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Decision Support

# Autonomous and advertising-dependent 'word of mouth' under costly dynamic pricing

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ABSTRACT

Autonomous 'word of mouth', as a channel of social influence that is out of firms' direct control, has acquired particular importance with the development of the Internet. Depending on whether a given product or service is a good or a bad deal, this can significantly contribute to commercial success or failure. Yet the existing dynamic models of sales in marketing still assume that the influence of word of mouth on sales is at best advertising-dependent. This omission can produce ineffective management and therefore misleading marketing policies. This paper seeks to bridge the gap by introducing a contagion sales model of a monopolist firm's product where sales are affected by advertising-dependent as well as autonomous word of mouth. We assume that the firm's attraction rate of new customers is determined by the degree at which the current sales price is advantageous or not compared with the current customers' reservation price. A primary goal of the paper is to determine the optimal sales price and advertising effort. We show that, despite costly price adjustments, the interactions between sales price, advertising-dependent and autonomous word of mouth can result in complex dynamic pricing policies involving history-dependence or limit cycling consisting of alternating attraction of new customers and attrition of current customers.



## 1. Introduction

Word of mouth is an essential medium of marketing influence for products and services (Rosen, 2000). With the development of the Internet, *autonomous word of mouth*, which is beyond firms' direct control, has become much more salient (e.g., Moe & Trusov, 2011; Shrihari & Srinivasan, 2012; Yadav & Pavlou, 2014). By portraying a given product or service as either a good or a bad deal, autonomous word of mouth (WOM) can make the difference between commercial success and failure. This is why firms should be aware of the strength of interactions between their products' market value and autonomous WOM when designing pricing and communication strategies.

Nonetheless, the existing dynamic models of sales in marketing assume that the influence of WOM on sales is at best mediated by advertising effort (see Feichtinger, Hartl, & Sethi, 1994; Huang, Leng, & Liang, 2012). As a result, they disregard the role of autonomous WOM and how it can be shaped over time by a product's market value. These omissions can produce ineffective WOM management and therefore misleading pricing and communication policies.

This paper seeks to bridge the gap by introducing a dynamic sales model of a monopolistic firm's product where, as in Gould (1970), advertising-dependent WOM and advertising allow the firm to attract new customers. We extend Gould (1970) by introducing autonomous WOM that does not depend on advertising effort. We further assume that the firm's attraction rate of new customers is determined not by the number of remaining potential customers, as in most marketing models, but by the degree at which the current sales price is advantageous or not, i.e., the price advantage. Price advantage is measured by the difference between the current sales price and a reservation price based on the current customers' maximum willingness to pay to repurchase the product.

The notion of price advantage is closely related to price fairness. Bolton, Warlop, and Alba (2003) found that U.S. consumers assess comparatively higher prices as less fair and comparatively lower prices as more fair. Ferguson, Ellen, and Bearden (2014) showed that price fairness is highest when a price is advantageous and lowest when it is disadvantageous. In addition, greater price unfairness leads to greater intention to spread negative word-of-mouth (see also, for instance, Campbell, 1999; Zeelenberg & Pieters, 2004). In this context, "spreading negative word of mouth is a low-cost action that helps

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buyers cope with their negative feelings of disappointment or regret and prevents other customers in their social network from being exploited" (Xia, Monroe, & Cox, 2004). An illustration of extreme reaction to perceptions of price unfairness is the public relations nightmare endured by Amazon.com when a customer discovered that he was charged a higher price for the same same-title DVDs on the basis of his purchasing history (Adamy, 2000).

Conversely, when the price is advantageous, suspicion of the seller does not come into play and the price is accepted as fair (Ferguson et al., 2014). This latter result is consistent with Grewal, Monroe, and Krishnan (1998) according to which greater perceived transaction value brings about greater perceived acquisition value. Furthermore, "consumers are more likely to experience satisfaction with a shopping experience involving a rebate and, subsequently, are more likely to express intentions to engage word-of-mouth communication about the product" (Hunt, Keaveney, & Lee, 1995).

Through the latter mechanism, a price decrease generates positive WOM, as suggested in Dean (1976) and Nagle, Hogan, and Zale (2011, p. 127) and conjectured in Ajorlou, Jadbabaie, and Kakhbod (2014). An empirical evidence of a link between price reduction and WOM is provided by Godinho de Matos, Ferreira, and Belo (2015). Based on a randomized experiment using movies over Video-on-Demand (VoD) system of a large European telecommunications provider offering triple-play to more than half a million households, the authors show a positive effect of word-of-mouth on the sales of movies in this VoD system, which is particularly large for the movies offered at discounted prices. In fact, 50 percent of the sales attributed to WOM in this VoD system are associated to movies offered at discounted prices. The authors conclude that firms that use social network information to shape promotion campaigns and determine target consumers are likely to perform better.

