Retailer's credit preference under perfect competition Based on the Stackelberg model

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Abstract. Trade credit is provided by suppliers to meet the purchase needs of retailers, playing a more and more important role in trade. In this paper, the effects of preferential credit on retailers' business decisions are investigated under capital constraints in a perfectly competitive market. In this game model, the loan competition conditions are considered when banks and manufacturers offer preferential credit to capital-constrained retailers. In the proposed model, different credit lines and preferential credit discount rates are mainly related to the exogenous collateral of retailers and the risk appetite of banks and manufacturers. The effects of bank financing and trade credit on a retailer's inventory decision are also discussed under different circumstances of whether the retailer's financing amount exceeds the credit limit. The equilibrium wholesale price and optimal order quantity of retailers under different circumstances are deduced. Moreover, the effects of discount rate, institutional risk preference and collateral quality on the two are obtained. These results reveal that the factors affecting the decision-making of retailers and manufacturers are also different in different situations.

Keywords: trade credit; supplier financing; debt; preferential credit; bank financing; funding restrictions.

1. Introduction

Trade credit, which is the credit provided by upstream suppliers to downstream retailers to meet their purchasing needs, is ubiquitous in practice. Compared with traditional bank financing, trade credit has certain advantages, e.g., mitigate information asymmetry, reduce moral hazard, increase order volume for capital-constrained retailers [1], and reduce financing costs [2, 3], improve buyer's bargaining power [4], etc. Trade credit is widespread in developed countries such as Germany, France and Italy. Some large companies (e.g., HP, IBM and SONY) even offer payment deferral policies to their distributors and/or retailers [5].

Consider supply chain decisions under capital constraints and trade credit conditions, most of the existing literature focuses on the theory of trade credit under capital constraints and the newsboy framework related to capital constraints on retailers. Trade credit in competitive markets has been found to bring additional benefits to the supply chain [6, 7]. Chod [8] proposes a model to study how debt financing distorts retailers' inventory decisions and develops an optimal inventory decision. All of these papers consider capital constraints in the supply chain, however, few of them consider the issue of concessional credit. Cheng et al., [9] studies a retailer financing model under preferential credit, but not based on a perfectly competitive market that is closer to the actual state of SMEs.

Contemporarily, preferential trade credit is a kind of trade credit given to enterprises mainly for attracting foreign capital, supporting industrial development and establishing long-term cooperative relations [10]. Companies with high quality operating conditions, or those supported by the government, can obtain financing inventory from banks with concessional credit, which lends at lower interest rates. There is little literature on the impact of concessional credit on supply chain management of retailers under capital constraints. When retailers receive preferential credit, following questions are usually considered.

For SMEs, it is necessary to find which of the preferential credit from banks or the preferential credit from manufacturers is more powerful for retailers. When manufacturers consider competing with banks to obtain loans for retailers, they can offer discounted trade credit based on the retailer's performance. Banks are willing to lend to retailers with good assets. In this way, one can bring more income to oneself. Therefore, banks will also offer discounted bank rates to attract retailers. It is fascinating to investigate the effects of retailers are purchasing in these competitive environments, and the extent the preferential credit to retailers from manufacturers and banks affected the supply chain.

Based on these problems, this paper aims to examine the impact of concessional credit offered by banks and manufacturers. Under capital constraints, with high-quality assets facing different discount rates, one can choose bank credit or manufacturer credit. At the end of the transaction, the retailer pays off the loan and interest. However, a default occurs when the retailer's income is insufficient to pay for the goods due to market risk. This means that the retailer cannot sell its inventory, but the remaining inventory is not bought back by the manufacturer. When considering the default risk, the bank will assess the quality of the retailer based on the bank's risk appetite for the retailer's default and the situation of the retailer's collateral assets (which is difficult to achieve liquidity in the model), and design the contract, including the convenience of preferential credit lines for the retailer. In addition, manufacturers can observe credit lines assessed by banks (it is believed that this is a non-information asymmetric market). Manufacturers will provide discounted trade credit based on their risk appetite for default risk. This paper attempts to address the following issues: (1) Does the risk appetite of banks and manufacturers affect retailers' purchasing decisions based on prime credit? (2) How does the retailer's asset quality (collateral) affect the purchasing strategy? (3) When the retailer obtains financing from bank credit or trade credit, does the preferential credit benefit the retailer?

