



# Financing for Newsboys with Information Asymmetry from Small Suppliers

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**Abstract.** This paper studies the bank credit and trade credit in a supply chain consisting of two asymmetric suppliers and one retailer with uncertainty demand and internal capital information asymmetry. Under two types of credit, we derive the key parameters under Stackelberg equilibrium, and demonstrate that high relative diversion risk level and low internal capital limit the bank credit, which affects the retailer's order strategy. If the capital-constrained retailer only chooses one credit, retailer with high relative diversion risk level chooses trade credit, retailer with low relative diversion risk level chooses bank credit. Under low relative diversion risk level, retailer with low internal capital chooses bank credit, while high internal capital retailer's preference for specific credit depends on risk-free interest rates of two credit. We further demonstrate that the retailer gains more profits from the big supplier in competition and big supplier needs to provide interest rates no higher than the bank's risk-free rate to win competition with small supplier. The value of small supplier competition to retailer decreases with the small supplier's production cost and bank's risk-free interest rate, and the retailer with low internal capital can gain more value of competition than the retailer with high internal capital.

**Keywords:** capital constraint; newsvendor; bank credit; trade credit; information asymmetry; competition

## 1 Introduction

Adequate cash flow is the foundation of every business for operation in the supply chain. Arcadia Group (Hanna Ziady 2020) and Rue21 (Jordan Valinsky 2024) <sup>[1]</sup>announced bankruptcy, partly due to insufficient cash flow. In addition, due to rising energy costs and global shutdowns, Chesapeake Energy (Cathy Bussewitz and Tali Arbel 2020) in the United States and Speedcast International Ltd (Fraser Tennant 2020) in Australia have had to apply for bankruptcy protection. In March 2023, US regulatory authorities closed Silicon Valley Bank (SVB) and designated the Federal Deposit Insurance Corporation (FDIC) as the receiver, citing "insufficient liquidity and insolvency" (Jesse Pound 2023). Limited liquidity of cash is a common constraint to

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corporate procurement decisions, constraints on business capital forced the enterprises to purchase products with credit.

The remainder of this paper is organized as follows. In section 2, we review the relevant literature. In section 3, we introduce basic model, notation and assumptions in detail. In Section 4, we consider the supply chain with small supplier competition, analyze the credit decisions of retailer and study the value of competition for the retailer. In Section 5, we carry out numerical simulations to support the results of this paper. In Section 6, we draw conclusions and propose possible extensions.

## 2 Literature Review

Our research is related to supply chain operations management and finance, and there is a large amount of academic research on the intersection of these two fields (Birge 2014). Three streams of the literature are related to our research, that is, credit financing under capital constraints, information asymmetry and the principal-agent theory, supply chain competition.

The first stream of literature focuses on credit financing under capital constraints. Most of the theory of trade credit is concentrated in a two-tier supply chain of a supplier and a retailer (Chod 2016, Jing et al. 2012). Jia, Qiang and Keung (2021)<sup>[2]</sup> study investigates how demand uncertainty reduction (DUR) affects the decisional dynamics within a supply chain, which comprises a supplier and a capital-constrained retailer, who chooses between bank credit and trade credit financing. Shi and Li (2021)<sup>[3]</sup> investigated how demand uncertainty reduction affects the decisional dynamics within a supply chain. Many literatures consider more forms of financing. Eccles and Siciliani (2026)<sup>[4]</sup> study how information about prior loan applications shapes competition in credit markets, and examine whether credit registers should record applications that did not lead to origination. Kouvelis and Zhao (2011)<sup>[5]</sup> proposed bankruptcy costs and analyzed the optimal ordering decisions under trade credit in the retailer's bankruptcy newsvendor model. Kouvelis and Zhao (2012)<sup>[6]</sup> considered that both retailers and suppliers are capital constrained, and they use a Stackelberg game framework (supplier as a leader) to arrive at an optimal trade credit contract with retailers facing uncertain demand.

