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Research on Product Procurement Strategy of Competitive Retailers under the Background of Capital Constraints

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Abstract

This paper studies a manufacturer and two competing retailers with asymmetric market power and facing capital constraints and purchasing strategy choices. Considering that both competitive retailers have capital constraints and market power is asymmetric, When retailers with strong market power and weak market power make simultaneous decisions, the decision-making of purchasing quality differentiated products of supply chain members and the financing selection strategies of retailers are discussed. The manufacturer is the leader in Stackelberg, and the two retailers compete for volume and make product purchasing and financing decisions simultaneously or sequentially.We describe simultaneous decision (Nash game) , and solve the optimal order quantity, wholesale price and profit of each supply chain member.

Keywords

Capital-constrained Retailers; RFID; Cournot Competition; Market Power; Financing Choice.

1. Introduction

Due to the different income levels of consumers, the quality differentiated product strategy of enterprises can meet the needs of more consumers, and thus improve the market share and profit of enterprises. Huawei, Xiaomi, Hisense, Haier, GM, Volkswagen and other enterprises have adopted this strategy. Low quality products have more price advantages than high quality products, so they can help enterprises to rapidly expand the market and lay a foundation for the promotion of high-quality products, especially for brand products newly manufactured or entering new markets. For example, Xiaomi expands the market with its Mi series mobile phones, and then launches mi Note series to enter the high-end market. High-quality products can improve consumers' perception of low-quality products and promote the sales of low-quality products. For example, in order to gain more market share and profits, Apple mobile phone actively explores the low-end market.

With the diversification of consumer demand and product quality differentiation, the competition between products is becoming increasingly fierce. With the intensification of market competition, more and more retail enterprises adopt differentiated product sales strategy, that is, to sell a variety of differentiated products at the same time to meet different consumer needs.For example, JINGdong mall will sell huawei Nova, Honor Play and other mobile phones at the same time, while Suning and Gome will sell multiple brands of computers at the same time.However, product differentiation will also affect consumers' purchase choices, which may lead to reduced or even no demand for products, which is detrimental to retail enterprises.

In addition, with the intensification of market competition, the expansion of production scale and improvement of the production cost, fund shortage problem increasingly prominent, if the retailer choose high quality products, the high costs of ordering and uncertain earnings will make them inevitably faced a serious shortage of funds, this situation is particularly striking in

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small and medium-sized enterprises. According to the fourth national Economic Census released at the end of 2019, by the end of 2018, China had 18.07 million small, medium and micro enterprises as legal persons, accounting for 97.3 percent of the total.In terms of the structure of small, medium and micro enterprises, there were 239,000 medium-sized enterprises, accounting for 1.3% of the total.Small enterprises 2,392,000, accounting for 13.2%; There were 15.439 million micro-enterprises, accounting for 85.4%. Small and medium-sized enterprises are the new force of national economic and social development. China's small and medium-sized enterprises have the typical characteristics of "five, six, seven, eight, nine", contributing more than 50% of tax revenue, more than 60% of GDP, more than 70% of technological innovation, more than 80% of urban employment, more than 90% of the number of enterprises. Small and medium-sized enterprises are generally faced with capital shortage, which seriously restricts the healthy development of enterprises, and even leads to bankruptcy of enterprises. In the first half of 2019, a number of U.S. retailers closed stores due to bankruptcy, with more than 7,000 stores closing across the U.S. retail industry.

Supply chain is the unity of logistics and capital flow, which flow towards each other. The capital shortage of nodal enterprises hinders the transaction activities of supply chain, resulting in low efficiency of supply chain. At present, to deal with the problem of insufficient funds, supply chain enterprises mainly adopt bank financing and trade credit financing.Small and medium-sized enterprises are difficult to obtain financing from banks and other external financial institutions due to their weak capital and poor capital liquidity, and their resistance to operational risks is low.In order to improve the operation performance of supply chain, trade credit financing emerges with the transaction activities of nodal enterprises.Fabbri and Klapper study found that trade credit financing in countries such as China and India may be the only source of financing small and medium-sized enterprises, in addition, many large enterprises, such as hewlett-packard and procter &gamble and SONY are its downstream retailers provide trade credit financing, to alleviate the retailer's inventory risk and funding problems, realize the industrial chain of long-term win-win cooperation.In this context, when retail enterprises with capital constraints sell products, how to choose financing methods and procurement strategies has become a new problem they face, and different procurement strategies and product differentiation competition will also affect the pricing decisions of supply and demand.

