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Decision Support

Risk sharing and information revelation mechanism of a one-manufacturer and one-retailer supply chain facing an integrated competitor

Tiaojun Xiao *, Danqin Yang

School of Management Science and Engineering, Nanjing University, Hankou Road 22, Nanjing, Jiangsu 210093, China

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ABSTRACT

This paper develops an information revelation mechanism model of a one-manufacturer and one-retailer supply chain facing an outside integrated-competitor under demand uncertainty. We investigate how the manufacturer designs a wholesale price-order quantity contract to induce the retailer to report his risk sensitivity information truthfully. We try to explore the effects of the outside competitor and the risk-sharing rule on the optimal price-service level decisions of the retailer and the optimal wholesale prices of the manufacturer. We find that the strategic interaction plays an important role in the effect of risk sensitivity on the order quantity for the retailer. When the fraction of the risk cost shared by the manufacturer is sufficiently large (small), the optimal wholesale price for the high risk-averse retailer is higher (lower) than that for the low risk-averse retailer.

1. Introduction

In the business world, sometimes, a firm had to make decisions before a variety of uncertainties are resolved, in particular, demand uncertainty. The uncertainties bring risk to the firm. The firm's attitude towards risk has aroused unprecedented concern because it affects the behavior and decisions of the players to a large degree. However, the risk sensitivity of one player is often private information for the player and the other players do not know it. It is also very difficult for the other players to observe the risk sensitivity. Thus, the player with private information on risk sensitivity often has an incentive to conceal true information (i.e., report wrong information to the others). This paper studies the information revelation mechanism of a supplier and the price-service level decisions of her retailer. The consideration of the outside competitor further complicates the decisions.

Incomplete information and uncertainty open the door to opportunistic behavior and strategic manipulation. Retailers may distort their orders to receive larger allotments due to uncertainty and their privacies of the optimal stock levels (Cachon and Lariviere, 1999). Especially, private information on risk sensitivity might incur substantial penalty, for example, in a make-to-order system, the upstream supplier might suffer stock out cost from erroneously estimating when the retailers are very risk averse. Moreover, the retailers often have incentives to conceal their risk sensitivity to be in a better bargaining position. The mechanism design literature often only considers the effects of the factors in a system on the mechanism (Weng, 1995, 1999; Ugarte and Oren, 2000; Corbett and de Groote, 2000). However, in the real world, a supply chain often competes with some outside firms or chains. To capture the notable competition dimension from the outside firm, we incorporate an outside integrated-manufacturer into the basic model. Our main purpose is to address the effects of the outside integrated-manufacturer on both the supplier's revelation mechanism and the retailer's optimal decisions.

We assume that the supply chain consists of one risk-neutral manufacturer/supplier and one risk-averse retailer, competing with an outside integrated-manufacturer in retail price and service level under demand uncertainty. The demand uncertainty can incur a risk cost for the retailer. The supplier designs a wholesale price-order quantity contract to induce the retailer to report his type information (risk sensitivity) truthfully. In the real world, some players often share risk with each other, in particular, in high-tech industries such as semiconductor, and telecommunications (see Jin and Wu, 2007). We assume that the supplier shares the risk cost with the retailer, i.e., the supplier pays the retailer a risk subsidy to offset a part of the retailer's risk cost.

Our paper complements the literature by studying the effects of the outside integrated-manufacturer and the risk-sharing rule on both the revelation mechanism design and the retail price-service level decisions. We also illustrate the motivation of the supplier to use the information revelation mechanism by using a numerical example. We find that the risk-sharing rule remarkably influences the members' decisions and the motivation of the supplier to use the mechanism. When the retailer becomes more conservative, the retailer prefers lowering the retail price to stimulate a

* Corresponding author. Tel.: +86 25 83686733.
E-mail addresses: xiaotj@nju.edu.cn, xiaotiaojun@263.net (T. Xiao), yangdanqin@163.com (D. Yang).

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higher demand and lowering the service level to save the investment due to the strategic interaction between the retailer and the outside integrated-manufacturer, which is complementary to Weng (1999).

The reminder of the paper is organized as follows. The related literature is reviewed in Section 2 and then the basic model is presented in Section 3. Section 4 investigates the optimal retail prices and service levels when the retailer reports his real type information. Section 5 concerns the wholesale price-order quantity contract, and explores how some main parameters affect the mechanism and the motivation of the supplier to use the information revelation mechanism by using numerical examples. Finally, in Section 6 we summarize the results and point out the directions for future research.

2. Literature review

This paper is closely related to price and service competition, risk management, and revelation mechanism design.

2.1. Price and service competition

Many papers explicitly modeled service competition. Boyaci and Gallego (2004) assumed that the market share of one channel depends on the service levels of the channel and the retailer in the rival channel. Xiao et al. (2005) developed a coordination model of a supply chain consisting of one manufacturer and two retailers competing in the investment of sales promotion after demand disruption. However, more retailers are competing in both retail price and service (see, Raju and Zhang, 2005; Tsay and Agrawal, 2000; Bernstein and Federgruen, 2004; Allon and Federgruen, 2007). Ernst and Powell (1998) dealt with the incentive of a manufacturer to induce her retailer to provide a desired service level. Most of the above papers assumed that the demand is deterministic. In our model, the retailer plays a retail price-service level competition with the outside integrated-manufacturer under demand uncertainty. We will find that the demand sensitivity to service levels influences the results to a large degree.

