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Interfaces with Other Disciplines

Pulsation in a competitive model of advertising-firm's cost interaction

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ABSTRACT

The literature reveals contradiction between theoretical results (superiority of uniform policy under a concave advertising response function) and empirical results (concavity of the advertising response function and the superiority of a pulsation policy). To reconcile the above difference, this paper offers a resolution based on (1) the concavity of the advertising response function; (2) the convexity of the firm's cost function; and (3) over-advertising. The resolution is reached upon maximizing the net profit per unit time over the infinite planning horizon subject to an exogenous advertising budget constraint. Theoretical results for monopolistic markets are found mostly generalized to competitive markets. A numerical example is introduced to gain more insight into the theoretical findings and an approach is introduced and implemented to empirically assess the shape of a firm's cost function and the advertising policy to be employed.

1. Introduction and related literature

A firm's marketing effort that considerably relies on advertising often requires a commitment of significant amount of resources. Therefore, the issue of whether it is best to adopt a pulsation policy (alternating advertising between high and low levels) or one uniform policy (even-spending of advertising) that costs the same over time continues to be of significant interest.

Sasieni (1971) in his pioneering article shows that with decreasing marginal returns to advertising spending (concave advertising response function), a uniform advertising policy is superior to cyclic policies of the same cost in the long run. However, empirical evidence (Ackoff & Emshoff, 1975; Eastlack & Rao, 1986) suggests that a pulsation advertising policy could be superior to uniform spending over time. Due to the contradiction between theoretical and empirical findings, few models have been published with the purpose of substantiating advertising pulsation. Notable studies in this respect in monopolistic markets are summarized in Table 1. In this regard, Simon and Arndt (1980) and Mantrala (2002) indicate that there is a limited empirical support for a convex advertising response function or an S-shaped one. Sasieni (1989, p.360) mentions that he has not observed the phenomenon of asymmetric response (hysteresis) described in Simon (1982).

Unlike the thoughtful studies reviewed in Table 1 that attempted at reconciling the difference between the theoretical and the empirical findings in the literature through reliance upon certain mechanisms solely within the marketing function, this research offers a novel reconciliation mechanism within the marketing-firm's cost interface. Through analytical proofs, numerical illustrations and empirical analyses, the results indicate the potential superiority of a pulsation policy for monopolistic markets in the presence of concavity in the advertising response function if the firm's total cost function is convex and the firm over-advertises. Consistent with Tull et al. (1986), over-advertising is defined as setting the advertising budget at a level above the unconstrained optimal expenditure that maximizes firm's profit.

Is over-advertising a departure from rationality? The answer to this question is perhaps not. Tull et al. (1986) suggest that advertising managers can afford to over-spend to gain share without much loss in terms of foregone profit (the flat maximum principle). Chintagunta (1993) finds that the flat maximum principle is robust for both static and dynamic duopolies and concluded that over-advertising is justified in good times and under-spending in bad times. Other reasons for over-advertising have been mentioned in the literature. Excess budgets may be simply due to the rote application of percentage-of-sales rules-of-thumb, with the driving ad-sales ratio set too high (Tellis & Weiss, 1995). Aykac, Corstjens, Gautschi, and Horowitz (1989) mention that what appears to be over-spending relative to the optimum budget in a deterministic analysis may, in fact, be a risk-averse management's response to estimation uncertainty. Chemmanur and Yan (2009) and Lou (2014) provide evidence that managers adjust firm

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Table 1
Findings of main monopoly studies substantiating advertising pulsation.

Study	Modeling framework	Planning horizon	Performance measure	Mechanism motivating pulsation
Mahajan and Muller (1986)	Continuous	Finite	Total awareness	Convexity in advertising response function
Sasieni (1971)	Continuous	Finite	Discounted profit	
Mesak and Darrat (1992)	Continuous	Infinite	Average sales rate	
Simon (1982)	Discrete	Finite	Discounted profit	Asymmetric response to high and low levels of advertising
Mesak (1985)	Continuous	Infinite	Average sales rate	
Mesak (1992)	Continuous	Infinite	Average sales rate	
Hahn and Hyun (1991)	Discrete	Finite	Discounted profit	Interaction of fixed and pulsing costs
Feinberg (1992)	Continuous	Infinite	Average undiscounted profit rate	S-shaped advertising response function and exponential-smoothing filter
Naik, Mantrala, and Sawyer (1998)	Continuous	Finite	Total awareness	Message quality/wearout
Bronnenberg (1998)	Discrete	Finite	Average gain in period market share	Markovian market share in response to turning advertising on turning advertising on and off
Mesak and Ellis (2009)	Continuous	Infinite	Average sales rate	Convexity of the product of market potential and advertising response functions
Monopoly model of present study	Continuous	Infinite	Average undiscounted profit rate	Interaction of shape of firm's cost function and advertising budget

advertising, in part, to attract investor attention. The above observations are interesting because the bulk of empirical studies of firms' advertising budgets suggest that most firms over-advertise (Aaker & Carman, 1982; Abraham & Lodish, 1990; Prasad & Sen, 1999).