To solve the first issue, a Stackelberg game model is applied involving a manufacturer, a capital constrained retailer, and a bank. The different risk appetites of banks and manufacturers are considered that provide credit to retailers. On account of the differences in credit lines, two situations are found in bank credit. Case 1 is a bank loan exceeding the credit limit while case 2 is the bank loan is below the credit line. According to the results, the risk appetite of banks increases, the order quantity of retailers increases in case 1. In case 2, however, the optimal order quantity may not change with the bank's risk appetite. In addition, manufacturers' risk appetite may have no effect on the volume of orders under trade credits. Discount rates lead to higher wholesale prices, shifting profits from retailers to manufacturers.

As for the second question, the impact of retailer collateral in a decentralized supply chain is examined. In a fragmented supply chain, retailers' profits fall, especially if trade credit is chosen. The benefit of preferential credit is mainly transferred to manufacturers, leading to the increase of manufacturers' profits. Nevertheless, as collateral increases, the impact on total profit in the supply chain is positive.

Regarding to the third question, the effects of concessional credit on bank credit and trade credit are compared. Based on the analysis, trade credit can expand the transfer of benefits. The benefits of the discount rate are fully transferred to manufacturers under trade credit, which in some ways resembles bank credit. Retailers, however, may be incentivized to order more in trade credits. That is, prime credit has a positive impact on retailers.

This paper reveals two key management implications. First, prime credit does not incentivize retailers to order more goods under trade credit because the benefits of prime credit are passed on to manufacturers through higher wholesale prices. Second, the retailer's collateral does not bring more profit to the retailer, but it can improve the efficiency of the entire supply chain. If retailers with good assets raise money from banks, banks with a higher appetite for risk will be better off.

The rest of this article is structured as follows. Section 2 presents basic models and assumptions. In Section 3, Stackelberg equilibrium of bank credit and trade credit is derived. Eventually, a brief summary is given in section 4.

2. Method

In this paper, a supply chain system consists of a retailer with capital constraint (hereafter referred to as ‘he’ in the following), a manufacturer (she) which owes sufficient capital, and a competitive commercial bank (it). The retailer decides the optimal order quantity to maximize his profit. The manufacturer decides the wholesale price in the supply chain. In a perfectly competitive product market, retailers are faced with a fixed price of p and stochastic demand of D, which is with a continuously differentiable distribution function $F(D)$.

Retailers face capital constraints and do not have enough money to pay for orders immediately, i.e., they need to seek credit. Bank credit from banks and trade credit from manufacturers can help finance retailers. Because the credit market is so competitive, banks and manufacturers will offer a certain amount of preferential credit. Banks lend at discounted rates and value preferential lines of credit against the retailer's mortgage assets. This collateral is exogenous and will not be used for debt payments because of low liquidity. Besides, under the credit market conditions, it is assumed that the retailer can borrow the preferential credit balance to pay the trade credit. Therefore, under the assumption of information symmetry, when the manufacturer observes the credit balance of the retailer, one will give the retailer a discount trade credit. The preferential credit line (L_C) is determined by the banks, depending on collateral (T_C) and mortgage rate (g). In addition, the discount rate depends on the level of risk appetite of banks and manufacturers for a default by retailers, which is h and e respectively. When bank loan L_B is lower than L_C, we have the bank interest rate as follows.

$$r_{C,B} = r_B - u \times h \times L_C \tag{1}$$

$$L_C = g \times TC \tag{2}$$

The multiplication rule is applied to represent discounted value, which is common in the field of supply chain finance [11]. In the model, $r_{C,B}$ is the discount interest rate of banks in the credit line. r_B means the bank interest rate apart from the credit Line. u is a parameter of the discount rate, representing the discount degree after the bank's risk evaluation.

Similarly, manufacturers, after assessing credit lines and their risk appetite, arrive at discount rates based on normal rates. That is:

$$r_{C,M} = r_M - e \times u \times (L_C - L_B) \tag{3}$$

In the equation above, r_M means the normal trade credit interest rate, $r_{C,M}$ is the discount interest rate of trade credit, and L_B is the bank loan. If the retailer only uses trade credit, $L_B = 0$, one obtains

$$r_{C,M} = r_M - g \times e \times u \times TC. \tag{4}$$

In a perfectly competitive market, an enterprise can only sell products at a fixed price p, without affecting the price.

In the model, the retailer orders q pieces at the wholesale price of w, and q satisfaction maximizes the retailer's profit. The cost for the manufacturer to produce the product is k, and for a retailer with limited capital, The working capital is T and $wq \geq T$, the retailer needs to finance from the bank or the manufacturer and repays $(wq - T)(1 + r)$ in the end. In this model, it is assumed that the retailer has enough collateral to protect it from bankruptcy. Additionally, the retailer and supplier decisions conform to Stackelberg equilibrium. In the following part, two cases will be discussed: bank financing and trade credit financing. Key notation is summarized in Table 1.

