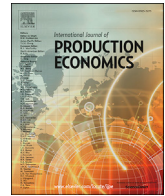


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International Journal of Production Economics

journal homepage: www.elsevier.com/locate/ijpe

Supply chain coordination under vendor managed inventory-consignment stocking contracts with wholesale price constraint and fairness



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ARTICLE INFO

Keywords:

Supply chain coordination
Wholesale price constraint
Fairness
VMI-CS contract

ABSTRACT

In the retailing industry, dominant retailers usually set constraints on a supplier's wholesale price and obtain most of the supply chain profit. This unfair profit allocation may cause bankruptcy of small suppliers due to low margins. This paper investigates the supply chain coordination under a vendor managed inventory-consignment stocking contract with wholesale price constraint and fairness considerations. First, we derive the retailer's optimal wholesale price constraint (WPC) and the supplier's optimal production quantity. Then, we derive the supply chain coordination condition by considering the fairness of profit allocation between the retailer and the supplier. Our analyses show that increasing the fairness preference not only restricts the retailer's utility function and WPC, but also increases the supplier's expected profit and production quantity. Furthermore, supply chain coordination can be achieved only when the retailer has a large fairness preference. Through a simulation study of multiple-period decision-making problems, we illustrate the benefits and motivation for the retailer to consider fairness in profit allocation when production cost and market demand are uncertain.

1. Introduction

Within the ever-expanding global supply chain environment, “big-box” retailers like Walmart have been openly selecting suppliers that provide products with a low cost and high quality in a global manner. Because most of those retailers generate large sale volumes, becoming their supplier can guarantee a manufacturer with stable market shares and high utilization of production capacity. Most of the suppliers highly rely on low labor costs and are sensitive to fluctuations in the raw material price, labor cost, and currency exchange rate. The “big-box” retailers are dominant in key decision making (e.g., inventory control and price) in the supply chain. In addition, these retailers usually have various supplier substitution options (Kumar 1996) to achieve the cost leadership. In contrast, the suppliers of these “big-box” retailers are normally followers in the supply chain. Due to the leader-follower relations in the supply chain, the supplier's wholesale pricing decision has been restricted by the dominant retailer setting a wholesale price constraint (WPC). Correspondingly, the supplier has few other options (e.g., raising wholesale price or switching to other retailers) rather than accepting the restricted wholesale price to secure the market share (Fishman, 2006). However, the low profit margin makes the suppliers

vulnerable to even a small degree of negative effect from the business environment (e.g., a boost in raw material price).

To resolve the above-mentioned issue, we propose to adopt vendor managed inventory-consignment stocking (VMI-CS) contracts in the supply chain. A VMI-CS contract is a form of consignment contract, which is already widely adopted in a number of industries (Battini et al., 2010) and often used by dominant retailers to reduce the private transaction costs of meter pricing (Markovits, 2014). However, the wholesale pricing behavior of dominant retailers negatively impacts the supply chain that uses a consignment contract in the following ways. First, the behavior lowers the supplier's unit profit, which results in self-defeating practices of the supplier. For instance, Walmart's supplier Kraft Foods, shut down thirty-nine plants, laid off 13,500 workers, and eliminated a quarter of its products due to low profit margins (Lynn, 2006). Moreover, an extremely low profit margin of the supplier may eventually compromise the supply chain cooperation. These behaviors can have negative impacts on the long-term growth and the strength of supply chain cooperation (Linton et al., 2007). Second, the low-price strategy puts the retailer in a dilemma between low retail price and high product quality. Consumers express that the quality and safety of products are their priorities when making a purchase decision, rather than the low price, which has led to a revenue

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<https://doi.org/10.1016/j.ijpe.2018.05.009>

Received 25 January 2017; Received in revised form 3 April 2018; Accepted 9 May 2018

decline. That is because a low retail price is often perceived as low quality and less safety (Trefis Team, 2014). All these challenges for consignment contract application need to be addressed to improve supply chain performance.

In a VMI-CS contract, the supplier retains full ownership of inventory and bears the risks associated with overstocking. In this paper, the supplier determines the production quantity (i.e., supply quantity or stock level) for the product. If the retailer utilizes its dominant power to restrict the product wholesale price, the supplier may only have little potential profit. This scenario hurts the fair allocation of supply chain profits and may eventually result in supply chain disruptions. Numerous studies have shown that the fairness factor plays a key role in reducing channel conflicts and maintaining partner relationships in a supply chain (Fehr and Schmidt, 1999; Corsten and Kumar 2005; Wu and Niederhoff, 2014). In a supply chain, distributive fairness is related to inequity aversion (Cui et al., 2007). Thus, in order to reduce channel conflicts and maintain supply chain member partnership, it is necessary for dominant retailers to consider distributive fairness in the contract design to balance the allocation of supply chain profits. However, supply chain coordination and profit allocation under the VMI-CS contract design have not been fully examined under the condition that the wholesale price is constrained by the dominant retailer. This paper studies the supply chain coordination problem under a VMI-CS contract by considering the wholesale price constraint and the fairness of supply chain profit allocation.

