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Disruption management for a dominant retailer with constant demand-stimulating service cost

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ABSTRACT

In this paper, we consider coordination model of a one-manufacturer and multi-retailer supply chain with a dominant retailer's sales promotion opportunity and possible demand disruption. An appropriate contractual scheme can be used to fully coordinate the supply chain even if the demand disruption occurs. In our study, we also analyze how the demand disruption affects the coordination mechanism. When the demand is disrupted, the manufacturer only needs to adjust the maximum variable wholesale price and the subsidy rate under the linear quantity discount scheme. For each case of the demand disruption, we find that the higher the market share of the dominant retailer, the lower its average wholesale price will be. Meanwhile, the higher service cost leads to the higher subsidy rate provided by the manufacturer. The optimal wholesale/retail price, order quantity and subsidy rate can be greatly influenced by the demand disruption. If the disrupted amount of demand is sufficiently small, however, the manufacturer needs to take some special measures to prevent the retailers from deviating the order quantity of the original plan. To demonstrate these findings, we illustrate our propositions by numerical examples.

1. Introduction

The disruption management and coordination mechanisms of supply chain are of growing interest in the business community, to both academics and practitioners alike. The conventional research on supply chain coordination focuses on the decision-making under normal environment, and investigates how to plan an optimal coordination scheme in order to maximize the channel profit. Therefore, some coordination mechanisms, such as buyback scheme and quantity discounts scheme, can be used to regulate the relationship among the supply chain's members. When such a scheme is being executed, however, various disruptions may occur, raising concerns on whether the originally planned coordination scheme is still valid in the new disrupted environment. Unexpected changes of the market demand are very common in practice. There are some significant/major disruptions, for example, the terrorist attack to World Trade Center on September 11, 2001, was one of the social security incidents, which resulted in decrease of the demand in the airline industry dramatically, while the outbreak of SARS caused a large sudden increasing demand for respirators and disinfectors; the epidemic of mad cow disease affected a large degree of the demand for beef consumption.

Although the probability of all these unexpected events is very small, the influence is tremendous. As reported in Kleindorfer et al. (2003), disruptions from accidents in the industry have led to huge economic losses and environmental damages. A representative example is the March 2000 fire at the Philips microchip plant in Albuquerque, New Mexico. That plant supplied chips to both Nokia and Ericsson. Nokia learned of the impending chip shortage in just three days and took advantage of their multi-tiered supplier strategy to obtain chips from other sources. Ericsson, however, could not avoid a production shutdown because it was sourcing only from that plant. As a result, the company suffered $400 million in lost sales. Nokia's share of the handset market increased from 27% to 30% because Nokia had taken better measures (Latour, 2001). Additionally, and a host of other major companies (e.g., Hershey, Apple, Wal-Mart) who rely on timely delivery of products and services to meet customer needs have often incurred major losses due to supply chain disruptions, too. Moreover, small scale disruptions occur much more frequently. Therefore, the disruptions have made companies aware of the need for active disruption management.

Simultaneously, this paper researches the dominant player's behavior in a supply chain. In the practical supply chain operations, there often is a dominant retailer competing with multiple fringe retailers (Riordan, 1998; Shepherd, 1997). As Wal-Mart grew, for instance, the relationship between Wal-Mart and Tandy evolved into main partnerships. Wal-Mart's sale volume accounted for 39% of Tandy's in 2002 (Useem, 2003). While, in 2004, with its

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$285 billion sales, Wal-Mart dwarfed any other competitors and became one of the largest companies in the world (Maier, 2005). The dominant retailer often is a price leader and a main or largest distributor of the supplier. Other fringe retailers are price followers and the market demand share of each retailer is very small (see, Weinstein, 2000). In order to have a higher market demand, players usually invest to promote their products. Advertisement, post-sale service, and other sales promotion investment constitute a high proportion of a player's operational cost. We assume that only the dominant retailer can provide the advertising service to promote sales.

In this paper, we consider coordination of a one-manufacturer and multi-retailer supply chain with one dominant retailer's sales promotion opportunity and possible demand disruption. We analyze the effects of the demand disruption on the optimal order quantity, retail price and subsidy rate. Usually, an operation without disruption is defined as a *normal operation* and the operation with disruption is defined as an *irregular operation* in this paper. One main difference between irregular operation and normal operation is that the sudden change of demand will cause certain extra deviation costs for the decision-maker (Causen, Hansen, & Larsen, 2001; Xia, Yang, Golany, Gilbert, & Yu, 2004; Yu & Qi, 2004). That is, the deviation penalty is incorporated into the utility functions in the irregular operation. For simplicity, we assume that the fringe retailers are identical and the information of changed demand is common knowledge to all players. With the demand disruption, the manufacturer should produce more products ordered by the retailer(s) when the demand increases suddenly, or, employs a return policy to handle unsold products from the retailer(s) when the demand decreases suddenly. In both cases, deviation costs are assumed to be incurred to the manufacturer. Additionally, we find that a coordination contract in the demand-disruption case differs from the case without disruption due to a deviation penalty applied for the production quantity change.