## 3 Model and Notation

Consider a supply chain consisting of a capital-constrained retailer ("he"), two asymmetrical suppliers ("she"), in which retailer orders products from big suppliers within a single sales season. The retailer with limited liability can borrow from bank or big supplier. In condition of bank credit, the retailer borrow credit to purchase products, meanwhile, he may transfer credit to other risk items (Burkart et al. 2004), therefore, it makes sense to provide appropriate contracts to keep away moral hazard. In condition of trade credit, the big supplier allows the retailer first ordering products and then postponing payment after the end of the sales season. Because products are generally not easy to transfer, furthermore, in the process of supply chain financing, we do not

consider the moral risk of trade credit. However, the retailer may hide true internal capital information in trading, how to design contracts with asymmetry information plays a very practical role.

We analyze two scenarios: In the case of a supply chain without small supplier, retailer can choose bank credit or trade credit and then orders products from big supplier, based on Stackelberg game, big supplier becomes the leader, and retailer is follower. In the case of a supply chain with small supplier, retailer becomes the leader in the game, ordering products from small supplier with the help of bank credit, at this time, the trade credit contract provided by big supplier for retailer would consider the impact of the competition.

Conditional on the retailer’s internal capital  $y$ , we divide retailers into two types,  $H$  and  $L$ , based on the size of internal capital. The probability that the internal capital is a high type  $B_H$  is  $\phi_H$ , a low type  $y_L$  is  $\phi_L$ , among that  $y_H > y_L$ , and  $\phi_L = 1 - \phi_H$ . We assume that market demand is a continuous random variable, with density function  $f(\xi)$ , cumulative distribution function  $F(\xi)$ , And we can also define  $\bar{F}(\xi) = 1 - F(\xi)$ . Similar to the existing literatures, we assume that demand distribution satisfies increasing failure rate.

The sequence of events in the model is as follows: (1) The big supplier provides wholesale price contracts to retailer, consisting of trade credit contracts (including wholesale price and credit interest rate  $(w_i^T, r_i^T) \ i \in (L, H)$ ) corresponding to two types of retailers and wholesale price  $w_i^B$  corresponding to bank credit. When the wholesale price  $w_i^B$  is feasible, and the retailer needs to pay for the products at the beginning of the sales season. When the wholesale price  $w_i^T$  is feasible, and the retailer can defer payments at the end of the sales season. (2) Under the given contract, the retailer determines financing strategy and optimal order quantity  $q$ . If retailer chooses bank credit, the bank provides a contract with credit limits and interest rate  $(\bar{L}_i, r_i^B) \ i \in (L, H)$ , retailer can choose to cooperate with big supplier, or reject big supplier and then cooperate with small supplier by providing an acceptable wholesale contract, which includes wholesale  $w'_s$ . If retailer chooses trade credit, he can only participate big supplier’s contract. (3) The retailer makes financing decision and sells products to the customer at an exogenous price of  $p$ . At the end of the sales season, the sales revenue of the retailer would be repaid to the creditor (bank or big supplier). To represent different financing scenarios, the superscript “ $B$ ” represents parameters under bank credit, the superscript “ $T$ ” represents parameters under trade credit. The subscript “ $L$ ” represents parameters for low-internal capital, the subscript “ $H$ ” represents parameters for high-internal capital. For example,  $\Pi_R^T$  represents the retailer’s expected terminal cash flow under trade credit,  $w_L^T$  represents the low-internal retailer’s wholesale price under trade credit.

Model notation is summarized in Table 1.

