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Manufacturer–retailer contracting with asymmetric information on retailer's degree of loss aversion

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ABSTRACT

In a recent paper [Wang C., Webster S., 2007. Channel coordination for a supply chain with a risk-neutral manufacturer and a loss-averse retailer. Decision Sciences 38 (3), 361–389.], the authors study a supply chain consisting of a risk neutral manufacturer and a loss averse retailer and show that the supply chain can be coordinated by three contracts: buy back (BB), gain/loss sharing (GL) and gain/loss sharing and buy back (GLB). They assume that the retailer's degree of loss aversion is common knowledge. However, this assumption cannot reflect real situations, since in the real industry, one party's degree of loss aversion is usually unknown by other parties. In the present paper, we propose a principal-agent model, assuming the retailer's degree of loss aversion to be asymmetric information. Within the principal-agent framework, we obtain the following results: (1) An optimal MGL (modified GL) contract menu, which is based on the GL contract studied in Wang and Webster (2007), is derived for the manufacturer (the principal) by mechanism design theory; (2) Under the MGL contract menu, information asymmetry lowers the production quantity, decreases the manufacturer's profit and deteriorates supply chain performance, while increasing the retailer's utility; (3) The MGL contract menu can coordinate the supply chain with asymmetric information in an implementable way if the wholesale price is endogenously determined by the manufacturer and its lower bound is 0.

1. Introduction

Traditional literature mainly focuses on supply chains with risk neutral members, who maximize expected profits or minimize expected costs. However, many evidences point out that most decision makers do not practice as the models with the risk neutrality assumption predict (e.g., Kahn (1992), Fisher and Raman (1996), and Patsuris (2001)). In view of this, some researchers have advocated studying supply chains by relaxing the restrain of risk neutrality in order to represent more realistic situations (e.g., Anupindi (1999), Tsay et al. (1999), and Wu et al. (1999)).

Some studies have deviated from the risk neutrality assumption and incorporated other objective functions rather than profit maximization. One stream of these studies is the models incorporating loss aversion, which is a critical feature of the prospect theory in the field of psychology (Kahneman and Tversky, 1979). Loss aversion means that people are more averse to losses than they are attracted to same-sized gains. It is both intuitively appealing and well supported in finance, economics, marketing, and organizational behavior (Rabin, 1998; Camerer, 2001). In a recent paper, Wang and Webster (2007) propose a model to analyze a supply chain consisting of a risk neutral supplier and a loss averse retailer. They show that such a supply chain can be coordinated by three different kinds of contracts: buy back, gain/loss sharing (GL), gain/loss sharing and buy back (GLB) contracts. In that paper, the authors assumed that the retailer's degree of loss aversion is common knowledge. However, this assumption cannot reflect real situations very well since in the real industry one party's degree of loss aversion is usually unknown by others. In order to reflect more realistic situations of a manually operated supply chain, it is necessary to study the case that the degree of loss aversion is asymmetric information to supply chain members, i.e., the retailer's degree of loss aversion is private information, unknown by the manufacturer.

In the present paper, we propose a principal-agent model to study a similar supply chain, which consists of a risk neutral manufacturer (the principal) and a loss averse retailer (the agent). What's more, the retailer's degree of loss aversion is asymmetric information among the supply chain members. The information asymmetry on the degree of loss aversion gives rise to several interesting questions: (1) Do the contracts coordinating the supply chain without asymmetric information still coordinate the supply chain with the asymmetric information in an implementable way? (2) How does information asymmetry affect the

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production quantity of the supply chain, total supply chain profit, manufacturer's profit and the retailer's utility?

Generally, in a principal-agent model, an optimal contract menu should be found standing at the point of the principal. For the agent, there is a participation constraint: the agent should get a profit or utility that is greater than its reservation one. Following this principle, we identify an optimal truth-telling contract menu (truth-telling means the contract menu can induce the retailer to report the truthful degree of loss aversion) by assembling some modified GL contracts. Furthermore, we find that under the optimal contract menu, the supply chain production quantity is smaller, total supply chain profit is lower, the manufacturer's profit is lower and the retailer's utility is higher with asymmetric information than without it. We also show that the coordinating contracts provided in Wang and Webster (2007) cannot coordinate the supply chain with the asymmetric information in an implementable way. However, under the optimal contract menu, the supply chain can be coordinated if the wholesale price is endogenously determined by the manufacturer and its lower bound is 0.

Next, we review the literature related to the present paper. First, the present paper is related to the supply chain models which deviate from the assumption of risk neutrality. There are mainly two streams of this literature: models incorporating risk aversion and models incorporating loss aversion.

