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Supply chain contract mechanism under bilateral information asymmetry

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ABSTRACT

In this paper, we investigate the problem of designing a mechanism under a bilateral asymmetric information structure. More specifically, we consider a supply chain consisting of one risk-neural manufacturer and one risk-averse retailer, they have private information regarding the manufacturing costs and degree of risk aversion, respectively. We firstly construct a model under the bilateral information asymmetry using the M-V approach. We then provide a wholesale price contract under bilateral information asymmetry to examine if the true information is revealed. We find that the manufacturer and the retailer overstate their information to gain more individual profit. To achieve the coordination, we propose an innovative coordinating contract mechanism, which contains the trading quantity, the transfer payments, and the profit allocation rules. With this coordinating contract, the manufacturer and the retailer announce their true private information and maximize their expected individual profit as well as the supply chain's profit. We find that the private information of risk aversion degree doesn't affect the supply chain performance under the coordinating contract. Further, the implementation of the contract is relevant to the two parties' profits and to the difference between the expected value of information and the true information. Finally, the numerical examples are presented to illustrate the main results.

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1. Introduction

In a decentralized supply chain, the firms are often separate and independent economic entities, and each member has its own state information. These informed firms may act independently and opportunistically to optimize their own benefit by misreporting their private information. Therefore, the information asymmetry is easily double-sided, i.e., both the up-stream and downstream have superior information. For example, in a supply chain under ODM (Original Design Manufacturer) form. A buyer (e.g., Sony) specifies the requirement of product to a manufacturer (e.g., Flextronics) then sells the product to the market. The manufacturer does some design work for the product and there are many variations, e.g., the production cost, the risk aversion degree. Thus, the manufacturer and the retailer may misreport their private information after production beginning. Since information sharing is

vital for making decisions, supply chain coordination depends on double-sided shared information.

Supply chain coordination is generally difficult to achieve in the case of one-sided private information, and the coordinating contract is a problem of controlling the informed party's response. There is always some room for misrepresenting relevant information as some empirical observations (Crocker & Slemrod, 2007). So, under the double-sided asymmetry case, two parties may both misreport their private information. Hence, the contract design problem becomes one where a game is designed with bilateral and incomplete information (Bolton & Dewatripont, 2005). To achieve the coordination, the challenge is to design the incentive schemes for controlling the strategic behavior of one party interacting with the other as well as sharing true information. What kind incentive schemes can induce the two parties to share true information and align their actions? What are the features of the coordinating contract under bilateral information asymmetry?

The purpose of this paper is to investigate the contract features and design coordinating contract under bilateral information asymmetry, as well as examine the implementation of the contracts. Different from the analyzing bilateral information

asymmetry in the fields of economics theory (e.g., Maskin & Tirole, 1990, 1992) and auction mechanism (e.g., Chen, Federgruen, & Zheng, 2001; Dutta, Sarmah, & Goyal, 2010; Jin & Wu, 2004), we centralize our research on supply chain management under information asymmetry. We concern more about the supply chain parties' behaviors under different contract forms and the contract features. While Maskin and Tirole (1990, 1992) and Pavlov (2009) consider the bilateral information asymmetry under the informed principal-agent model, we don't consider this framework. We consider a more general case that there's no leader or follower in the supply chain. This is because in general neither can control the entire supply chain (Li & Wang, 2007), especially when two parties both have information advantages. Further, the auction mechanism can be applied to supply chain management for improving efficiency (Babaioff & Walsh, 2005). And the rules are well known; there is (almost) no doubt that the game being played is the game described in a model (Pavlov, 2009). But under bilateral information asymmetry, the game may not be played as the rules described, especially in some stochastic environments. Thus, we focus on the innovative incentive schemes which are different from the auction mechanism. The incentive schemes are based on AGV (Arrow, 1979; d'Aspremont & Gérard-Varet, 1979) mechanism, but compromising the supply chain contracts (revenue sharing contract). Additionally, the incentive schemes enable ex-ante cooperation.

