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The impact of pricing policy on sales variability in a supermarket retail context

James W. Hamister, Nallan C. Suresh*

Department of Operations Management & Strategy, School of Management, State University of New York, Buffalo, NY 14260, USA

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Abstract

The bullwhip effect is recognized to be a significant cost driver in supply chains. One of the measures proposed frequently to counter bullwhip effect is price stability, through everyday low pricing (EDLP). However, this study suggests that with an auto-regressive (AR1) demand process, the use of constant, instead of dynamic pricing may result in lower profitability and higher-demand volatility. An optimal price and stocking level policy is developed with normally distributed demand in this study and the model is tested using parameters from a supermarket scanner data set to determine the impact of two pricing policies. The hypothesis that low prior-period demand leads to discounted pricing is also tested and partially supported.

Keywords: Bullwhip effect; Pricing; Supply chain management; Retail industry

1. Introduction

There has been a long-standing belief among the operations management community that certain marketing behavior can adversely affect operational performance. For instance, excessive promotions and price discounting may drive up sales variability and increase cost levels, especially in the upstream stages of the supply chain through the bullwhip effect. This research looks into the issue of pricing behavior to compare one of the proposed solutions to this problem, everyday low pricing (EDLP), to the case of dynamic pricing, when demand can be characterized by an auto-regressive (AR1) process. A model is developed to optimize period price and inventory level for the retail level of the supply chain, drawing on extensions of the infinite period newsvendor problem. This model is tested using parameters extracted from actual scanner data in order to understand the implications of this model under realistic circumstances.

Inventory control has been widely studied in the operations management literature, yet to date little attention has been given to the topic of retail sales variation resulting from inventory control procedures. This research extends the newsvendor model to consider the question of sales variation, which has important supply chain implications in reducing the bullwhip effect, the well-known amplification of variation as orders progress up the supply chain. Reduction in sales variation at the terminal end of

*Corresponding author. Tel.: +716 645 3279; fax: +716 645 5078.
E-mail addresses: jwh4@buffalo.edu (J.W. Hamister), ncsuresh@buffalo.edu (N.C. Suresh).

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the supply chain has the potential to improve the overall efficiency of the upstream suppliers.

This paper is organized as follows. Section 2 reviews the relevant literature with respect to bullwhip effect in supply chains. Section 3 proposes a dynamic model which develops optimal inventory policy decisions when demand can be described as an AR(1) process. Section 4 describes a set of empirically based simulation experiments that are used to test the implications of the theoretical model using data and parameters from a US-based supermarket chain. Section 5 discusses conclusions, limitations, and suggests further research topics.

2. Literature review

The relevant literature for this study is organized into the following topics: inventory control when demand is serially correlated, empirical pricing behavior, and bullwhip effect.

2.1. Inventory control with serial correlation

The operations management literature typically solves inventory and order batching questions based on the assumption that prices are determined exogenously, which can be referred to as the operations approach (OA) (Boyaci and Gallego, 2002). There are, however, interesting instances, such as extensions of the newsvendor problem that solve price and volume decisions simultaneously (Mills, 1959; Federgruen and Heching, 1999; Petruzzi and Dada, 1999). This stream of research establishes optimum period pricing and stock levels. Interestingly, many of these models conclude that optimal price levels are constant, and price does not depend on inventory status when demand is stationary. The intuition behind this result is that the optimal price decision should not depend on stock level or prior sales data. An optimal price in the current period will continue to be the optimal price in the following period independent of the actual sales results in the prior period. Relaxing the assumption of demand independence changes this conclusion. When sales in the current period are correlated with sales in the prior-period, price is positively related to prior-period sales (Maccini and Zabel, 1996).

Stock-out avoidance motives, together with serial correlation in demand has been shown to induce firms to behave so that the variance of production exceeds the variance of sales (Maccini and Zabel, 1996). This concept is applicable under a wide range of circumstances facing firms, including additive as well as multiplicative demand uncertainty, a general form of serial correlation in demand, and whether inventory and shortage costs apply, and whether payment occurs at time of order or delivery. Serial correlation in demand can cause "counter smoothing," which implies production variation exceeding sales variation, increasing the level of bullwhip experienced by upstream suppliers.

Past research has examined the impact of AR(1) demand processes on service levels (Lagodimos et al., 1995), replenishment (Urban, 2000; Lee and Chew, 2005; Disney et al., 2006), and the value of information sharing (Lee et al., 2000; Raghunathan, 2001; Gavirneni et al., 1999). When auto-correlation is ignored, inventory policies generally are suboptimal, resulting in lower levels of customer service, increased inventories and stock outs, as well as suboptimal order levels.

The value of information sharing among supply chain partners is also greater when demand processes are AR(1), which is particularly relevant to the high-tech and grocery sectors (Lee et al., 2000). Interestingly, actual demand information sharing may be less necessary than sharing the nature of the demand function (Raghunathan, 2001), since suppliers may use this information to generate more accurate forecasts without resorting to detailed information sharing.

2.2. Empirical pricing issues

There are a number of potential reasons that retailers experience demand as an AR(1) process. In the strategy literature, the pricing process has been considered as a firm capability (Dutta et al., 2003). The resource-based view of the firm suggests that firms generate rents through value creation and value extraction (Barney, 1991; Peteraf, 1993). Maximizing profits requires the ability to set profit maximizing prices to extract value created; otherwise that value is appropriated by the consumers. Under this stream of research, firms invest in capabilities to optimizing pricing policies in order to extract maximum rents. However, this research also suggests that pricing policies are in practice much more difficult than the economics literature would suggest. Pricing can be complicated by the problem of large numbers of products, cross-price elasticities that are difficult to capture, unknown competitive responses, etc. In summary, pricing