Table 1. Key Notation

Notation	***Definition***
p	Sales price
w	Wholesale price
k	Unit production cost
T	Retailer' s initial capital
π_r	Expected retailer's profit
π_m	Expected manufacturer's profit
r_B	Bank interest rate
r_M	Trade credit interest rate
$r_{C,B}$	Bank discount interest rate
$r_{C,M}$	Trade credit discount interest rate
r	Expected interest rate
q	Ordering quantity decided by the retailer
TC	Collateral
g	Mortgage rate
D	Demand
L_B	Bank credit
L_T	Trade credit
L_C	Preferential credit line
h	Risk preference level of bank
e	Risk preference level of manufacturer

Assumptions. (Ai) $p > w > k$; and $r_M > r_B$;

(Aii) No private information, all three players have full information on all parameters. All participants are risk-neutral and seek to maximize their expected profits. Capital markets are perfect, i.e., there are no bankruptcy costs, taxes, or transaction costs;

(Aiii) There is no strategic default risk for the retailer, i.e. the weaker retailer will repay its loan obligations to the maximum extent possible.

3. Results and Discussion

3.1 Bank Financing

In this section, we use backward induction to describe the Stackelberg-Nash equilibrium under bank financing and analyze the supply chain decisions under two different situations. In case 1, the retailer's bank loan is at A low level and does not exceed the credit limit, where $L_B \leq L_C$. In case 2, $L_B > L_C$. According to these two different situations, the retailer determines the optimal order quantity and the manufacturer determines the optimal wholesale price according to the different profit functions. The action sequence of retailers is set as follows: (1) Financing from banks; (2) To pay the manufacturer to get the product; (3) Cash income from sales of products; (4) To repay the bank loans.

3.1.1 The retailer's problem

When purchasing products, the retailer is required to pay the manufacturer an amount of wq. In the case of limited initial capital (T), the retailer needs to borrow money from the bank in the amount of $wq - T$. At the end of the period, one needs to pay the bank $(wq-T)(1+r)$, r as the case may be. In a perfectly competitive market, the demand for a product is D and the price of a product is p. Then the retailer's profit function is:

$$\pi_{r,B} = p \times min[q, D] - (wq - T)(1 + r) - T \tag{5}$$

3.1.1.1 Case 1. Bank loan does not exceed the credit line, LB ≤ LC

In this case, the bank provides the retailer with preferential credit based on the retailer's collateral. The amount paid by the retailer to the bank at the end of the period is *(wq-T) (1+$r_{C, B}$)*. Combined with equation (5), the retailer's profit function becomes:

$$\pi_{r,B} = p \times min[q, D] - (wq - T)\left(1 + r_{C,B}\right) - T \tag{6}$$

Proposition 1 When the retailer is given preferential credit from a bank (given the sales price and wholesale price), the optimal order quantity $q^*_{B,1}$, 1 satisfies the first-order optimality condition of its expected profit function, which is given as follows:

$$\frac{\partial \pi_{r,B}}{\partial q} = p - pF(q) - w\left(1 + r_{C,B}\right) = 0 \tag{7}$$

$$q^*_{B,1} = \bar{F}^{-1}\left(\frac{w \times (1 + r_B - u \times h \times g \times TC)}{p}\right) \tag{8}$$

When the bank loan is below the credit line, the optimal order quantity based on a given sales price and wholesale price is affected by the wholesale price (w), bank interest rate (r_B), bank risk appetite level (h) and retailer collateral (TC).

Corollary 1 (Effect of bank decision) In case 1: (i) $\frac{\partial q^*_{B,1}}{\partial h} > 0$, q^* is increasing in bank risk preference; (ii) $\frac{\partial q^*_{B,1}}{\partial r_B} < 0$, q^* is decreasing in r_B.

Corollary 2 (Effect of collateral) In case 1: (i) $\frac{\partial q^*_{B,1}}{\partial TC} > 0$, with the increasing of retailer's collateral, q^* increases; (ii) $\frac{\partial q^*_{B,1}}{\partial g} > 0$, q^* increases in collateral rate.

The implication is that one has more collateral when the retailer has enough quality, and the mortgage rates set by banks are very high. Banks will give retailers more favorable credit lines, reducing financing costs. The retailer wants to borrow more money from the bank based on the discount rate, and the optimal order volume increases.