**Table 1.** Summary of notation.

| Symbol | Meaning              |
|--------|----------------------|
| $p$    | Product retail price |

|                             |   |
|-----------------------------|---|
| $c, c'$                     | Unit production cost of big supplier and small supplier, respectively         |
| $y_i$                       | Retailer's internal capital, $i \in (L, H)$                                   |
| $\phi_i$                    | The probability of retailer type, $i \in (L, H)$                              |
| $\Pi_R^j, \Pi_S^j, \Pi_B^j$ | Profit of retailer and supplier, respectively $j \in (B, T)$                  |
| $w_i^j$                     | Wholesale price, $i \in (L, H), j \in (B, T)$                                 |
| $q_i^j$                     | Order quantity, $i \in (L, H), j \in (B, T)$                                  |
| $r_i^j$                     | Interest rate in trade credit or bank credit, $i \in (L, H), j \in (B, T)$    |
| $L_i, \bar{L}_i$            | Credit size and credit limit in bank credit, $i \in (L, H)$                   |
| $r_f$                       | Risk-free interest rate under bank credit                                     |
| $\bar{r}$                   | Risk-free interest rate when retailer invests internal capital to other items |
| $r_s$                       | Risk-free interest rate under trade credit                                    |
| $\varphi$                   | The retailer realizes $\varphi$ (percent) for every unit of diverted cash     |

Our main assumptions follow:

A1: The bank, retailer and suppliers are all risk neutral.

A2: The bank operates in a competitive financial market.

A3: The retailer is creditworthy and will repay their credit obligation (if any) to the extent possible.

A4: We assume that retailer can earn  $\varphi$  for per unit of diverted cash in bank credit (Burkart et al., 2004). However, in trade credit, products are often not easily transferred, therefore, moral hazard is not considered.

## 4 Supply Chain with Small Supplier Option

In this section, we study the supply chain consisting of a big and a small asymmetric competitive supplier, a capital-constrained retailer. As (Özer, Ö, Raz G. 2011) assumed, two suppliers provide homogeneous products, and the retailer chooses one supplier for cooperation. The retailer can only obtain trade credit when collaborating with big supplier; When the retailer chooses bank credit, he can cooperate with big or small supplier. The bank is only the financing party and does not participate in the overall operational decision-making of the supply chain, which means that the bank does not care which supplier the retailer cooperates with, that is, the bank credit contract remains unchanged. From the perspective of big supplier, her objective is to win competition with small suppliers by providing suitable trade contracts for retailer. Therefore, we will focus on trade credit contracts under competition and the value of competition for retailer.

Small supplier hopes to cooperate with the retailer to establish reputation, and the business of retailer accounts for a large proportion of small supplier. These factors lead the retailer to be the leader of the game, while small supplier is follower, that is, the

retailer can establish contract terms to determine wholesale price. Without losing the generality, the expected profit of small supplier is assumed to be zero. This is in line with reality, in order to broaden their recognition in the industry, many small companies who are in the early stage of the venture would cooperate with relatively large company even if they don't make profits.

Assuming the bank credit interest rate is  $r$ , then for a retailer, his expected terminal cash flow function is:

$$\Pi_R = \mathbf{E}[p\min(q, \xi) - (wq - y)(1 + r)]^+$$

In addition, the small supplier is at least profitable, otherwise, she would reject the contract. We assume  $\Pi'_s$  denoting the profit of the small supplier and production cost is  $c'$ , then:

$$\Pi'_s = (w - c')q \geq 0$$

Next, we study wholesale price  $w'_s$  when retailer chooses small supplier.

$$\Pi_R = \mathbf{E}[p\min(q, \xi) - (w'_s q - y)(1 + r)]^+ \tag{1}$$

$$\Pi'_s = (w'_s - c')q \geq 0 \tag{2}$$

Taking the first derivative of  $\Pi_R$  with  $w'_s$ , we have:

$$\frac{\partial \Pi_R}{\partial w'_s} = -q(1 + r)\bar{F}\left(\frac{(w'_s q - y)(1 + r)}{p}\right) < 0 \tag{3}$$