A few articles have addressed the issue of advertising pulsation in competitive markets. On the theoretical side, Park and Hahn (1991) develop a model of advertising competition in a duopoly that uses discrete-time dynamics and show that pulsing can be superior even when the change in market share is a concave function of advertising. Villas-Boas (1993) and later Freimer and Horsky (2012) show the optimality of pulsing under the assumption that response is governed by certain discrete Markov processes. While Villas-Boas (1993) find that alternating (out-of-phase) pulsing is more profitable than matching (in-phase) pulsing, Freimer and Horsky (2012) show just the opposite. In a series of articles, Mesak and Callaway (1995a,1995b) and Mesak (1999), examine advertising scheduling schemes using a game theoretic approach. These articles find that whether firms involve in a uniform advertising policy or a pulsation counterpart depends on the shape of the advertising response function. On the empirical side while Dube, Hitsch, and Manchanda (2005) and Doganoglu and Klapper (2006) provide support that in many consumer goods competitive markets firms tend to employ advertising pulsation in practice, data provided in Bronnenberg, Kruger, and Mela (2008) and examined by Freimer and Horsky (2012) suggest that competing brands advertise and seize to advertise mostly in-phase.

The firm's total cost represents the sum of the cost of goods sold and selling, general and administrative expenses. The above costs are routinely reported in the financial statements of the business enterprise (details of such costs are found in Section 5). The convexity of total cost is typically found in a firm which uses its production facility intensively, which decreases operating efficiency, thereby resulting in an increase in marginal cost. Also, it arises when multiple production sources are available to the firm and thus it chooses the sources from the cheapest to the most expensive (Kim & Lee, 1988). Eliashberg and Steinberg (1987) cite production and economics literature that employ a convex linear-quadratic cost function. Kim and Lee (1988), however, offer that concave costs become an issue in situations involving economies of scale in the production process, or for a firm operating at a below capacity level.

The closest studies to this research are Mesak and Darrat (1992) for monopolistic markets and Mesak (1999) for oligopolistic markets. Mesak and Darrat's (1992) study as well as the monopolistic version of our model employ a modified version of the Vidale and Wolfe (1957) dynamic advertising response model attributed to Little (1979). Mesak and Darrat (1992), however, do not consider in detail firm's cost in their modeling effort as we do. While Mesak and Darrat (1992) show that a pulsation policy is superior to its uniform counterpart in the presence of convexity in the advertising response function and linearity in the production cost function, the present study demonstrates the potential superiority of a pulsation policy in the presence of concavity in the advertising response function, convexity in the firm's cost function and over-advertising. Whereas Mesak (1999) who only considers linear production cost employs a conventional Lanchester model of combat introduced by Little (1979) that does not include a sales decay constant, the competitive version of our model employs a revised version of the Lanchester model that allows for the presence of a sales decay constant. In particular, our competitive version of the model extends a duopoly model of market share articulated by Wang and Wu (2001) to an oligopolistic setting that deals with sales. While Mesak (1999) shows analytically the superiority of the uniform policy of advertising spending by all rivals, when they have concave advertising response functions, our study demonstrates analytically the potential superiority of advertising pulsation policies of firms when their advertising response functions are concave, but some of the firms have cost functions that are convex and they are over-advertising. In addition, presence and prevalence of convex cost functions are empirically examined for several industries using data related to the 500 Fortune companies.

The present article is concerned with long-term, steady-state response and employs demand functions of rival firms that are deterministic. Huang, Leng, and Parlar (2013) provide a recent review of demand functions in decision models. Hauser and Wernerfelt (1989, p. 393) argue that such a focus is appropriate for long-term strategic decisions involving competition. De Giovanni (2009, p. 556) believes that such orientation is desirable in games that involve multiple players. The study is seen applicable to products in the maturity stage of their product life cycles.

The rest of the paper is organized as follows. The second section outlines the theoretical model in a monopoly. In the third section, a comparison between the uniform advertising policy and alternative pulsation policies is presented and illustrated through a numerical example. The fourth section extends the modeling effort to deal with competitive markets. The fifth section discusses how to empirically assess the shape of the firm's cost function together with the prevalence of its different shapes. The sixth section concludes the paper. To improve exposition, derivation of key formulas, mathematical proofs of eleven theoretical results and issues related to the empirical work are reported in a supplementary companion (Appendices A–E).