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Pricing strategy and coordination in a dual channel supply chain with a risk-averse retailer

Bo Li *, Peng-Wen Hou, Ping Chen, Qing-Hua Li

College of Management and Economics, Tianjin University, Tianjin, China

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ABSTRACT

This paper considers a dual channel supply chain consisting of a risk-neutral supplier and a risk-averse retailer, in which the market demand is uncertain and the supplier opens an e-channel, thus directly participating in the market. At the beginning of the sales season, the supplier and the retailer construct their initial stocks, and they follow a consistent pricing strategy. Under the Value-at-Risk (VaR) criterion and the Conditional Value-at-Risk (CVaR) criterion, we formulate the problem as a Stackelberg game model and obtain the equilibrium solutions in the decentralized and centralized situations. Based on the advantage of the CVaR measure, we further explore the effects of the retailer's risk indicator on the retail price, the ordering quantities of the two channels and the profits of the two members, and the total profits of the supply chain. Further, an improved risk-sharing contract is presented to coordinate the dual-channel supply chain and ensures that both supply chain members achieve a win–win outcome. In addition, we make an extension to the case of the inconsistent prices in the two channels, and we also verify that the dual-channel supply chain can be coordinated by the similar improved risk-sharing contract.

1. Introduction

With the rapid development of the Internet, there are a growing number of suppliers interested in establishing an e-channel in addition to the traditional retail channel to participate in the market directly, such as Apple, HP and Polo Ralph Lauren. We call this distribution system, which consists of retail and direct channels, a dual-channel supply chain. Generally, the traditional retail channel may attract customers who prefer the process of shopping with friends in a “brick and mortar” store. However, to save transportation costs and time, some customers may choose to purchase products through the direct channel after searching the product photographs and descriptions online (Chen et al., 2012). Undoubtedly, the supplier will encroach upon some of the retailer's market share when he opens a direct channel and then channel conflict occurs.

Therefore, there is a question as to whether the supplier opening up a direct channel is always detrimental to channel performance. Keenan (1999) tried to explain to the retailer that the direct channel was targeting a different market segment and that if there were no direct channel, these customers would not buy his product. Cohen (2000) showed that sometimes firms established the direct channel for the sole purpose of obtaining marketing information and sales support and left the actual sales to the retailer. Chiang et al. (2003) noted that through the direct channel, the supplier could control the retailer's price even if he had no actual sales, and the degree of the double marginalization problem in the supply chain would be mitigated. Moreover, some researchers found that the introduction of a direct channel always resulted in a wholesale price reduction, which might actually benefit both the retailer and the supplier (Chiang et al., 2003; Tsay and Agrawal, 2004; Cattani et al., 2006). Geng and Mallik (2007) considered inventory competition between the retail channel and the direct channel in a dual channel supply chain. They indicated that a mild capacity constraint could improve the situation of both agents and increase the profit of the whole supply chain. Xu et al. (2013) noted that customers preferred dual channels that offered them more shopping choices and experiences, and this trend forced the supplier to introduce a direct channel as a necessary strategy. Lu and Liu (2015) showed that if the online channel was independent of the manufacturer, then the retailer could benefit from the online channel entry. Ding et al. (2016) indicated that under some conditions, operating dual channels were benefit to the manufacturer. In fact, retailers have also realized that it is not

* Correspondence to: No. 92, Weijin Road, Nankai District, College of Management and Economics, Tianjin University, Tianjin 300072, China.
E-mail address: libo0410@tju.edu.cn (B. Li).

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profitable to boycott the direct channel because this behavior only prompts customers to buy elsewhere (Hanover, 1999). Thus, though the firms using the dual channel strategy inevitably initiate channel conflict, in some situations, both agents may benefit from this model. However, the above papers all assume that the agents in dual channel supply chain are risk neutral and that maximization of their expected revenue is their objective. In practice, in recent years, the business environment has witnessed rapid and frequent changes and has become a more complex environment with high uncertainty. In a fluctuating environment, the agents in the supply chain focus more on risk aversion or loss minimization in their decision-making processes. Thus, in this paper, we analyze a dual channel supply chain where the supplier has a direct channel in addition to the traditional retail channel and the retailer has risk-averse behavior; furthermore, we seek to elucidate the supply chain coordination problem when conflict of the two channels exists.

Interest in the issue of members' risk-aversion, experienced a surge in the 1990s because a majority of scholars at that time were attracted to researching this interesting problem (Wu et al., 2010). Bouakiz and Sobel (1992) showed that in a multi-period inventory model, establishing a base policy was profitable for the decision maker with an exponential utility criterion. Eeckhoudt et al. (1995) explored the effects of risk attitude on managers' decision-making when the manager had to determine an inventory level before he knew the market demand. Agrawal and Seshadri (2000) considered a single-period supply chain, which consisted of a unique supplier and multiple risk-averse retailers under the framework of the mean-variance method. They found that the risk could be shared among the members by offering mutually beneficial risk sharing contracts and the retailers would increase their order quantities to the expected optimal levels. Chen and Federgruen (2000) compared the efficiencies of some basic inventory models with standard analyses and a systematic mean-variance balance analysis. Ohmura and Matsuo (2016) showed that if both the manufacturer and the retailer were high risk averse, then the full-return policy could be more preferred by them than the no-return policy.

