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Contract design for two-stage supply chain coordination: Integrating manufacturer-quality and retailer-marketing efforts

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ABSTRACT

This paper investigates the issue of channel coordination for a two-stage supply chain with one retailer and one manufacturer. The demand is influenced by the retailer's sales effort and manufacturer's quality improvement efforts. We found that using the traditional two-part tariff contract alone cannot coordinate the supply chain well. Joining the two-part tariff contract with the quality effort cost sharing model remains ineffective in managing the two-stage supply chain. To effectively coordinate the channel members, we propose an innovative supply chain contract that integrates the endeavors of the manufacturer and the retailer. We identify the optimal level of retail sales effort, optimal level of quality-improvement effort and optimal supply chain profit. Sensitivity analyses are conducted to examine the impacts of changes in the costs of sales effort and quality effort on the performance of the supply chain.

1. Introduction

In a decentralized supply chain, double marginalization is a common phenomenon since both the up-stream and down-stream members possess market power, and each aims to maximize its own profit and set price above marginal cost (Dellarocas, 2012). To overcome this problem and improve SC efficiency, supply chain contracts are developed to motivate members' collaboration (Cachon, 2003). Major coordination mechanisms consist of quantity-flexibility contract (Tsay, 1999), sales rebate contract (Taylor, 2002), revenue-sharing contract (Cachon and Lariviere, 2005), quantity-discount contract (Li and Liu, 2006) and buy-back contract (Chen, 2011). Through effective supply chain contracts, the objectives of supply chain members are aligned.

Our research was motivated by the need of a medical device firm (RPN) which specializes in high-tech products and is a leading provider of novel products that serves the sleep and respiratory markets. Management in the sleep/wake and insomnia market has to determine how much resource to allocate to the sales of the Blue Light product and whether to participate in the manufacturer's product quality improvement efforts. Specifically, members of the supply chain may exploit the sales channel and the quality channel to increase the market demand. RPN's sales group has actively developed solutions to increase the market demand, enhance business ideas, and boost brand reputations. In addition to marketing efforts (e.g., promotion and advertising), in due course RPN would like to ask the manufacturer to take part in the "cooperative marketing," and share the advertising expenses to allow for larger scale campaign publicity.

Similarly, the manufacturer of the Blue Light is contemplating to invest in technology and management to improve product quality. Dai et al. (2012) regard warranty period as a proxy to a product's quality. Based on whether the manufacturer or the supplier sets the warranty period, they investigate how product quality and product warranty decisions interact with each other and influence supply chain performance. In our research, we emphasize that investing quality-improvement effort will result in newer and advanced products and subsequently increase customer demand and market share. To ensure product excellence, RPN decides to participate in manufacturer's quality programs. RPN has assembled a quality team to help its suppliers to improve product quality. The quality team from RPN works with manufacturer's employees to examine and improve the production process, to sample and inspect finished products, and to enhance quality awareness of management. Despite increasing need to synchronize retailer's marketing events with manufacturer's production activities, little research has been done to simultaneously coordinate both the retail sales effort and the production quality-improvement effort.

In this paper, we propose an effective contract to coordinate supply chain, which is based on two types of conventional contracts: two-part tariff contract and cost sharing contract. In the TPT contract, the manufacturer offers a contract comprising a wholesale price and a lump-sum fee to the retailer. The latter contract is designed to share the cost of retail sales effort, the cost of the quality-improvement effort, and/or both of the costs between the supply chain players.

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We consider two fundamentally distinct scenarios: (a) centralized supply chain, where all members of the supply chain are managed by a dominant decision maker whose objective is to maximize the total expected profit of the supply chain, and (b) the decentralized supply chain, where each member is an independent decision maker aiming to maximize his own profit. The contribution of this paper are threefold: (i) we show that a two-part tariff contract alone cannot coordinate and improve the supply chain performance; (ii) we develop a contract combining the two-part tariff and quality effort cost sharing, and find that it remains ineffective in coordinating the supply chain; (iii) in addition to considering the two-part tariff contract, we then construct a new supply chain contract, in which the manufacturer shares the cost of marketing effort and the retailer shares the cost of quality effort in production. We found that the comprehensive contract proposed can effectively coordinate the supply chain and significantly improve the SC profit.