The literature considering risk averse decision makers is rich (e.g., Lau (1980), Eeckhoudt et al. (1995), Agrawal and Seshadri (2000), Gan et al. (2004, 2005), Choi (2007), Choi et al. (2008a, 2008b), Wei and Choi (2010), Chiu et al. (2011), Choi and Chiu (2012)). Lau (1980), Eeckhoudt et al. (1995), Choi et al. (2008a) and Choi and Chiu (2012) investigate the optimal decisions of risk averse newsvendors under various risk measures (e.g., mean-variance, mean-downside-risk, etc.). Gan et al. (2004) provide the definition of coordination of supply chains consisting of risk averse members. Choi et al. (2008b), Wei and Choi (2010) and Chiu et al. (2011) consider the issues of supply chain coordination based on well-known contracts such as the buyback contract, the wholesale pricing and profit sharing contract and the target sales rebate contract. Agrawal and Seshadri (2000) and Gan et al. (2005) propose new contracts to improve supply chain performance and achieve supply chain coordination. Choi (2007) studies fashion retailers' pre-stocking and pricing decisions with risk considerations. Unlike these papers which assume that supply chain members are risk averse, our paper employs a loss aversion framework.

The studies on loss aversion are relatively limited but are growing fast in recent years. Sorger (1998), Greenleaf (1995), Kopalle et al. (1996), Fibich et al. (2003) and Popescu and Wu (2007) discuss the optimal pricing strategies of firms when considering customers' reference and loss aversion effects on historical prices. Schweitzer and Cachon (2000) and Wang and Webster (2009) discuss the optimal decisions for loss averse newsvendors. More generally, an exponential-type S-shaped utility function is used in Zhao et al. (2009). Recently, Ma et al. (2012) deal with a loss-averse newsvendor model with two ordering opportunities and market information updating. The above papers only analyze the decision making of a single enterprise rather than a supply chain. Ho and Zhang (2008) conduct a laboratory study to investigate how the use of the fixed fee in pricing contracts affects market outcomes of a manufacturer-retailer channel. Wang (2010) proposes a model where multiple newsvendors with loss aversion compete for inventory from a risk neutral supplier and identify two kinds of effects: demand stealing effect and loss aversion effect. It is shown that while the demand stealing effect increases total order quantity, the loss aversion effect decreases total order quantity. Shen et al. (2011) investigate a supply chain contract model where a loss-averse manufacturer purchases the components at a fixed price in advance and if there is a shortage, he will purchase extra units at a stochastic price. Liu et al. (2013) study a newsvendor game in which two substitutable products are sold by two different retailers (newsvendors) with loss-averse preferences. All the literature above assumes complete information, including the supply chain (channel) members' degrees of loss aversion. In contrast, the present paper assumes that the retailer's degree of loss aversion is asymmetric information.

Second, the present paper is also related to the principal-agent models which consider asymmetric information. Although the publications in this area are rich, they mainly focus on two kinds of asymmetric information: production cost information and market demand information. Examples for the first kind of asymmetric information include Corbett and de Groote (2000), Ha (2001) etc., and examples for the second kind include Cachon and Lariviere (2001), Ozer and Wei (2006) etc. More recently, new types of asymmetric information have emerged into literature, for example, quality (e.g., Kaya and Ozer (2003)), and risk sensitivity (Wei and Choi, 2010 and Xiao and Yang, 2009). Different from their papers, our work considers asymmetric information on supply chain member's degree of loss aversion.

Finally, the present paper is related to the literature on supply chain contracts and supply chain coordination. For this literature, see the comprehensive review by Cachon (2003).

The rest of the paper proceeds as follows. In Section 2, we describe our principal-agent model. In Section 3, assuming the wholesale price exogenously determined, we provide the optimal contract menu for the manufacturer and analyze the effects of information asymmetry. Section 4 discusses the cases of endogenous wholesale price and Section 5 investigates the issues of supply chain coordination. Finally, in Section 6, we come to the concluding remarks and future research directions.

2. Principal-agent model

Consider a supply chain consisting of one manufacturer (she) and one retailer (he). There is one selling season with stochastic demand for a single product and a single opportunity for the retailer to order inventory from the manufacturer before the selling season begins. The product is produced by the manufacturer at a unit cost c and sold by the retailer to customers at an exogenous retail price p. Leftover products at the end of the selling season are salvaged with a value of s per unit($s<c<p$). Without loss of generality, s is normalized to 0. The manufacturer sells products to the retailer at a wholesale price w. The market demand D possesses a cumulative distribution function (CDF) $F(x)$ and a probability density function (PDF) $f(x)$.The CDF $F(x)$ is defined over an interval $I\subset[0,+\infty)$ (we normalize the lower bound of I to 0 without loss of generality). As in most contract literature based on the newsvendor framework (e.g. Tsay et al. (1999), Cachon (2003)), we assume $F(x)$ is differentiable and strictly increasing on I. All parameters above are assumed to be common knowledge.

According to Wang and Webster (2007), we further assume that the manufacturer, which is the principal, is risk neutral, and the retailer (the agent) is loss averse, since the manufacturer can diversify her assets across multiple firms, while the retailer's income is tied to the manufacturer. Specifically, we assume that the retailer has a kinked piecewise linear utility function as

$$U(x)=\begin{cases} x-x_0, & \text{if } x>x_0,\\ \lambda(x-x_0), & \text{if } x\le x_0,\end{cases}$$

where x_0 is the reference point of the profit and λ ($\lambda\ge 1$) is a coefficient that measures the degree of loss aversion (larger λ represents higher degree of loss aversion). Although this piecewise