In this paper, a two-level supply chain composed of a manufacturer and two capital constrained retailers is studied, in which the manufacturer is the Stackelberg leader of the supply chain.Considering that all competitive retailers have capital constraints and market power asymmetry, this paper discusses the decision of purchasing quality differentiated products of supply chain members and the financing selection strategy of retailers when retailers with strong market power and retailers with weak market power make simultaneous decision.n.

2. Literature Review

2.1. Research on Product Quality Differentiation

Keskin and Birge (2019) discuss how a company can build a product line with uncertain quality costs.They found that a minimum quality standard helped companies get the best price.Cui (2019) and Jain and Bala (2018) investigate the impact of investment strategies on differentiated quality competition.Rodriguez and Aydın (2015) showed that manufacturers may prefer retailers to carry goods with high demand variability, but retailers prefer goods with low demand variability.Dzyabura and Jagabathula(2017) found that dual-channel retailers should sell popular products when offline channels dominate, and informational products when online channels dominate.

Liu et al. (2013) studied the dynamic pricing of differentiated products.Giri (2017) studied the pricing of differentiated products considering the impact of consumers' return behavior.Wang et al. (2016) studied the influence of channel operating costs on retailers' channel selection considering that a single manufacturer sells two alternative products with differentiation at the same time.Hsieh et al. (2020) considered that manufacturers purchase parts from two competitive suppliers to produce differentiated products, and studied the pricing of differentiated products and parts ordering.Zhou Xiongwei et al. (2019) studied product pricing strategies based on network externalities and quality differentiation.Ma Dongsheng et al. (2021) consider the pricing strategy of quality-differentiated products based on strategic customer behavior.In the above literature on differentiated products, the pricing or ordering of differentiated products is studied by combining different influencing factors, and the product differentiated competition among different manufacturers or suppliers is all considered.Jin Liang et al. (2021) studied retailers' purchasing strategy of product quality differentiation, and the research showed that dual-source purchasing strategy is the best purchasing strategy for retailers.

2.2. Capital Constraints and Financing Methods

There is also literature on capital constraints and financing methods.When supply chain enterprises have capital constraints, supply chain financing is an effective method, in which one supply chain member lends funds to another supply chain member to pay for business activities on the due date. Cash flow shortage is one of the main reasons supply chain members seek loans. Both bank credit and trade credit financing are common in supply chain finance (Zhao and Huchzermeier, 2015;Xu et al., 2018).In practice, capital constraint is common in all types of enterprises.There are two kinds of researches on capital constraint of enterprises, which can be divided into capital constraint of downstream buyer enterprises and capital constraint of upstream manufacturing enterprises.

When the downstream buyer enterprises have capital constraints, they can solve the problem of capital constraints by applying for deferred payment from upstream suppliers or external financing pins from banks and other financial institutions.Cai etc. Compared with bank financing, trade credit can better coordinate the supply chain when retailers have capital constraints.Kouvelis etc. Compared with bank financing, optimal trade credit contracts are more attractive for capital constrained supply chains.Yan etc. This paper analyzes how credit guarantee under bank loan affects financing balance and system coordination.Yang, etc. Considering a two-level supply chain consisting of a single supplier and two competitive retailers with capital constraints, the effect of retailer external financing on the optimal decision-making of on-chain members and supply chain performance is discussed.

Different from the existing literature, this paper considers the product quality factors and studies the product procurement strategy of capital constrained retailers. This paper combines trade credit financing with bank financing, and links market forces with financing interest rate.This paper analyzes the asymmetrical retailer financing mode selection of market forces and explores the influence of market forces on financing.

3. Literature References

3.1. Model Description and Basic Assumptions

This paper consider a well-funded manufacturers and two market forces composed of asymmetric retailer supply chain as the research object, the retailers are capital constraint problems, needs to be done to the quality of the products purchasing choice and financing way to choose, choose to purchase high quality or low quality products, choose the way to bank financing or trade credit. M Suppose the manufacturer is a Stackelberg leader in the supply chain, selling a good with a unit cost of production through two retailers. Where, cost changes with product quality, unit product cost $c=\{ku^2,k(tu)^2\}$, is the manufacturer's unit product quality cost coefficient, represents the product quality difference level, represents the manufacturer's quality level of high-quality products.