The paper is organized as follows. In Section 2 we review the literature. Section 3 formalizes the problem. We investigate the centralized supply chain model in Section 4. Section 5 addresses the decentralized environment. We study the two-part tariff contract and investigate the quality improvement cost sharing model. To maximize supply chain collaboration, we develop a new contract, which considers both the quality-improvement cost sharing and retail sales effort cost sharing. Section 6 provides a numerical study to optimize the retailer's sales effort, the manufacturer's quality effort, and the total supply chain profit. The effects of cost changes in marketing and quality efforts on SC performance are investigated. Conclusions and future research are provided in Section 7.

2. Related literature

The first group of literature relevant to our research involves coordination of retailers' sales efforts. Taylor (2002) shows that a properly designed rebate and returns contract can coordinate the channel with sales-effort dependent demand. He finds that the provision of returns strengthens the incentives for retailers to make more sales effort. However, such a contract requires four parameters and is complex. Cachon and Lariviere (2005) give a simpler quantity discount contract to coordinate the supply chain. Krishnan et al. (2004) consider a two-stage supply chain including a risk-neutral manufacturer and a risk-neutral retailer. They show that buy-back contract by itself cannot coordinate the supply chain, and combining buy-back contract with cost-sharing agreements is best to achieve channel coordination. Later, He et al. (2009) examine retail-price and sales-effort dependent stochastic demand. They find that appropriate returns policy with sales rebate and penalty contract can properly coordinate the supply chain and lead to a win–win situation for all SC members. Tsao and Sheen (2012) deem promotion cost sharing as a critical mechanism to coordinate the supply chain. Xing and Liu (2012) examine an online retailer's promotional activity. The main difference between our paper and the above literature is that we focus on contract coordination when demand is influenced by both the retail sales effort and the quality-improvement effort.

The second area of research centers on optimal contract design in the supply chain. Foros et al. (2009) consider a supply chain where the manufacturer may undertake noncontractible sales efforts to increase market demand. Kaya (2011) contrasts outsourcing vs. in-house production, and compares supply chain contracts with effort dependent demand. Many researchers have focused on optimal contract design about the resale price maintenance contracts with sales effort dependent demand. For example, Gurnani and Xu (2006) study a resale price maintenance contract and examine whether it is anti-competitive. Then again, Lau et al. (2010) investigate the usefulness of resale price maintenance contracts given retail effort cost and parameters uncertainties. Mukhopadhyay et al. (2009) examine the effectiveness of a franchise fee contract and a retail price maintenance contract. They did not address manufacturer quality-improvement efforts and coordination issues. Related works can be found in Tsay and Agrawal (2000), Taylor (2006), Roels et al. (2010), Dan et al. (2012), Wu (2012) and Liu et al. (2013).

Table 1
Summary of the related literature.

Authors	Demand pattern		Type of contract
	Marketing effort	Quality effort	
Part A: Summary of literature about contract coordination			
Taylor (2002)	✓		Rebate and returns
Cachon and Lariviere (2005)	✓		Quantity discount
Krishnan et al. (2004)	✓		Buy-back with cost sharing
He et al. (2009)	✓		Sales rebate and penalty
Tsao and Sheen (2012)	✓		Promotion cost sharing
Xing and Liu (2012)	✓		Price match and selective compensation rebate

Authors	Marketing effort	Quality effort	Focus
Part B: Summary of contract design and relevant literature			
Foros et al. (2009)	✓		Slotting Allowances
Kaya (2011)		✓	Supply chain contracts choice
Gurnani and Xu (2006)	✓		Role of using a resale price maintenance
Lau et al. (2010)	✓		Usefulness of resale price maintenance
Mukhopadhyay et al. (2009)	✓		Optimal contract design
Tsay and Agrawal (2000)	✓		Channel dynamics under price and service competition
Taylor (2006)	✓		Optimal sale-timing
Roels et al. (2010)	✓		Contracting choice that arise in collaborative services
Dan et al. (2012)	✓		Pricing policies
Wu (2012)	✓		Pricing and service decisions
Liu et al. (2013)			Quality game in multi-period
Gurnani et al. (2007)	✓	✓	Effect of timing of price commitment decisions
Gurnani and Erkoc (2008)	✓	✓	Supply contracts choice
This paper	✓	✓	Coordination with a new supply contract