In this paper, we consider a supply chain with one up-stream firm (manufacturer) and down-stream firm (retailer). The retailer specifies a requirement of product to a manufacturer, and the manufacturer undertakes some design work. The manufacturer has the advantage of knowing the production cost. Facing a stochastic market demand, the retailer may prefer to be risk averse. The extent of the risk aversion may not be known by the manufacturer. Under such a setting, the manufacturer and the retailer negotiate a contract before production beginning, and the contract is contingent on the announced information after production beginning. We restrict our attention to the framework (Nash game) and discuss the supply chain efficiency and coordination under bilateral information asymmetry. Firstly, we give a wholesale price contract under bilateral information asymmetry as a benchmark and investigate the efficiency loss of the supply chain. We also compare the companies' decisions with those under one-sided information asymmetry. Then, we give a coordinating contract. We propose an innovative transfer payment based on AGV (Arrow, 1979; d'Aspremont & Gérard-Varet, 1979) mechanism, and examine the efficiency of our designed mechanism. The contract mechanism may be applied to a supply chain under ODM (Original Design Manufacturer) form. When the retailer specifies the requirement of product to a manufacturer, they can make an agreement on information sharing and profit allocation to enable the ex-ante cooperation. When they share their information, they can achieve the ex-post profit allocation.

The remainder of this paper is organized as follows. Section 2 reviews the literature. Section 3 describes the model. Section 4 analyzes the wholesale price contract with bilateral asymmetric information. Section 5 designs the coordinating contract under bilateral asymmetric information and examines the efficiency. Section 6 provides the numerical examples to illustrate the main results. Section 7 concludes this paper and presents directions for future research. Proofs are presented in the appendixes.

2. Literature review

This paper can be regarded as a study of supply chain efficiency and mechanism designing. In order to highlight our contributions, we review three aspects of literature that are particularly relevant to our study.

Macalay (1963) demonstrates that instead of relying on formal, court-enforceable contracts, firms cooperate by relying on informal agreements. Levin (2003) considers an agency problem with moral hazard or hidden information. The principal commits to pay the agent based on the outcome of his or her actions, but a formal contract is not written. This informal contract can be seen as a kind of relationship contract. Recently, many researchers have explored these contracts in operations management. Taylor and Plambeck (2007a) compare two different relation contracts: price-only contracts and contracts with price-and-quantity promises. The price-only contract commits the buyer to purchase a fixed quantity, whereas the price-and-quantity promises only specifies a per-unit price. Taylor and Plambeck (2007b) consider a supply chain for an innovative product; instead of the court-enforceable contracts, the firms adopt an informal agreement (rational contract) to create incentives for cooperation. In contrast to the above mentioned relational contracts, we address the contingent contract (not court-enforceable contract) under bilateral information asymmetry. We also design the incentive scheme to facilitate the cooperation of the two supply chain firms.

Since the asymmetric information is an important aspect of the supply chain, a large amount of research has concentrated on the impact of the asymmetric information and the information sharing mechanism. These related studies regarding the unilateral asymmetric information are mainly centralize on the asymmetric demand information (e.g., Feng, Lai, & Lu, 2014; Gan, Sethi, & Zhou, 2010; Hsieh, Wu, & Huang, 2008; Yue, Austin, Wang, & Huang, 2006, etc.) and the asymmetric cost information (e.g., Çakanyildirim et al., 2012; Ha, 2001; Lau, Lau, & Zhou, 2006; Lei, Chen, Wei, & Lu, 2015; Shen & Willems, 2012; Wang, Lau, & Lau, 2009; Yang, Xiao, Choi, & Cheng, 2015, etc.). Under the asymmetric information case, screening contracts (or menus of contracts) are frequently used for aligning the incentives in the supply chain with private information (Voigt, 2014).

However, the fact that the private information is asymmetric to one party, as implicitly assumed in the above-mentioned literature has some practical limitations. The supply chain models under the bilateral asymmetric information scenario also have aroused some researchers' interests. The literature mainly concentrates on economic theory and auction mechanism as well as supply chain management. Chatterjee and Samuelson (1987) analyze that the seller and the buyer achieve bilateral asymmetric information by bargaining strategy, and their private information is the evaluation of commodity price. Zhang and Luo (2009) explore the trade credit in a coordinating supply chain under bilateral information asymmetry senior. In the proposed model the manufacturer possesses the private information regarding its own capital cost while the retailer has the private information about the budget constraints or capital cost. Esmaeili and Zeephongsekul (2010) consider a supply chain in which the buyer and seller have private information about demand information and purchase costs respectively. Pavlov (2009) consider a bilateral asymmetric case that the supplier and the retailer both have private information about their costs. Wang, Guo, Wang, and Zhong (2014) consider the bilateral costs information asymmetry, and design a profit allocation contract. Some bilateral asymmetric information problems can be seen in the analysis of auctions (e.g., Babaioff & Walsh, 2005; Chen et al., 2001; Dutta et al., 2010; Jin & Wu, 2004). In contrast to the previous research of bilateral information asymmetry, our work focuses on bilateral information asymmetry under risk aversion environment. The retailer favors risk aversion and the aversion degree is private information and the manufacturer has his private production cost. This setting is different from the research on the bilateral information