Table 1 describes the meanings of the parameters.

Assume that there are two financing methods to fund the retailer's choice:

(1) Bank financing: With capital constraint, the retailer applies for a loan from the bank at the interest rate before the beginning of the sales period to pay the wholesale cost of the product, and reimburses the loan principal and interest to the bank after the end of the sales period.

(2) Trade credit financing: Before the sales period begins, the manufacturer delivers the products to the retailer in accordance with the order quantity. After the sales, the retailer pays back the corresponding principal and interest of the loan at the trade credit interest rate set by the manufacturer.With the literatureSimilarly, we also assume that the trade credit interest rate is related to the market power of retailers, that is, the trade credit interest rate given by manufacturers and is respectively r_b/γ and $r_b/(1-\gamma)$.

Table 1. Key parameter description

symbol	instructions
γ	The Market Power of retailers R_L $\gamma \in (0.5,1)$
t	The quality level difference between the two products, () $t \in (0,1)$
r	Bank base Rate $r \in (0,1)$
u	The quality level of a manufacturer's high-quality products
tu	The quality level of a manufacturer's low-quality products
k	Manufacturer's unit product quality cost coefficient
c	Unit product cost $c = \{ku^2, k(tu)^2\}$
β	Consumers' quality preferences
p_{i-k}^x	When two retailers make decisions at the same time, the retailer's selling price in the scenario and in the financing scenario, where, R_i x k $i = L,S$ $x = \{HH, HL, LH, LL\}$ $k = \{TT, TB, BT, BB\}$
q_{k-i}^x	The quantity ordered by the retailer in the scenario and in the financing scenario when both retailers make simultaneous decisions R_i x k
w_{k-i}^x	The wholesale price of the retailer in the scenario and in the financing scenario when both retailers make simultaneous decisions R_i x k
φ_k	The financing rate of the retailer in the financing scenario R_L k
ϕ_k	The financing rate of the retailer in the financing scenario R_S k
π_{k-i}^x	When two retailers make simultaneous decisions, the retailer's profits in the RFID adoption scenario and in the financing scenario R_i x k
π_{k-M}^x	When both retailers make simultaneous decisions, the manufacturer makes profits in the RFID adoption scenario and in the financing scenario x k

According to whether the two retailers sell high-quality products, there are four procurement strategy scenarios: two retailers both sell high-quality products, R_L Selling only high quality products, R_S Selling only high quality products, Both retailers sell low quality products known as scenarios.

3.1.1. Profit Model of All Retailers Purchasing High Quality Products (Scenariohh)

In this scenario, all retailers purchase high-quality products, and the Product quality difference $t=0$. At the same time, manufacturers will produce high-quality products and provide them to downstream retailers. Because both retailers are facing the problem of capital constraint, they will choose trade credit financing or bank financing to solve the problem of capital constraint.If the retailer chooses trade credit financing, the manufacturer will provide the product for the retailer before the sales period, and when the sales period ends, the retailer will repay the loan principal and interest according to the trade credit interest rate.If the retailer chooses bank financing, he will use the loan to order the product at the wholesale price set by the manufacturer before the sales period begins and repay the bank loan principal and interest at the bank lending rate when the sales period ends.

Suppose the wholesale price set by the manufacturer is w_{k-i}^{HH}, and the quantity of products ordered by the retailer and at the same time are q_{k-L}^{HH} and q_{k-S}^{HH}. π_{k-L}^{HH}, π_{k-S}^{HH} and π_{k-M}^{HH} are respectively the profit function of retailer and manufacturer under the financing choice of scenario, then:

$$\begin{cases} \pi_{k-L}^{HH} = (\gamma a - q_{k-L}^{HH} - dq_{k-S}^{HH} + \beta u)q_{k-L}^{HH} - w_{k-L}^{HH}q_{k-L}^{HH}(1+\varphi_k) \\ \pi_{k-S}^{HH} = \left((1-\gamma)a - q_{k-S}^{HH} - dq_{k-L}^{HH} + \beta u\right)q_{k-S}^{HH} - w_{k-S}^{HH}q_{k-S}^{HH}(1+\phi_k) \\ \pi_{k-M}^{HH} = w_{k-M}^{HH}q_{k-L}^{HH}(1+\varphi_k) + w_{k-S}^{HH}q_{k-S}^{HH}(1+\phi_k) - ku^2(q_{k-L}^{HH} + q_{k-S}^{HH}) \end{cases} \tag{1}$$