Get the first derivative of  $\Pi'_s$  with  $w'_s$ :

$$\frac{\partial \Pi'_s}{\partial w'_s} = q > 0 \tag{4}$$

Therefore, the small supplier's profit increases with  $w'_s$ , and the retailer's cash flow decreases with  $w'_s$ . So, as the leader, retailer can get the optimal contract when the wholesale price is equal to the small supplier's production cost, i.e.,  $w'_s = c'$ . According to the  $\mathbf{E}\min\{p\min(q_i^B, \xi), L_i(y_i)(1 + r_i^B)\} = L_i(y_i)(1 + r_f)$ , the retailer's terminal cash flow function and optimal order quantity is:

$$\Pi_R = \mathbf{E}p\min(q, \xi) - (c'q - y)(1 + r_f) \tag{5}$$

$$q^* = F^{-1}\left(\frac{p - c'(1 + r_f)}{p}\right) \tag{6}$$

Next, considering the problem of big supplier. The big supplier maximizes her profit by offering suitable contract (including wholesale price  $w_i^{T2}$  and interest rate  $r_i^{T2}$ ). Unlike the situation without small supplier, she must consider retailer's other purchasing options.

$$\Pi_R^{T2}(w_L^{T2}, r_L^{T2}, y_L) \geq \Pi_R(c', r_f, y_L) \tag{7}$$

$$\Pi_R^{T2}(w_H^{T2}, r_H^{T2}, y_H) \geq \Pi_R(c', r_f, y_H) \tag{8}$$

The left side of (7) and (8) respectively indicate the profit that low-type retailer and high-type retailer can earn when accepting trade credit contract with small supplier's competition. The right side of (7) and (8) indicate the profit that the retailer can earn when purchasing products from small supplier. Therefore, the model of the big supplier's problem in this section is as follows:

$$\begin{aligned} \Pi_S^{T2} = & \phi_L\{(w_L^{T2}q_L^{T2} - y_L)(1 + r_L^{T2}) - cq_L^{T2}\} \\ & + \phi_H\{(w_H^{T2}q_H^{T2} - y_H)(1 + r_H^{T2}) - cq_H^{T2}\} \end{aligned} \tag{9}$$

$$\Pi_R^{T2}(w_L^{T2}, r_L^{T2}, y_L) \geq \Pi_R(c', r_f, y_L) \tag{10}$$

$$\Pi_R^{T2}(w_H^{T2}, r_H^{T2}, y_H) \geq \Pi_R(c', r_f, y_H) \tag{11}$$

$$\Pi_R^{T2}(w_L^{T2}, r_L^{T2}, y_L) \geq \Pi_R^{T2}(w_H^{T2}, r_H^{T2}, y_L) \tag{12}$$

$$\Pi_R^{T2}(w_H^{T2}, r_H^{T2}, y_H) \geq \Pi_R^{T2}(w_L^{T2}, r_L^{T2}, y_H) \tag{13}$$

Based on the above model, the specific analysis of the optimal contract provided by big supplier is shown in Theorem 1.

**Theorem 1.** Let  $x_i^{T2} = w_i^{T2}(1 + r_i^{T2})$ ,  $G_i^{T2}(x_i^{T2}) = pEmin(q_i^{T2}(x_i^{T2}), \xi) - x_i^{T2}q_i^{T2}(x_i^{T2})$ ,  $i \in (L, H)$ , the optimal solution for big supplier's problems in trade credit:

(1) For low-type retailer  $y_L$ :

$$\begin{aligned} x_L^{T2*} &= c(1 + r_L^{T2}) \\ r_L^{T2*} &= r_f + \frac{1}{B_L} \left[ -G_L^{T2}(x_L^{T2}) + G_L(c'(1 + r_f)) \right] \end{aligned}$$

(2) For high-type retailer  $y_H$ :

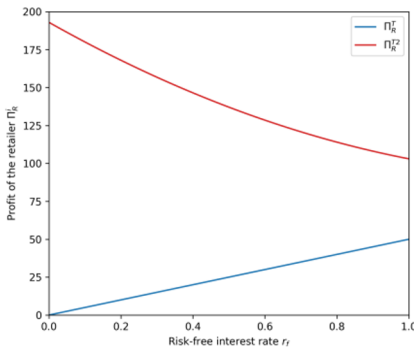
$$\begin{aligned} x_H^{T2*} &= c(1 + r_H^{T2}) \\ r_H^{T2*} &= r_f + \frac{1}{y_H} \left[ -G_H^{T2}(x_H^{T2}) + \frac{y_L - y_H}{y_L} G_L^{T2}(x_L^{T2}) + \frac{y_H}{y_L} G_L(c'(1 + r_f)) \right] \end{aligned}$$