2.2. Risk management

Risk sensitivity poses potential effects on the behavior and performance of firm. Risk sensitivity of the members of supply chain can cause system-wide inefficiency, for instance, it is well known that a risk-averse retailer will order less than a risk-neutral one for a classical newsvendor problem (see, Agrawal and Seshadri, 2000; Eeckhoudt et al., 1995). This result may not hold in our settings. Balvers and Szerb (1996) found that the locations of the firms depend partly on their risk sensitivity in the Hotelling environment with demand uncertainty. Reynolds (2001) showed that the risk sensitivity of seller affects the retail price in a two-period bargaining setting with asymmetric information about the buyers' values. Weng (1999) analyzed the role of the attitude towards risk and coordination for a simply manufacturing and distribution system, where the distributor is risk averse if the probability of achieving the expected profit is very large. However, Weng (1999) pointed that the approach capturing the distributor's attitude towards risk may not be easy to generalize. Xiao and Yang (in press) developed a price-service competition model of two supply chains to investigate the optimal decisions of players under demand uncertainty, where each chain consists of one risk-neutral supplier and one risk-averse retailer.

In the risk management literature, although most papers assumed that the manufacturer or the retailer(s) fully bears the risk cost, the manufacturer may share a part of the risk cost with the retailer(s) (see, Lim, 2000; Xiao et al., 2007; Lee and Chu, 2005; Chen et al., 2006; Jin and Wu, 2007). Lee and Chu (2005) found that the members are better off transferring the stock level decision and keeping responsibility to supplier under some kinds of risk-sharing rules. Chen et al. (2006) proposed a risk-sharing contract of a two-stage supply chain with demand information updating, where the retailer partially shares the risk cost of the manufacturer. They found that the coordinated contract could improve the members' profits. He and Zhang (2008) considered some scenarios where the retailer shares the random yield risk with the supplier and compare the supply chain members' performances under different scenarios. Koeppl (2007) developed a dynamic risk-sharing model of two risk-averse agents to study the optimal decision of using self-governance for risk sharing. Koeppl (2007) pointed out that players have incentives to share income risk. We assume that the retailer has two types: high risk sensitivity and low risk sensitivity. The retailer may have an incentive to conceal his real type information. The supplier partially bores the retailer's risk cost incurred by demand uncertainty. We will analyze the effects of risk sensitivity on both the retail price-service level competition and the retailer's order quantity. We do not focus on how to design a risk-sharing rule but on the effects of the risk-sharing rule on the decisions.

2.3. Revelation mechanism design

Since Myerson (1979) gave the revelation principle, considerable researchers devoted themselves to establish incentive schemes to induce truthful information (see, Bradford, 1996; Lim, 2000; Ugarte and Oren, 2000; Sen, 2005; Hempelmann, 2006). Bradford (1996) and Lederer and Li (1997) discussed a multiple-agent case with different waiting or delay costs. Ugarte and Oren (2000) compared the efficiency of three coordination policies of internal supply chains: Centralized command and control, centralized revelation, and decentralized revelation. In the existing literature, asymmetry often refers to asymmetry of the cost structure information (see, Lee and Kim, 1996; Corbett and de Groote, 2000; Lau et al., 2006). Lee and Kim (1996) designed a menu of non-linear price contracts for regulator to induce the regulated firm and the retailer to reveal their real types. However, Li (2002) assumed that the manufacturer is unknown about the demand and cost uncertainties of the retailers playing a Cournot competition and examined the incentives for firms to share information vertically but did not design information revelation mechanism. Gurnani and Shi (2006) assumed that the beliefs of supply reliability is asymmetric, i.e., the buyer may have a different estimate of the supplier's ability to meet the order from that of the supplier herself. The above works failed to consider the risk sensitivity of players except that Gurnani and Shi (2006) trivially evaluated the impacts of the risk attitude of both the supplier and the buyer on the contracts incorporating a down payment or a non-delivery penalty into the Nash bargaining game. However, in reality, it is more reasonable that a retailer is risk averse under demand uncertainty. Tsay (2002) showed that the penalty of ignoring the retailer's risk sensitivity for the manufacturer could be substantial because the retailer may have an incentive to report wrong risk sensitivity information to the manufacturer. Thus, we assume that the retailer is risk averse to approach this reality. We will analyze how the supplier designs a wholesale price-order quantity mechanism to induce the retailer to report his risk sensitivity information truthfully and investigate how the risk-sharing rule affects the revelation mechanism and the motivation of the supplier to use the mechanism.

2.4. Economic system structure

Li (2002) suggested that information sharing in a supply chain should not be studied in isolation, namely, restricted to the gains