This paper complements the literature by investigating how to coordinate the supply chain with a dominant retailer and how the demand disruption affects the coordination mechanism. We find that the decentralized decisions of the players result in system inefficiency due to both double marginalization and the incentive providing demand-stimulating service, which is distorted in the decentralized system. The linear quantity discount scheme can gain an overall optimal performance of the entire supply chain under the normal operation. Furthermore, when the demand is disrupted, we still find that the coordination mechanism also keeps some manufacturer–retailer relationships comparing with the decisions under the normal operation. In details, with the demand disruption, the manufacturer only needs to adjust the maximum variable wholesale price and subsidy rate, while the discount slope is unchanged. Additionally, it is optimal for the manufacturer to keep the original production plan if the disrupted amount of demand is sufficiently small.

The remainder of this paper is organized as follows. The related literature is briefly presented in Section 2, and Section 3 describes the basic model, both centralized and decentralized decisions are also investigated in this section. Sections 4 and 5 study a coordination mechanism for normal and irregular operations, respectively. The analytical results are illustrated by numerical examples in Section 6. Finally, Section 7 summarizes the results and points out directions for future research.

2. Literature review

As far as we know, there are few papers on contract modeling that study the coordination mechanism combining with demand-stimulating service and demand disruption, and our paper is closely related to supply chain coordination management, demand-stimulating services and disruption management.

2.1. Coordination management

In the decentralized decisions, the optimal supply chain profit is usually not achieved due to double marginalization, that is, each player's relative cost structure is distorted when a transfer price is introduced within a supply chain. Designing coordination scheme has been an important issue aimed at reconciling conflicts and achieves a better coordination among players. Lariviere (1999) and Cachon (2003) provided excellent introduction and summaries on coordination management. Cachon and Lariviere (2005) compared the wholesale price scheme with the revenue-sharing scheme, and found that the two schemes were equivalent for a simple supply chain. Bernstein and Federgruen (2003) provided a nonlinear wholesale pricing scheme to coordinate the supply chain with competing retailers. Other papers, e.g., Chen (2001), Hou, Zeng, and Zhao (2009), Wang and Zhou (2010), also studied a coordination mechanism in the supply chain context.

The quantity discount scheme is investigated in our paper. Similar studies are introduced as following. Weng (1995) showed that the optimal all-unit quantity discount policy was equivalent to the optimal incremental quantity discount policy in achieving channel coordination. Zhou, Minand, and Goyal (2008) also designed a quantity discount scheme to induce the retailer to increase the order quantity so as to maximize the manufacturer's profit. Krichen, Laabidi, and Abdelaziz (2011) proposed a solution approach that generated stable coalition structures for the retailers taking into account the delay in payments and the discount quantity offered by the supplier. Other literatures on quantity discount schemes can be found in Tsay (1999), Monahan (1984), Li and Huang (1995), Jaber and Osman (2006), and Chiadamrong and Prasertwattana (2006). Our coordination model, the linear quantity discount scheme, is closely related to Ingene and Parry (1995) and Ingene and Parry (2000), which also established the existence of a menu of two-part tariffs that imitated all results of a vertically integrated system.

2.2. Demand-stimulating services

From the perspective of customers' behavior, besides price, service also influences the customers' preferences and their purchasing decisions, and hence market demand.

From the literature on demand-stimulating service, Perry and Porter (1990) showed that resale-price maintenance and franchise fee could correct the sub-optimal levels of the retail service caused by an externality of a service provision while only resale price maintenance alone was not enough. The retailer in the traditional channel can compete against the e-tail channel by adding some value-added services (Yao & Liu, 2005). Li, Huang, Zhu, and Chau (2002) developed three strategic models for determining equilibrium marketing and investment effort levels for a simple supply chain and offered a formal normative approach for analyzing the traditional cooperative advertising program. Bernstein and Federgruen (2004) developed game models to study the price and service competition under demand uncertainty. Yue, Austin, Wang, and Huang (2006) studied the coordination of co-op advertisement in a simple supply chain when the manufacturer offered price deductions to customers. Other literatures about advertisement service can be referred, e.g., Kim and Staelin (1999), Jorgensen, Sigue, and Zaccour (2000), Huang and Li (2001), Karray and Zaccour (2007), and Xie and Neyret (2009).

Usually, in a manufacturer–retailer channel, 'dominant' means a channel player has the power of controlling or influencing another member's decisions. Most literatures considering the dominant-retailer models often assume that the retailer has stronger bargain-