMC models and then present a stochastic IMC model for which explicit closed-loop solutions of the optimal advertising and market share are obtained. This enables us to understand the role of firm and market parameters such as synergy on the optimal advertising budget and allocation. For the proposed and existing IMC models, we show that the budget and allocation decisions can be made independently, greatly simplifying the implementation of IMC. We also show that there is an optimal long-run market share that the firm should try to maintain through appropriate use of IMC. Finally, the model and results are generalized to multiple (>2) instruments and multiple competitors.

1. Introduction

Firms frequently utilize multiple communications instruments, for example, advertising through multiple media outlets such as TV and print (Jagpal, 1981; Naik & Raman, 2003), concurrent advertising and promotion (Naik, Raman, & Winer, 2005), and concurrent advertising and detailing (Chintagunta & Vilcassim, 1994; Fruchter & Kalish, 1998; Gatignon & Hanssens, 1987; Gopalakrishna & Chatterjee, 1992). Empirical research has shown that the effects of these instruments are not independent of each other. For example, Naik and Raman (2003) report strong support for a positive interaction between print and television advertising on the sales of Dockers Khaki pants.Gopalakrishna and Chatterjee (1992) estimate the interaction of advertising and personal selling using data from an electric cables firm and also find a significant positive effect.

Interaction between the instruments of the communications mix targeted at the same market segments creates synergy — an increase in the effectiveness of each instrument due to the presence of the other instruments. In other words, the combined effect of a communications mix is greater than the sum of the parts (Naik & Raman, 2003). The presence of synergy should ideally lead firms to use Integrated Marketing Communications (IMC) (Schultz, 1993). IMC can be defined as the strategy of coordinating advertising, personal selling, sales promotion, public relations, and other promotional activities, with the goal of providing clarity, consistency, and maximum communications impact (Schultz, 1993). Practically, a company might place all its media decisions under one agency to allow for coordination and consistency between brand messages.

From a budgetary standpoint, IMC requires not only determining the total communications budget but also the allocation of the budget among different instruments, including the different media or the vehicles within media. For example, a salesperson whose company and products are well known is likely to get a better response. A firm may spend too little on advertising if this interaction effect is ignored. Absent IMC, not just over-advertising (Aaker & Carman, 1982) but also wrong allocation of the communications mix could take place (Gopalakrishna & Chatterjee, 1992). Research shows that proper allocation of advertising across media and products can have a bigger impact on profit than the level of the total ad budget (Doyle & Saunders, 1990). Thus, the research issues we consider are to determine optimal IMC budgeting over time, the optimal dynamic allocation to different communications instruments, and the dependence of these decisions on firm and market characteristics.

Despite the importance of IMC, analytical study has only recently begun to take off, because the interaction effects and

☆ This paper was not presented at any IFAC meeting. This paper was recommended for publication in revised form by Associate Editor Pirooz Vakili under the direction of Editor Berç Rüstem.

* Corresponding author. Tel.: +1 972 883 6245; fax: +1 972 883 5905.
E-mail addresses: aprasad@utdallas.edu (A. Prasad), sethi@utdallas.edu (S.P. Sethi).

0005-1098/$ – see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.automatica.2008.09.018

dynamics tend to make these models difficult to analyze. In this paper we propose an IMC model where the firm makes two advertising spending decisions that are synergistic. The model is tractable even under random disturbances. We provide explicit, closed-loop solutions of the optimal advertising spending decisions and market share. Comparative statics are presented. The analysis leads to a discussion of the impact of synergies on the total advertising budget and allocation among the instruments. Part confirms existing results and part provides new answers. We find that there is an optimal, long-run market share that the firm should try to maintain and it should reduce deviations from this caused by share decay and randomness through appropriate use of IMC.

We then extend the model to multiple (>2) instruments and show that the insights are unaffected. A general result is obtained that encompasses many IMC models in the literature, showing that allocation and budgeting decisions can be made separately. This result simplifies the application of IMC effects and enables us to extend the analysis to the situation with multiple competitors where the competing firms adopt IMC strategies.

The remainder of the paper is organized as follows. In Section 2 we survey relevant background literature on IMC. Section 3 builds on this information to conceptualize the model. In Sections 4 and 5 we provide the analysis, followed by an illustration and discussion. In Section 6 we extend the analysis to the case where there are more than two media and more than one firm. Section 7 concludes the paper along with suggestions for future research. Proofs of all results are in the Appendix.

2. Literature review

We examine advertising budgeting and allocation decisions in the presence of multiple instruments (synonymously, channels, vehicles, or media). The sales response approach to advertising has been studied by many researchers (Assmus, Farley, & Lehmann, 1984; Vakratsas, Feinberg, Bass, & Kalyanaram, 2004). Due to the carryover effect of advertising, optimal advertising budgets are obtained using dynamic optimization techniques (Erickson, 2003; Jorgensen & Zaccour, 2004). In the presence of multiple advertising instruments, one approach may be to select the best among them (Buratto, Grosset, & Viscolani, 2006). Not many models have considered advertising in them simultaneously (Feichtinger, Hartl, & Sethi, 1994). We review these models in this section.