When retailers decision-making order quantities at the same time, the first to the retailer's price demand function into the profit function π_{k-i}^{HH}, simultaneous expression for solving get order quantity q_{k-i}^{HH} about the wholesale price w_{k-i}^{HH}, and then through backward induction into the manufacturer's profit function w_{k-i}^{HH*}, in the case of negative definite Hesse matrix, then the optimal order of each member and maximum profits, as shown in Table 2.

According to the optimal solution of each parameter in Table 2, the financing subgame equilibrium of retailers under Nash game scenario is analyzed, as shown in Lemma 1:

Lemma 1. Nash Game: when $\gamma \in (0.5, \gamma^{HH})$,all retailers chose trade credit financing; when $\gamma \in (\gamma^{HH}, 1)$,retailers R_L chose trade credit financing and retailers R_S chose bank financing.

$$\gamma^{HH} = \frac{\begin{bmatrix} 2ad^2r^2 + 16ad^2r + 16ad^2 - 64ar - 64a - 3\beta d^3r^2u - 10\beta d^3ru - 8\beta d^3u + 2\beta d^2r^2u + 16\beta d^2ru \\ +16\beta d^2u + 8\beta dr^2u + 40\beta dru + 32\beta du - 64\beta ru - 64\beta u + 3d^3kr^2u^2 + 10d^3kru^2 + 8d^3ku^2 \\ -10d^2kr^2u^2 - 24d^2kru^2 - 16d^2ku^2 - 8dkr^2u^2 - 40dkru^2 - 32dku^2 + 32kr^2u^2 + 96kru^2 + 64ku^2 \end{bmatrix}}{a(d+2)\left(3d^2r^2 + 10d^2r + 8d^2 - 4dr^2 - 4dr - 32r - 32\right)}$$

It can be found from Lemma 1 that market forces are the key factors affecting retailers' financing choices.When the market power of retailers R_L is small, all retailers choose trade credit financing. With the increase of R_L market forces, the original financing choice will be changed, and R_S will chose bank financing to solve own capital constraints. This is because the bank interest rate is lower than the trade credit interest rate, and with the increase of R_L market power, R_S market power becomes smaller. The higher trade credit interest rate makes the financing cost of trade credit more heavy for retailers R_S, so R_S will choose the bank financing method with lower interest rate.

Table 2. Optimal wholesale price, order quantity and profit of retailers in Nash game scenario HH

