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Study on the coordination contract in supply chain under trade credit based on risk compensation

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ABSTRACT

Trade credit changes the inventory risk between supplier and retailer. This leads to failure in the coordination of the supply chain. Considering that the supplier bears the retailer's inventory risk under the credit condition, in this paper, the contract is constructed by combining the risk compensation and quantity discount contract to re-coordinate the supply chain and analyze the contract. The results show that the contract can achieve voluntary supply chain coordination; and when the seller's funds is within a certain range, the coordinate contract can perform in the form of the wholesale price contract, and the wholesale price is influenced by its own funds and product value. In the end, a numerical example is given to verify this conclusion.

1. Introduction

99% of companies are small and medium-sized in mainland China [1]. Capital constraint is their common problem and also one of the bottlenecks in the process of development. Under the background of the economic slowdown, not only some small and medium-sized companies but also some large ones face the risk of bankruptcy. Because of credit deficiency, some small and medium-sized companies cannot finance from financial institutions to ensure continued operation, and trade credit becomes an important option for them to solve the capital constraints. Credit is popular among companies, as that in P2P network [2]. According to the survey, at the beginning of this century, trade credit has occupied 80% of the trades among British companies' [3], and the same in the United States [4].

The uncertainty of market demand puts sellers under the inventory risk. Trade credit transfers this risk to suppliers if sellers cannot pay the account. And, suppliers will have the risk of bad debt and bankruptcy, etc. For example, the demand declined under the U.S. subprime mortgage crisis, which leads to retailer's lower revenue or even bankruptcy and a lot of bad debts to suppliers, causing some of the suppliers going bankruptcy and resulting in the risk of supply chain. The risk of supply chain has been listed as one of the world's most serious business risks in 2007 [5]. Therefore, when suppliers and retailers make trade credit, they need to consider the risk fully and strictly control the credit risk to increase their income and improve the efficiency of the supply chain. Supply chain coordination is best signifies efficiency, however, in face of the credit risk, how to control risk and realize supply chain coordination, especially how to realize supply chain coordination voluntarily? This is the key problem in the research of supply chain coordination.

Many literatures about trade credit studied the EOQ model based on the deterministic demand. Some of them discussed the retailer's optimal order, and then extended

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to perishable products [6,7]. The suppliers' optimal credit policies [8] and conditional trade credit policies [9] are studied as well. The supply chain coordination in trade credit has also become a heated discussion [10] and are researched in a variety of conditions and assumptions, such as considering the joint procurement [11] and competitive supply chain [12], etc. However, the demand of the product is influenced by competitive products, consumer preferences and so on, so it is dynamic and uncertain. It is this uncertainty that brings the inventory risk to retailers and credit sale risk to suppliers. As a consequence, it's necessary to study the supply chain trade credit based on uncertain demand.

Based on the assumption of demand uncertainty, the mainstream research studies retailer's inventory strategy, supplier's trade credit policy, efficiency and coordination by use of newsvendor model. Robb and Silver designed algorithm to study the optimal inventory strategy [13], but Gupta held that trade credit doesn't affect inventory strategy [14]. These literatures studied on the inventory strategy with the existing credit policy and some discussed the credit sales policy and supply chain efficiency. And some of them which have similar results with this paper , which are listed as follows. Through the research of the retailer's ordering strategy and supplier's credit policy, Ren etc. pointed out that suppliers can coordinate the supply chain and get all of the profits in the supply chain by adjusting the interest rate [15]. Lee etc. held that suppliers could use the buy-back contract, revenue sharing contract and quantity discount contract to coordinate the supply chain in the trade credit [16,17]. Chen analyzed the retailers' ordering strategy and the suppliers' wholesale pricing strategies and pointed out that the wholesale price contract can partly coordinate the supply chain [18]. At the same time, Gang studied the sellers of loss aversion and also got the conclusion that the buy-back contract can coordinate the supply chain under the trade credit [19]. His other research showed that suppliers can achieve risk control and supply chain coordination through pricing and selecting the retailers with some free capitals [20]. Yan pointed out that the wholesale price contract cannot achieve the supply chain coordination, and revenue sharing contract can achieve supply chain coordination, considering the voluntary of both the suppliers and sellers [21]. The current literatures are in dispute on whether the wholesale price contract can coordinate the supply chain under credit trading. The quantity discount contract used widely can realize coordination under the trade credit, but could it achieve voluntary coordination? Perishable goods are often seen as the research subject of trade credit. And what is the influence of the product with maintain value on the coordination? There are few literatures focusing on these questions.

This paper considers the uncertainty of market demand. Focusing on the products with maintain value, it is analyzed the influence of valuableness on order quantity and the profit of both the supplier and the retailer. It is researched if the contract combining credit risk compensation and quantity discount contract could achieve supply chain coordination voluntarily. This paper is different from the existing literatures. The coordination of the wholesale price contract is discussed by use of the risk compensation and quantity discount contract. Then, the impact of products' maintaining value on the contract is analyzed in order to offer theoretical basis and policy recommendations to the credit trading and supply chain management. At last, this paper uses the numerical examples to demonstrate the conclusions.

2. Model assumptions and notations description

2.1. notations

p Retail price of the product
c Unit cost of the supplier
ω Unit wholesale price
S Unit salvage value of the remaining at the end of selling period, and $S < c \le \omega < p$
y The demand per sales period
q Retailer's order quantity
η Retailer's own funds
π_r The expected profit function of retailer
π_s The expected profit function of supplier

2.2. Hypothesis

(1) Under constant retail price p, the market demand y is a random number within the scope of $[0, \infty)$ and its distribution function $F(y)$ is continuously differentiable to y and note $\bar{F}(y) = 1 - F(y)$. Its density function is $f(y)$. The distribution is the common knowledge of the supplier and retailer.

(2) The supplier decides wholesale price ω, and the retailer decides order quantity q to maximize his expected profit. The product is seasonal goods and cannot order again beyond sales period.

(3) Trade credit is adopted due to the retailer's limited capital. If the retailer cannot afford the goods (i.e. $\eta < \omega q$), he will pay it by his own money η when delivering the goods and the remaining payment $(\omega q - \eta)$ will be paid at the end of sales season, meaning suppliers should provide trade credit for this part of the goods. When $\omega q - Sq \le \eta < \omega q$ (which means $\omega q - \eta \ge Sq$), the suppliers have no credit risk because trade credit only means a delayed payment, similar to the situation of credit sell with no inventory risk transfer. This paper focuses on the situation the trade credit with inventory risk which means $\eta < \omega q - Sq$[1].

(4) At the end of sales season, if sales situation is good, the retailer pays the account $\omega q - \eta$. If the sales situation is bad, the retail can't repay account and he will give all his income py and salvage value $S * \min[q - y, 0]$ to the suppli-

[1] If the sum of retailer's own funds, final sales revenue and the final salvage value of not selling products is more than the total ordered dollar, the suppliers will not bear the risk of trade credit. In a word, when $\eta + py + S(q - y) \ge \omega y$, suppliers do not have the credit risk. It is written in another form that when $\eta \ge \omega q - Sq - (p - S)y$ the supplier has no credit risk. If $y = 0$, the inequation still holds. It means that even if sellers sell few products, they could pay the account by the salvage value of products. So when $\eta \ge \omega q - Sq$, it means that suppliers do not have credit risk, and trade credit only means delaying the payment.