Theorem 1 gives the optimal contract parameters for trade credit under competition. the optimal deferred wholesale price of big supplier to the retailer is  $(1 + r_i^{T2})$  times her production cost  $c$ , Indicating that big supplier still keeps wholesale prices as low as possible to attract retailer and win competition. However, compared to the scenario

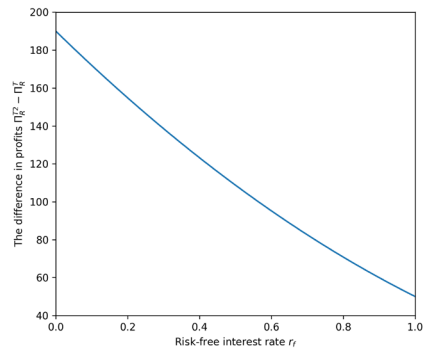
without competition, different trade credit interest rates have an impact on deferred wholesale prices. Similarly, the interest rate of low-type contract is only related to the corresponding internal capital and deferred wholesale prices, while the interest rate of high-type contracts is related to two types of internal capital and corresponding deferred wholesale prices.

### 5 Retailer’s Decision: With Small Supplier Option

Consider another example, suppose  $p = 2$ , the production cost of big supplier  $c = 0.9$ , the production cost of small supplier  $c' = 0.93$ , the internal capital of high-type retailers  $B_H = 100$ , the internal capital of low-type retailer  $B_L = 50$ . The difference in trade credit interest rates before and after competition, that is  $r_i^{T2} - r_i^T = -0.05$ ,  $i \in (H, L)$ . For the convenience of comparison, assume that  $r_f = \bar{r}$ .



**Fig. 1.** Impact of  $r_f$  on the low-type retailer’s credit decision



**Fig. 2.** Impact of  $r_f$  on the high-type retailer’s credit decision

The Y-axis of the Fig. 2 represents the retailer’s cash flow with small supplier minus the retailer’s cash flow without small supplier. Both Figs. 1 and 2 illustrate that regardless of the type of retailers, they will gain more cash flow from the big supplier in competition. This conclusion is consistent with Theorem 1 that the retailers can gain more cash flow from the big supplier when small supplier participates in competition, that is:  $\Pi_R^{T2}(w_i^{T2}, r_i^{T2}, y_i) > \Pi_R^T(w_i^T, r_i^T, y_i), i \in (H, L)$ .

### 6 Conclusions

Based on the classic newsvendor model and Stackelberg game, we study the credit decision between a retailer and two asymmetric suppliers under bank credit and trade credit in a supply chain, which has information asymmetry between upstream and downstream regarding the retailer’s internal capital. Further, we study the role of small supplier competition in supply chain.

Considering the bankruptcy of the retailer and internal capital information asymmetry, we use individual rationality constraint and incentive compatibility constraint under the trade credit contract, deduce the key parameters of wholesale price and credit interest rate under the Stackelberg game.

We study the situation that as to big supplier, she provides two kinds of corresponding contracts so as to screen retailers' types and sets the optimal deferred wholesale price to be as small as possible to attract the retailer for cooperation. Meanwhile, the interest rate offered by big supplier should be lower than that of a single trade credit, and it also needs to be no higher than the bank's risk-free interest rate in order to win competition, which results in a decrease in profits. For the retailer, competition leads to the big supplier offering lower interest rates and wholesale prices, thereby increasing the retailer's cash flow. The retailer needs to weigh the wholesale prices, which affect cash flow: big supplier offers lower production cost, while retailer can set wholesale price in the contract terms of small supplier. Next, we focus on the value of small supplier competition, for retailer, the value of competition is positive and decreases with small supplier's production cost and the bank's risk-free rate. We also demonstrate that compared to high-type retailer, the low-type retailer can gain more value of competition.

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