k	TT	TB	BT	BB
w_{k-L}^{HH*}	$\frac{\gamma(av+u(\beta+ku))}{2(r+\gamma)}$	$\frac{\begin{pmatrix}-\gamma(-ad^2r\gamma-2ad^2\gamma+2adr\gamma \\ -2adr+8ar\gamma+8a\gamma-\beta d^2ru \\ -2\beta d^2u-2\beta dru+8\beta ru+8\beta u \\ -d^2kr^2u^2-3d^2kru^2-2d^2ku^2 \\ +2dkr^2u^2+2dkru^2+8kru^2+8ku^2)\end{pmatrix}}{\left(d^2r^2+4d^2r+4d^2-16r-16\right)(r+\gamma)}$	$\frac{\begin{pmatrix}ad^2r\gamma+2ad^2\gamma+2adr\gamma-2adr \\ -8a\gamma+\beta d^2ru+2\beta d^2u-2\beta dru \\ -8\beta u+d^2kru^2+2d^2ku^2 \\ +2dkru^2-8kru^2-8ku^2\end{pmatrix}}{d^2r^2+4d^2r+4d^2-16r-16}$	$\frac{a\gamma+\beta u+kru^2+ku^2}{2(r+1)}$
w_{k-S}^{HH*}	$\frac{(1-\gamma)\left(a+u\left(\beta+ku\right)-a\gamma\right)}{2\left(1+r-\gamma\right)}$	$\frac{\begin{pmatrix}ad^2r\gamma-ad^2r+2ad^2\gamma-2ad^2 \\ +2adr\gamma-8a\gamma+8a-\beta d^2ru \\ -2\beta d^2u+2\beta dru+8\beta u-d^2kru^2 \\ -2d^2ku^2-2dkru^2+8kru^2+8ku^2\end{pmatrix}}{-d^2r^2-4d^2r-4d^2+16r+16}$	$\frac{\begin{pmatrix}(1-\gamma)(-ad^2r\gamma+ad^2r-2ad^2\gamma \\ +2ad^2+2adr\gamma+8ar\gamma-8ar+8a\gamma \\ -8a+\beta d^2ru+2\beta d^2u+2\beta dru-8\beta ru \\ -8\beta u+d^2kr^2u^2+3d^2kru^2+2d^2ku^2 \\ -2dkr^2u^2-2dkru^2-8kru^2-8ku^2)\end{pmatrix}}{(r-\gamma+1)(d^2r^2+4d^2r+4d^2-16r-16)}$	$\frac{a-a\gamma+\beta u+kru^2+ku^2}{2(r+1)}$
q_{k-L}^{HH*}	$\frac{\begin{pmatrix}ad\gamma-ad+2a\gamma-\beta du \\ +2\beta u+dku^2-2ku^2\end{pmatrix}}{2\left(4-d^2\right)}$	$\frac{\begin{pmatrix}adr\gamma-adr+2ad\gamma-2ad \\ +4ar\gamma+4a\gamma-\beta dru-2\beta du \\ +4\beta ru+4\beta u+dkr^2u^2+3dkru^2 \\ +2dku^2-4kru^2-4ku^2\end{pmatrix}}{16r+16-d^2r^2-4d^2r-4d^2}$	$\frac{(r+1)\begin{pmatrix}-adr\gamma+adr-2ad\gamma+2ad \\ -4a\gamma+dru+2\beta du-4\beta u \\ -dkru^2-2dku^2+4kru^2+4ku^2\end{pmatrix}}{d^2r^2+4d^2r+4d^2-16r-16}$	$\frac{\begin{pmatrix}ad\gamma-ad+2a\gamma-\beta du+2\beta u \\ +dkru^2+dku^2-2kru^2-2ku^2\end{pmatrix}}{2(4-d^2)}$
q_{k-S}^{HH*}	$\frac{\begin{pmatrix}ad\gamma+2a\gamma-2a+\beta du \\ -2\beta u-dku^2+2ku^2\end{pmatrix}}{2(d^2-4)}$	$\frac{\begin{pmatrix}(r+1)(adr\gamma+2ad\gamma+4a\gamma \\ -4a+\beta dru+2\beta du-4\beta u \\ -dkru^2-2dku^2+4kru^2+4ku^2)\end{pmatrix}}{d^2r^2+4d^2r+4d^2-16r-16}$	$\frac{\begin{pmatrix}adr\gamma+2ad\gamma+4ar\gamma-4ar \\ +4a\gamma-4a+\beta dru+2\beta du \\ -4\beta ru-4\beta u-dkr^2u^2-3dkru^2 \\ -2dku^2+4kru^2+4ku^2\end{pmatrix}}{d^2r^2+4d^2r+4d^2-16r-16}$	$\frac{\begin{pmatrix}ad\gamma+2a\gamma-2a+\beta du-2\beta u \\ -dkru^2-dku^2+2kru^2+2ku^2\end{pmatrix}}{2(d^2-4)}$
π_{k-L}^{HH*}	$\frac{\begin{pmatrix}ad\gamma-ad+2a\gamma-\beta du \\ +2\beta u+dku^2-2ku^2\end{pmatrix}^2}{4(d^2-4)^2}$	$\frac{\begin{pmatrix}(adr\gamma-adr+2ad\gamma-2ad \\ +4ar\gamma+4a\gamma-\beta dru-2\beta du \\ +4\beta ru+4\beta u+dkr^2u^2+3dkru^2 \\ +2dku^2-4kru^2-4ku^2)^2\end{pmatrix}}{(d^2r^2+4d^2r+4d^2-16r-16)^2}$	$\frac{\begin{pmatrix}(r+1)^2(-adr\gamma+adr-2ad\gamma \\ +2ad-4a\gamma+\beta dru+2\beta du-4\beta u \\ -dkru^2-2dku^2+4kru^2+4ku^2)^2\end{pmatrix}}{(d^2r^2+4d^2r+4d^2-16r-16)^2}$	$\frac{\begin{pmatrix}(ad\gamma-ad+2a\gamma-\beta du+2\beta u \\ +dkru^2+dku^2-2kru^2-2ku^2)^2\end{pmatrix}}{4(d^2-4)^2}$
π_{k-S}^{HH*}	$\frac{\begin{pmatrix}ad\gamma+2a\gamma-2a+\beta du \\ -2\beta u-dku^2+2ku^2\end{pmatrix}^2}{4(d^2-4)^2}$	$\frac{\begin{pmatrix}(r+1)^2(adr\gamma+2ad\gamma+4a\gamma \\ -4a+\beta dru+2\beta du-4\beta u-dkru^2 \\ -2dku^2+4kru^2+4ku^2)^2\end{pmatrix}}{(d^2r^2+4d^2r+4d^2-16r-16)^2}$	$\frac{\begin{pmatrix}(adr\gamma+2ad\gamma+4ar\gamma-4ar \\ +4a\gamma-4a+\beta dru+2\beta du \\ -4\beta ru-4\beta u-dkr^2u^2 \\ -3dkru^2-2dku^2+4kru^2+4ku^2)^2\end{pmatrix}}{(d^2r^2+4d^2r+4d^2-16r-16)^2}$	$\frac{\begin{pmatrix}(ad\gamma+2a\gamma-2a+\beta du-2\beta u \\ -dkru^2-dku^2+2kru^2+2ku^2)^2\end{pmatrix}}{4(d^2-4)^2}$
π_{k-M}^{HH*}	π_{TT-M}^{HH*}	π_{TB-M}^{HH*}	π_{BT-M}^{HH*}	π_{BB-M}^{HH*}