In fact, in addition to the mean-variance method, the Value-at-Risk (VaR) or the Conditional Value-at-Risk (CVaR) method as a measure of risk is often adopted. Wu et al. (2010) specifically reviewed the evolution of game-theoretic models in the context of risk attitude. They showed that CVaR had advantages over the mean-variance method and VaR method in both theory and application. Xu et al. (2006) considered a newsvendor problem and explored how the lost sale penalty cost and the degree of risk aversion affected the retailer's optimal order quantity under the framework of CVaR. Gotoh and Takano (2007) studied the minimization of downside risk in a single-period newsvendor problem using CVaR. Chen et al. (2009) noted that there existed an optimal price and order quantity for a newsvendor problem with additive demand and multiplicative demand models under the CVaR framework. Ma et al. (2012) analyzed a Nash-bargaining problem, which consisted one risk-averse retailer and one risk-neutral supplier, where the retailer adopted CVaR as her risk measure. Dai and Meng (2015) considered a risk-averse newsvendor model that the demand was depending on the price and the marketing effort level under the CVaR framework.

With the growing popularity of the dual-channel supply chain, marketing competition is becoming fiercer, and both vertical competition and horizontal games exist. Most of the literature is focused on how to coordinate members' decisions in the dual channel supply chain (Chiang, 2010; Chen et al., 2012), but the literature on the dual channel supply chain coordination with agents' risk-averse behaviors is quite limited. Gan et al. (2004, 2005) put forward a new definition of supply chain coordination with risk-averse agents using the VaR method and then designed a risk-sharing contract to achieve the Pareto-optimal solutions acceptable to each agent. Xu et al. (2014) discussed how a dual-channel supply chain was coordinated under a mean-variance model when the supply chain agents were risk-averse. They assumed that the production model was make-to-order and designed a two-way revenue sharing contract to coordinate the dual-channel supply chain.

Motivated by the above literature, we consider a dual channel supply chain in which there exists one perishable product with stochastic price-dependent demand, assuming that the supplier with the direct channel is risk-neutral and his retailer is risk-averse. Our work is most closely related to Xu et al. (2014). However, there are several significant differences between these two papers. The first is problem background, Xu et al. (2014) assumed a make-to-order policy in the dual channel supply chain, while we assume that the manufacturer produces a perishable product and both members need construct an initial stock at the beginning of the sales season, such as the seasonal products. Thus, the supplier needs to predict the demand from the retailer's order, or from the historic data, and make a decision about his stock for the direct channel before the sales period. Our assumption also represents a very popular production mode in application problems. The second is the risk-averse measure method. We compare the VaR and CVaR methods to evaluate the risk-averse behavior of the retailer rather than the average profit measure by the mean-variance method in Xu et al. (2014), especially the downside risk can be exactly measured by the CVaR method in our manuscript. The third is the coordination mechanism of the supply chain. Our paper establishes a Stackelberg game where the supplier is a leader and the retailer is a follower in making decisions on the retail price and the order quantities under a consistent pricing strategy. Different from the two-way revenue sharing contract in Xu et al. (2014), we design a new improved risk-sharing contract that coordinates the dual-channel supply chain and enables a win–win outcome for both the supplier and the retailer.

The reminder of this paper is organized as follows. In Section 2, we provide a description of our model and obtain the equilibrium solutions under the VaR method and the CVaR method. The comparison analysis of the results is explored under the CVaR criterion in Section 3. Section 4 proposes a new definition of coordination and an improved risk-sharing contract is developed to coordinate the dual channel supply chain. And finally, we summarize the major findings in this paper in Section 5. All proofs of our results are listed in the Appendix.

2. Model analysis

In this paper, we consider a dual channel supply chain consisting of a traditional retail channel and a direct channel opened by the supplier. Both channels only sell a single perishable product provided by the supplier, and we suppose that the supplier is risk neutral and the retailer is risk-averse. Gan et al. (2004) indicated that it was reasonable to assume that the supplier was risk neutral because he could diversify his risk by serving several independent retailers or channels, which was a common situation in practice. At the beginning of the sales season, the supplier and the retailer will predict the market demand of the direct channel and the independent retail channel and then construct their initial stocks, respectively. Further, considering the properties of perishable products, we suppose that the surplus value of the products at the end of sales season is zero. To simplify the calculation, we assume that there exists no production shortfall.

The parameter variables are defined as follows: