Optimal Advertisement Spending in a Duopoly with Incomplete Information

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ABSTRACT

This article presents the relationship between a firm’s advertisement spending and sales in a duopoly when information about the competitors’ advertisement spending is unavailable. The competitive interaction between the firms has been modeled as imperfect information Cournot and Stackelberg games and the conditions for subgame perfect Bayesian Nash equilibrium are presented. The results suggest that when the firms are similar in size and advertisement effectiveness, both firms are better off sharing their advertising plans with each other. On the other hand, when one of the firms is a market leader, the follower may profit from the leader’s advertisement spending and so is better off keeping the leader guessing. A practical approach to estimate the optimum advertisement budget based on the expected values of the competitors’ historic advertising spending is presented as well.

KEYWORDS
Duopoly, Game Theory, Incomplete Information, Optimal Advertisement Spending

1. INTRODUCTION

Firms often use advertisement to inform potential consumers about their products and features and to differentiate themselves from competitors. Such a tactic is a preferred means of competing in a duopoly as it leads to brand building and category growth while activities such as pricing and merchandising usually lead to the erosion of brand equity and potential price wars (Tellis, 2003; Tirole, 1988). However, determining the optimum advertisement budget is important as both low and high investments impact the firm’s profitability. Prior research has established that factors such as the base demand for the products, the firm’s production levels, the sensitivity of the demand to advertisements, and the competitor’s strategies influence the utility of advertisement for a firm (Chakravarti & Janiszewski, 2004; Mohanty, Clements, & Gupta 2018; Sethuraman, Tellis, & Briesch, 2011; Vakratsas & Ambler, 1999), and all these elements need to be considered in developing a firm’s advertisement strategy.

A vast body of literature discusses the optimal advertisement spending strategies for firms under different conditions (Bass, Krishnamoorthy, Prasad, & Sethi, 2005; Chintagunta & Vilkassim, 1992; Eliashberg & Chatterjee, 1985; Jørgensen & Zaccour, 2014; Paetz, 2017; Sasieni, 1989; Sethi, 1977). The literature on game theory-based approaches generally focus on the role that advertisements play in influencing the equilibrium when multiple firms are competing or collaborating. Research analyzing the “vertically integrated” firms focuses on the role of advertisement in coordinating retailers and suppliers (Aust and Buscher, 2014a) while the research analyzing the “horizontal” competition focuses on competition and market share dynamics within a product category (Alston, Freebairn, & James, 2001). Researchers, especially from the field of agriculture economics have also looked at the role

DOI: 10.4018/IJBAN.2018070101
of collaborative advertisements for competing firms (Alston, Freebairn, & James, 2001). However, these models typically assume that perfect information about the competitors’ strategies is available (Aust & Buscher, 2014a, 2014b; Bonatti, Cisternas, & Toikka, 2017). The reality, especially in the horizontal competitive structure, is that a firm is usually unaware of the competitor’s plans while deciding what its future advertisement spending should be. Further, a firm is typically unaware of the competitor’s products costs as well. They are thus faced with incomplete information.

The present study focuses on the horizontal competition between two firms in a duopoly, producing a substitutable good with no information available for the competitor’s future advertisement spending or product costs. Two models of competition—the Cournot, and the Stackelberg models—have been used to capture the different competitive scenarios between firms. We assume incomplete information and derive insights into a firms’ optimal advertisement spending strategies. The models answer questions such as what a firm’s optimal advertisement spending should be, if a firm has any incentive to play the role of a leader in a duopoly, and if information sharing can arise as a solution to the advertisement spending problem.

The paper is organized as follows. The second section outlines the main literature references on game theory models with advertisement spending. The third section presents the proposed game theoretic formulations for a duopoly using our proposed per-unit cost formulation for advertisement spending. The necessary conditions for the existence of Bayesian Nash Equilibriums (BNE) for the Cournot and the Stackelberg models under incomplete information are also derived. The fourth section builds on the BNE solutions to provide a practical approach to making decisions about advertisement spend and production level when faced with imperfect information about the competitors. The main conclusions and future applied work based on the model is presented in the final section.

2. LITERATURE REVIEW

The optimal advertisement spending strategies for firms have been analyzed in multiple domains such as industrial organization, operations research and marketing, and game theoretical models feature prominently in several of these studies (Bass et al., 2005; Naik, Prasad, & Sethi, 2008; Tirole, 1988). Extant research focuses broadly on either vertical or horizontal setups of firms.

2.1. Vertical Setup

Studies focusing on vertical integration and coordination between firms typically look into the bargaining process between the manufacturer and the retailers (Aust & Buscher, 2014a). The concept of cooperation plays a fundamental role in defining the potential incentives and rules for advertising a product. Berger (1972) and later Berger and Magliozi (1992) considered a situation in which a static game of the Stackelberg variety is played between the manufacturer and the retailer with the only decision variable being the level of advertisement spending. The authors assume full information and a linear demand in advertisement and prices and consider three scenarios: (a) the manufacturer as leader, (b) simultaneous decisions by the manufacturer and the retailer, and (c) a joint optimization solution. The results suggest that advertisement spending when the manufacturer and retailer collaborate (i.e., jointly optimize their decisions) yields the lowest advertisement spending and highest aggregated profits. However, the individual profits of the manufacturer are higher if it can be the leader in the bargaining process. The game has been extended to more than one manufacturer and/or retailers (e.g., Ahmadi–Javid & Hoseinpour, 2012; Bergen & John, 1997), and the results have been shown to be consistent in the more complex setups as well. Karray and Zaccour (2007) considered a model that accounts for the multiple manufacturers (brands) and multiple retailers (stores) when a customer can substitute both brands as well as stores. The main findings in this research suggest that the dominant strategy of manufacturers is to offer cooperative advertising programs to mitigate local competition.

Yue, Austin, Wang, and Huang (2006) and later Kunter (2012) introduced nonlinear demand and prices into the analysis with similar results. Yue et al. (2006) analyzed the implications of developing
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