We begin by recalling the model of Vidale and Wolfe (1957) that relates sales to advertising in the following manner:

$$\mathrm{d}x(t)/\mathrm{d}t = \rho u(t)(1-x(t)) - \delta x(t), \quad x(0) = x_0, \tag{1}$$

where $x(t)$ is the sales rate (expressed as a fraction of the total market) at time t, $u(t)$ is the advertising expenditure rate, ρ is a response constant and δ is a market share decay constant. The parameter ρ determines the effectiveness of advertising, while δ determines the rate at which consumers are lost due to product obsolescence, forgetting, and background competition. This formulation has several desirable properties, for example, market share has a concave response to advertising, and there is a saturation level (Little, 1979). Sethi (1973) provides the optimal advertising path for the Vidale–Wolfe model.

Extensions from this baseline model have been made, for example, the Lanchester framework where the decay term is replaced by explicit competitive effects. Notable for our purposes, the Vidale–Wolfe model allows for only one advertising decision. It was extended to two advertising decisions in a duopoly setting by Chintagunta and Vilcassim (1994). This was further extended to multiple advertising decisions in an oligopoly setting by Fruchter and Kalish (1998). The firm's problem and the market share dynamics in their model are given as

$$\begin{aligned} &\max_{u_i} V_i = \int_0^\infty \mathrm{e}^{-rt}\left(m_i x_i(t) - \sum_{j=1}^M u_{ij}^2\right)\mathrm{d}t,\\ &\frac{\mathrm{d}x_i(t)}{\mathrm{d}t} = \sum_{j=1}^M \rho_{ij}u_{ij}(t) - x_i(t)\sum_{n=1}^N\sum_{j=1}^M \rho_{nj}u_{nj}(t),\\ &x_i(0) = x_0^i, \quad i = 1,\ldots,N, \end{aligned} \tag{2}$$

where $i = 1,\ldots,N$ indexes the firms and $j = 1,\ldots,M$ indexes the elements of the communications mix. Note that m_i, $u_i(t)$ and $x_i(t)$ denote the profit margin, the vector of advertising decisions, and the market share of firm i, respectively. Results from the analysis are summarized as follows: (i) The proportion of the budget allocated to any instrument is constant and proportional to the square of that instrument's effectiveness share. (ii) The relative budget allocation between two instruments is equal to the ratio of squared effectiveness parameters of the instruments.

As Naik et al. (2005) point out, however, neither the Chintagunta and Vilcassim (1994) model nor the model of Fruchter and Kalish (1998) consider interaction effects between elements of the marketing mix. Another such model is Buratto and Grosset (2006), which however has the feature that one of the advertising instruments can influence the diffusion term in the sales response.

The model of Naik and Raman (2003) explicitly models the interaction between communications instruments. Their model, based on the Nerlove and Arrow (1962) framework, is

$$\begin{aligned} &\max_{u(t),v(t)} J = \int_0^\infty \mathrm{e}^{-rt}\left(mS(t) - u(t)^2 - v(t)^2\right)\mathrm{d}t,\\ &\frac{\mathrm{d}S(t)}{\mathrm{d}t} = \rho_u u(t) + \rho_v v(t) + ku(t)v(t) - (1-a)S(t). \end{aligned} \tag{3}$$

This can be solved to give

$$\begin{aligned} u^* &= \frac{m(\rho_v km + 2\rho_u(1+r-a))}{4(1+r-a)^2 - k^2m^2},\\ v^* &= \frac{m(\rho_u km + 2\rho_v(1+r-a))}{4(1+r-a)^2 - k^2m^2} \end{aligned} \tag{4}$$

from which it is simple to obtain the ratio of optimal advertising controls u^*/v^* and the total media budget. Furthermore, the analysis extends to a multimedia setting with pairwise interactions. Examination of the expressions shows that: (i) As synergy k increases, advertisers should not only increase the total advertising budget but should also allocate a larger proportion of the budget to the less effective activity. (ii) In the absence of synergy, the media budget should be allocated to various activities in proportion to their relative effectiveness. In the presence of synergy, as carryover a increases, the advertiser should decrease the proportion of budget allocated to the more effective activity.

In the extension paper by Raman and Naik (2004), a stochastic term is added to the dynamics. However, in both models the optimal decisions are constant and do not depend on time or market share. Interaction of any kind between sales and advertising expenditures, present in the Vidale–Wolfe model, is not allowed. However, the results represent a significant step in understanding IMC and the role of synergy.

The paper by Naik et al. (2005) returns to the Lanchester extension of the Vidale–Wolfe model but looks at interaction between price promotions $v_i(t)$ and advertising $u_i(t)$, for $i = 1,\ldots,N$ firms, rather than two advertising media. The model is written below:

$$\begin{aligned} &\frac{\mathrm{d}x_i(t)}{\mathrm{d}t} = (1-x_i(t))f_i - x_i(t)\sum_{j\neq i} f_j,\\ &x_i(0) = x_{i0}, \quad i = 1,\ldots,N,\\ &f_i \equiv \rho_{ui}u_i(t) + \rho_{vi}v_i(t) + k_i u_i(t)v_i(t). \end{aligned} \tag{5}$$