Overall, the above-mentioned literature suggests two important assumptions, that is, (i) as price disadvantage decreases, the intention to spread negative WOM decreases, and (ii) positive WOM increases with price advantage. Our model makes use of these two assumptions to characterize the optimal pattern of price-induced WOM in a context of costly price adjustments.

A primary goal of the paper is to analyze the optimal trade-off by a monopolistic firm between sales price and advertising effort for a given product, and its implications for dynamic pricing and WOM effectiveness. To address this issue, an optimal control problem is formulated where the attraction of new customers depends both on autonomous and advertising-dependent WOM. Depending on the magnitude of price advantage, the attraction of new customers is reversible and may turn into attrition of current customers, and vice versa. Due to adjustment efforts in production capacity, sales price variations are costly. In this context, the firm has to determine the optimal intertemporal tradeoff between investing in WOM effectiveness and incurring sales price adjustment costs.

The contribution of our paper is twofold. First, we extend the contagion sales models by introducing two important levers that might affect the typical pattern of advertising policies, namely autonomous WOM and price advantage. Second, we show that, despite price rigidity, the interactions between sales price, advertising-dependent and autonomous WOM can result in complex dynamic pricing policies involving history-dependence or limit cycling consisting of alternating attraction of new customers and attrition of current customers.

The paper is organized as follows. In the next section, we review the relevant literature. In Section 3, an optimal control model is formulated where a monopolistic firm seeks to determine the dynamic optimal strategy in terms of advertising and sales price adjustment efforts. In Section 4, we characterize the solution of the problem by qualitative means. Section 5 investigates the model with numerical means, and Section 6 concludes the paper.

## 2. Literature review

Our research lies at the intersection of three literatures, those concerning contagion sales models, autonomous WOM and price advantage.

Dynamic models of sales in a monopoly are usually based on the assumption that the evolution of instantaneous sales over time results from a combination of two kinds of influences: an attraction rate of new customers and an abandon rate of current customers due to forgetting. Dynamic models of sales differ from diffusion models because they rely on the evolution of instantaneous rather than cumulative sales (see Jørgensen & Zaccour, 2004).

Some well-known specifications of these two influences, attraction rate of new customers and abandon rate of current customers, are presented in Table 1, where $s(t) = S(t)/M$ is the sales rate with $S(t)$ the stock of current customers, $M$ the constant market potential, $u(t)$ the advertising effort, $p(t)$ the sales price, $\gamma$, $\varphi$ and $\delta$ positive constants, and $\Theta$, $\Xi$, $\Omega$, $\Phi$, and $\Psi$ positive real functions.

The models above assume that advertising effort is crucial in attracting new customers because it signals the existence of the product (Nelson, 1970). These models divide the existing literature into two streams, depending on whether the influence of WOM on new customers is nonexistent (Vidale, Wolfe, 1957; Sethi, 1973; Sasieni, 1971; Feichtinger, 1982; Feinberg, 2001; Mahajan & Muller, 1986) or at best mediated by advertising effort (Feinberg, 2001; Gould, 1970; Ozga, 1960; Sethi, 1979).

The latter stream of the literature, to which our paper contributes, assumes a contagion process toward new customers based on advertising-dependent WOM that gives rise to history-dependent advertising policies. In the context of a contagion sales model, Gould (1970) was the first to identify multiple long run equilibria, one of them being an unstable focus and the two others saddle points whose basins of attraction are separated by the so-called Skiba threshold (Skiba, 1978). Depending on whether the initial magnitude of WOM (i.e., the initial number of current customers) is above or below the Skiba threshold, it is optimal either to find a trade-off between an increase in sales through advertising effort and the related costs, or to gradually reduce the advertising effort and stop selling the product.

To date, the literature on contagion sales models has disregarded two important intertwined levers that might affect the typical pattern of advertising policies described above: autonomous WOM and price advantage.

Autonomous WOM, as a channel of social influence that is not under the firm's direct control, has recently gained considerable attention in the marketing literature, notably because of the development of online product ratings. Previous research has mainly focused on identifying the consequences and antecedents of WOM.

**Table 1**
Specification of dynamic monopolistic models of sales.

| | Vidale-Wolfe (1957) Sethi (1973) | Ozga (1960) Gould (1970) Sethi (1979) | Sasieni (1971) | Feichtinger (1982) | Mahajan and Muller (1986) | Feinberg (2001) |
|---|---|---|---|---|---|---|
| Attraction rate | $\gamma u(1-s)$ | $\varphi us(1-s)$ | $\Theta(s,u)$ | $\Xi(p,u)$ | $\Omega(u)(1-s)$ | $\Omega(u)\Phi(s)$ |
| Abandon rate | $\delta s$ | $\delta s$ | | $\delta s$ | $\delta s$ | $\Psi(s)$ |