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Strategic inventory: Manufacturer vs. retailer investment

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ABSTRACT

This paper presents a two-period supply chain model under demand induced by selling price and investment effort in the presence of strategic inventory. We compared six different scenarios to identify optimal pricing decisions. An incremental quantity discount contract was applied to verify supply chain coordination. Our findings show that manufacturer-investment efforts cannot always persuade the retailer carrying strategic inventory to maintain harmony among supply chain participants; however, retailer-investment efforts can promote harmony when strategic inventory is used. The retailer's decision to carry strategic inventory is catastrophic from the perspective of supply chain coordination, but benign for the decentralized supply chain.

1. Introduction

In multi-period supply chain environments, retailers carry additional inventories strategically to encourage the manufacturer to reduce the wholesale price in early periods. Anand et al. (2008) were the first to recognize this strategic measure of the retailer. They showed that the retailer's optimal strategy is carrying strategic inventory and that the manufacturer cannot prevent the retailer from this action. Arya and Mittendorf (2013) explored the role of consumer rebates offered by manufacturers in ameliorating the effectiveness of strategic inventories. They claimed that consumer rebates make the retailer less aggressive in carrying strategic inventories and the manufacturer less exploitative in setting wholesale prices. Moreover, the retailer, manufacturer, and consumer all benefit from manufacturer consumer rebates even when the retailer carries inventory strategically. Arya et al. (2014) further extended the role of strategic inventory to determine the trade-offs in procurement decisions in centralization versus decentralization environments. They showed that the seemingly imperfect nature of centralization may prove desirable when a retailer relies on external suppliers and strategically manages inventory. In this paper, we explore the influence of manufacturer and retailer investment efforts on strategic inventory. In an alternative approach to that of Arya and Mittendorf (2013), we sought to verify whether the manufacturer-investment effort can encourage harmony between supply chain members. To the best of our knowledge, the impact of a retailer's joint decision to carry strategic inventory and investment-effort expenditures on each supply chain member has not been discussed.

Unlike most of the literature on supply chain management for exploring a single period decision, we studied the roles of strategic inventory in a two-period setting. However, little literature shows the characteristics of the two-period supply chain model. Recently, Linh and Hong (2009) studied a two-period newsvendor model for short life cycle products in dynamic markets. They applied a revenue sharing contract for coordination. Pan et al. (2009) claimed that products such as personal computers and mobile phones are sold with multi-period pricing, and they formulated a two-period model to determine pricing and ordering decisions. Chen and Xiao (2011) applied a dynamic programming approach to find the optimal decision in a two-period supply chain model with a game-

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Table 1
Articles on investment decision under two-echelon supply chain.

Articles	Manufacturer investment−effort	Retailer investment−effort	Period	Demand	Strategic Inventory	Information
Gurnani and Erkoc (2008)	✓	✓	Single	Deterministic	×	Asymmetric
He et al. (2009)	✓	×	Single	Stochastic	×	Symmetric
Lau et al. (2010)	×	✓	Single	Deterministic	×	Symmetric
Lau et al. (2012)	×	✓	Single	Deterministic	×	Symmetric
Brunner (2013)	×	✓	Single	Stochastic	×	Symmetric
Saha (2013)	✓	×	Single	Deterministic	×	Symmetric
Wu (2013)	×	✓	Single	Deterministic	×	Symmetric
Ma et al. (2013)	✓	✓	Single	Deterministic	×	Symmetric
Zhao and Wei (2014)	×	✓	Single	Fuzzy	×	Asymmetric
Zha et al. (2015)	×	✓	Single	Stochastic	×	Asymmetric
Gao et al. (2016)	✓	✓	single	deterministic	×	symmetric
Yan and Zaric (2016)	×	✓	single	deterministic	×	symmetric
Basiri and Heydari (2017)	✓	✓	single	deterministic	×	symmetric
Ma et al. (2017)	✓	✓	single	deterministic	×	asymmetric
Present study	✓	✓	two	deterministic	✓	symmetric

theory framework model under stochastic price-dependent demand. Wang et al. (2015) developed a two-period supply chain model for short life cycle products in dynamic markets to indemnify optimal advertising policies of a retailer. Yang et al. (2016) proposed a flexible trade-credit contract mechanism for a financially constrained retailer in a two-period supply chain framework. Maiti and Giri (2017) found that the two-period supply chain is a common framework in the fashion and textile industries, and they studied the impact of dynamic pricing under price-dependent demand. The literature cited explains the importance of two-period supply chain. However, none of it addressed the inventory-carrying decision of a retailer in the presence of investment effort.

According to Taylor (2002) and Cachon and Lariviere (2005), investment effort is an integral part of retailing that stimulates demand. Although those who use it incur significant operational cost, the increased demand benefits supply chain participants. An increasing number of retailers and manufacturers are incorporating various types of investment efforts into their operations to attract customers who buy their products and to compete with their rivals. For instance, a retailer can invest in local media advertising, provide attractive shelf space, and hire well-trained sales personnel to guide consumer purchases and enhance demand. However, the manufacturer can stimulate demand through investment in global advertisement, product quality improvement, packaging, green technology innovation, and so forth. In general, the retailer or manufacturer can apply various techniques for boosting demand by investment, referred to as *investment effort* throughout this paper. We made no assumption about the specific type of investment effort used; the term refers only to the dollars expended by the supply chain member on demand-enhancing activities. A great deal of research in operation management considers the importance of joint decisions on pricing and investment effort. Table 1 presents a summary of some of the important published research on this key issue and also shows the contribution of our study.

From Table 1, one can observe that the optimal nature of the investment effort under the two-period supply chain model has not been discussed to date. In addition, no attention has been paid to strategic inventory decisions. In this study, our focus is on the behavior patterns of each supply chain member regarding investments over two periods. Some interesting research questions linked to this study include the following:

Does the manufacturer's investment effort in both periods eliminate the retailer's strategic inventory?
What is the role of strategic inventory in the retailer's own investment effort?
Are the investment patterns of the manufacturer and retailer identical when under the influence of strategic inventory?
How do equilibrium decisions in decentralized and centralized supply chains evolve with the use of strategic inventory?

To explore answers to these research questions and provide insights into the influence of a retailer's strategic inventory on the performance of supply chain members, we developed a two-period supply chain model with a manufacturer and a retailer under price-investment-induced demand. Because the supply chain performance can be enhanced if participants use contractual incentives to enhance the profit of the entire supply chain (Cachon, 2003), researchers have paid considerable attention to the designs of coordination schemes for chain members. In this study, an incremental quantity discount (IQD) contract was suggested for the supply chain. The abundant academic literature on quantity-discount contracts includes work by Sheen and Tsao (2007), Cachon and Kok (2010), and Nie and Du (2017). In addition to linear wholesale price discounts, under an IQD, the manufacturer offers an aggressive quantity-discount plan to coordinate the supply chain and improve the profit of each member while maintaining fairness for all. This type of discount model is continuous, differentiable, and concave (Cachon and Kok, 2010).

We developed the proposed supply chain model in a decentralized environment by considering the Stackelberg game structure. In a supply chain model, it is assumed that the retailer orders the exact amount of product required for each period, and the manufacturer attempts to distribute the quantity. However, the influence of ordering extra products and carrying them as a strategic inventory to fulfill the demand of the next period has not been discussed in the literature. In a common practice, the retailer orders several times through the life cycle of a product, and over the time between these orders,some products are carried from one period to