3.1.1.2 Case 2. Bank loan is higher than the credit line, LB > LC

In this case, the bank provides the retailer with preferential credit based on the retailer's collateral. The amount paid by the retailer to the bank at the end of the period is *(wq -T) (1+r)*. There are:

$$(wq - T)(1 + r) = L_C\left(1 + r_{C,B}\right) + (wq - T - L_C)(1 + r_B) \tag{9}$$

$$r = \frac{(wq - T - L_C) r_B + L_C r_{C,B}}{wq - T} \tag{10}$$

Combining equation (7) and equation (10), the retailer's profit function becomes:

$$\pi_{r,B} = p \times min[q, D] - L_C\left(1 + r_{C,B}\right) - (wq - T - L_C)(1 + r_B) - T \tag{11}$$

Proposition 2 When the retailer is given preferential credit from a bank (given the sales price and wholesale price), the optimal order quantity $q^*_{B,2}$, 1 satisfies the first-order optimality condition of its expected profit function, which is given as follows:

$$\frac{\partial \pi_{r,B}}{\partial q} = p - pF(q) - w(1 + r_B) = 0 \tag{12}$$

$$q_{B,2}^* = \bar{F}^{-1}(\frac{w \times (1+r_B)}{p}) \tag{13}$$

Equation (12) determines the optimal order quantity of the retailer when the bank loan of the retailer exceeds the credit limit. It can be seen that the optimal order quantity is influenced by the wholesale price and the bank interest rate. Based on the results, similar to case 1, the optimal order quantity is affected by the bank interest rate and the wholesale price, and the optimal order quantity in case 2 decreases with the increase of bank interest rate. The difference, however, is that collateral and bank risk reference levels do not significantly affect order decisions.

Proposition 3 Considering the optimal order quantity based on case 1 and case 2, we have $q_{B,2}^* \leq q_{B,1}^*$ with a given sales price and a wholesale price.

3.1.2 The manufacture's problem

When retailers place orders, manufacturers need to choose the best wholesale price to maximize profits. In reverse induction, we assume that the manufacturer already knows the retailer's decision scheme when making the decision. The manufacturer has a profit function:

$$\pi_{M,B} = (w - k)q \tag{14}$$

Proposition 4 In a decentralised supply chain, in which the retailer receives preferential credit from bank, the wholesale price in case 1 ($w_{B,1}^*$) and case 2 ($w_{B,2}^*$) are uniquely given by the following.

$\bar{F}^{-1}\left(\frac{1+r_B-u\times h\times g\times TC}{p}\right) + \left(\frac{1+r_B-u\times h\times g\times TC}{p}\right) \times (\bar{F}^{-1})'(\frac{w\times(1+r_B-u\times h\times g\times TC)}{p})$= 0,in case 1

$\bar{F}^{-1}\left(\frac{1+r_B}{p}\right) + \left(\frac{1+r_B}{p}\right) \times (\bar{F}^{-1})'(\frac{w\times(1+r_B)}{p})$= 0,in case 2

This determines the optimal wholesale price for different situations. Let's consider the meaning behind proposition 4. The relationship between wholesale and a series of exogenous variables (bank risk appetite, bank interest rate) is complex. The results show that the mortgage, mortgage interest rate, bank interest rate and bank risk appetite will affect the manufacturer's optimal wholesale price decision in case 1. In case 2, however, only the bank rate will affect the wholesale price.

3.2 Trade Financing

In this section, we use backward induction to describe the Stackelberg-Nash equilibrium under trade finance. The retailer determines the optimal order quantity and the manufacturer determines the optimal wholesale price according to different profit functions. The action sequence of retailers is set as follows: (1) Financing from manufacturers; (2) To pay the manufacturer to get the product; (3) Cash income from sales of products; (4) Repayment of the manufacturer's loan.

3.2.1 The retailer's problem

When purchasing products, the retailer is required to pay the manufacturer an amount of *wq*. In the case of limited initial capital(*T*), the retailer needs to borrow money from the manufacturer in the amount of *wq -T*. At the end of the period, he is required to pay *(wq -T) (1+ r)* to the manufacturer, with *r* to be determined on a case-by-case basis. In a perfectly competitive market, the demand for a product is *D* and the price of a product is *p*. Then the retailer's profit function is:

$$\pi_{r,T} = p \times min[q, D] - (wq - T)(1 + r_M - eugTC) - T \tag{15}$$

$$r = r_M - eugTC \tag{16}$$

Proposition 5 When the retailer obtains the manufacturer's preferential credit (known the sales price and the wholesale price), the optimal order quantity q_T^* satisfies the first-order optimal conditions of its expected profit function, and the following can be obtained:

$$\frac{\partial \pi_{r,T}}{\partial q} = p - pF(q) - w(1 + r_M - eugTC) = 0 \tag{17}$$

$$q_T^* = \bar{F}^{-1}\left(\frac{w \times (1 + r_M - eugTC)}{p}\right) \tag{18}$$

Equation (18) reflects the optimal order quantity when the retailer only uses trade credit as loan. We deduce the different effects of manufacturer's decision and collateral on retailer's optimal order quantity.