Regarding the subject of supply chain coordination under a VMI-CS contract, Wang et al. (2004) is the research work that is related to our study. Wang et al. (2004) studied a consignment contract with revenue sharing. By using an iso-price-elastic and multiplicative demand model, they fully characterized the decentralized decisions and derived closed-form performance measures. Different from Wang et al. (2004), in our model, the production (supply) quantity is determined by the supplier, the product sale price is exogenous, and the market demand is in a general form. Instead of using revenue sharing, we introduce fairness consideration to coordinate the supply chain. To the best of our knowledge, this paper contributes to the literature in the following aspects:

- (1) We model a VMI-CS contract by considering the wholesale price constraint and the supply chain profit allocation fairness, and derive the retailer's optimal WPC and the supplier's optimal production quantity.
- (2) We then derive the supply chain coordination condition, which is achieved only when the fairness preference is significantly large.
- (3) Our analyses show that increasing the fairness preference does not only restrict the retailer's utility function and WPC, but also encourages the growth of the supplier's expected profit and production quantity.

The remainder of this paper is organized as follows. Section 2 reviews the related literature. Section 3 provides model assumptions and various notations used throughout the paper. Section 4 provides the model for the VMI-CS contract with wholesale price constraint and fairness, and Section 5 discusses the effect of wholesale price constraint and fairness on supply chain decisions and performances. Section 6 discusses the supply chain coordination problem. Section 7 provides simulation experiments. Section 8 concludes the paper with future directions and extensions.

2. Literature review

The model setting we consider in this paper has three distinctive features: (1) VMI-CS contracts, (2) a dominant retailer who enforces a wholesale price constraint, and (3) fairness. In this section, we conduct a literature review based on these model features.

Firstly, we discuss papers that only address the employment of consignment contracts in supply chain management. Sarker (2014)

provided a comprehensive survey on consignment stocking policy models for supply chains. To investigate the optimal decisions under consignment contract, Wang et al. (2004) studied the consignment contract with revenue sharing. Using an iso-price-elastic and multiplicative demand model, they fully characterized the decentralized decisions and derived closed-form performance measures. In addition, they showed that under a consignment contract, both the overall channel performance and the performance of individual companies are affected by the demand price elasticity and the retailer's share of channel cost. Hu et al. (2014) investigated consumer non-defective returns behavior under consignment contracts. They found that the salvage value of returns is a key factor for vendors making return policy. Lim et al. (2015) investigated consignment contracts with revenue sharing for a supply chain consisting of a capacitated retailer and multiple manufacturers. They showed that there exists a unique optimal revenue share if all products have identical price elasticity or price elasticity no larger than 2. For virtual product supply chains, Avinadav et al. (2015a, 2015b) discussed the effect of risk sensitivity on a mobile application supply chain under a consignment contract. They showed that the retailer's (the platform provider) utility function has no effect on the equilibrium strategies. In the topic of supply chain coordination for consignment contracts, Li et al. (2009) studied the consignment contract with revenue sharing. In their model, the manufacturer chooses the delivery quantity and the retail price of the product, and the retailer determines the revenue shares. They showed that when the demand distribution is slightly restricted, the decentralized supply chain can be perfectly coordinated. In addition, cooperation results in better profits for both the manufacturer and the retailer. Zhang et al. (2010) studied a coordination problem in a consignment channel with multi-tier bonus structure and revenue sharing with side payment. They found that revenue sharing with side payment contracts not only fully coordinated the channel, but they could also be customized to meet the needs of suppliers of different scales for extra retailer services (e.g., warehousing and transportation). Our paper focuses on the supply chain coordination under a consignment contract. Different from Li et al. (2009) and Zhang et al. (2010), in our model the dominant retailer sets the wholesale price based on the pre-defined unit profit; then, the supplier determines the production quantity based on the given wholesale price. Furthermore, we consider the fairness in terms of the profit allocation within the supply chain.

In our contract model, we transfer the order quantity decision from the retailer to the supplier as its production quantity. Dominant retailers' objective is to maximize the profit, and they will be willing to transfer the order quantity decision if they can obtain a higher profit by doing so. According to Markovits (2014), dominant retailers can use the mechanism to reduce the private transaction cost of meter pricing. Similar replenishment decision making mechanism is also adopted in VMI-CS contracts in which the supplier determines the production (supply) quantity (Li et al., 2009). VMI-CS contracts have been addressed by several researchers in the literature. A few papers have demonstrated that VMI-CS contracts can improve supply chain performance. Chen et al. (2010) utilized VMI-CS contracts to analyze the supply chain coordination under both cooperative and non-cooperative scenarios in a dominant manufacturer setting. Ben-Daya et al. (2013) studied the benefits of VMI-CS contracts under decentralized and centralized supply chain decision making structures. They found the conditions for both supplier and retailer to be better off under VMI-CS contracts. Lee et al. (2016) used an EOQ model to analyze vendor-managed inventory (VMI) systems with stockout cost sharing under limited storage capacity. They showed that the integration of VMI with stockout-cost sharing can achieve the same replenishment decisions and system performance when the supplier's reservation cost equals the minimum supply chain total cost. Gumus et al. (2008) demonstrated that VMI-CS contracts can reduce vendor's cost and supply chain total cost compared with consignment stock policy only. Zaroni et al. (2012) explored the learning and forgetting effects for the vendor's production under VMI-CS contracts. The paper showed that VMI-CS contracts can provide the vendor with cost advantage by

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