Corollary 3 (Effect of manufacturer decision): (i) $\frac{\partial q_T^*}{\partial w} < 0$, under trade credit conditions, the optimal order quantity decreases with the increase of the wholesale price; (ii)$\frac{\partial q_T^*}{\partial r_M} < 0$, the interest rates offered by manufacturers have a negative impact on q_T^*; (iii) $\frac{\partial q_T^*}{\partial e} > 0$, when the manufacturer's risk appetite increases, the optimal order quantity decreases.

Corollary 4 (Effect of collateral) $\frac{\partial q_T^*}{\partial TC} > 0$, the higher the collateral value, the greater the optimal order.

It can be inferred that preferential trade credits have a positive effect on the order quantity of retailers. With financing from manufacturers with a high-risk appetite, retailers will increase their order volumes. Meanwhile, the higher the quality of the retailer's collateral, the greater the optimal order.

3.2.2 The manufacture's problem

When retailers place orders, manufacturers need to choose the best wholesale price to maximize profits. In reverse induction, it is assumed that the manufacturer already knows the retailer's decision scheme when making the decision. The manufacturer has a profit function:

$$\pi_{M,T} = (w - k)q + (wq - T)(r_M - eugTC) \tag{19}$$

Proposition 6 In a decentralized supply chain, when the retailer obtains preferential credit from the manufacturer, the wholesale price is determined by the following.

$$q_T^* \times (1 + r_M - eugTC) + [(w - k) + w \times (r_M - eugTC)] \times \frac{1 + r_M - eugTC}{p} \times (\bar{F}^{-1})' \left(\frac{w \times (1 + r_M - eugTC)}{p}\right) = 0 \tag{20}$$

Where $q_T^* = \bar{F}^{-1}\left(\frac{w \times (1 + r_M - eugTC)}{p}\right)$.

According to proposition 6, the optimal wholesale price decided by manufacturers is affected by their risk appetite level.

4. Conclusion

In summary, this paper studies the effect of concessional credit on capital constrained retailers' business decisions. In a highly competitive credit market, banks use collateral to offer preferential credit to quality retailers. Manufacturers also offer trade credit at discounted interest rates based on the retailer's credit line assessed by the bank. Banks' risk appetite and manufacturers' risk appetite may influence credit discount rates.

According to the results, in the case of bank credit, if the bank credit is smaller than the preferential credit line, the retailer's optimal order quantity will increase with the reduction of financing cost as the bank's risk appetite increases. When the bank interest rate rises, the optimal order quantity will decrease because of the increase in financing cost. The higher the retailer's mortgage quality and mortgage rate are, the higher the optimal order quantity is. Wholesale prices rose as banks' risk appetite increased. Retailers' collateral has a positive impact on supply chain decisions. If the bank credit is greater than the preferential credit line, the optimal order quantity and the equilibrium wholesale price are only related to the bank interest rate, and have nothing to do with the collateral and risk appetite.

Under the conditions of trade credit, the higher the risk appetite of manufacturers, the higher the order quantity of retailers. Trade credit rates have a negative impact on order volumes. Manufacturers' appetite for risk can affect wholesale prices. In terms of the Stackelberg model, as the first mover, the manufacturer can adjust to transfer the retailer's profits to itself. Collateral from retailers will increase orders.

The effect of bank credit and trade credit is demonstrated on supply chain management under preferential credit conditions. There are some attractive opportunities for further research, including (i) The possibility of considering a mix of bank financing and trade credit financing; (ii) Perfectly competitive markets do not exist in real life; (iii) The specific value cannot be solved, i.e., it is impossible to compare the two credit models which is better. In the future, it is worthwhile to consider applying some methods to solve the equilibrium wholesale price and the best order quantity, and discuss the profit situation of retailers and manufacturers subsequently. These results play a helpful role in the financial constraint supply chain management from the perspective of real operators.

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