3.1.2. Only R_L Profit Models for Purchasing High Quality Products (Scenarios HL)

Suppose the wholesale price set by the manufacturer is w_{k-i}^{HL}, and the quantity of products ordered by the retailer and at the same time are q_{k-L}^{HL} and q_{k-S}^{HL}. π_{k-L}^{HL}, π_{k-S}^{HL} and π_{k-M}^{HL} are respectively the profit function of retailer and manufacturer under the financing choice of scenario, then:

$$\begin{cases}\pi_{k-L}^{HL}=(\gamma a-q_{k-L}^{HL}-dq_{k-S}^{HL}+\beta u)q_{k-L}^{HL}-w_{k-L}^{HL}q_{k-L}^{HL}(1+\varphi_k) \\ \pi_{k-S}^{HL}=\left((1-\gamma)a-q_{k-S}^{HL}-dq_{k-L}^{HL}+\beta tu\right)q_{k-S}^{HL}-w_{k-S}^{HL}q_{k-S}^{HL}(1+\phi_k) \\ \pi_{k-M}^{HL}=w_{k-L}^{HL}q_{k-L}^{HL}(1+\varphi_k)+w_{k-S}^{HL}q_{k-S}^{HL}(1+\phi_k)-ku^2q_{k-L}^{HL}-k(tu)^2q_{k-S}^{HL}\end{cases} \tag{2}$$

According to the optimal solution of each parameter in Table 3, the financing subgame equilibrium of retailers under Nash game scenario is analyzed, as shown in Lemma 2:

Lemma 2. Nash Game: when $\gamma \in (0.5, \gamma^{HL})$,all retailers chose trade credit financing; when $\gamma \in (\gamma^{HL}, 1)$,retailers R_L chose trade credit financing and retailers R_S chose bank financing.

Table 3. Optimal wholesale price, order quantity and profit of retailers in HL scenario under Nash game

k	TT	TB	BT	BB
w_{k-L}^{HL*}	$\frac{\gamma(a\gamma+\beta u+ku^2)}{2(r+\gamma)}$	$\frac{\begin{pmatrix}-\gamma(-ad^2r\gamma-2ad^2\gamma+2adr\gamma \\ -2adr+8ar\gamma+8a\gamma-\beta d^2ru \\ -2\beta d^2u-2\beta drtu+8\beta ru+8\beta u \\ -d^2kr^2u^2-3d^2kru^2-2d^2ku^2 \\ +2dkr^2t^2u^2+2dkrt^2u^2+8kru^2+8ku^2)\end{pmatrix}}{\left(d^2r^2+4d^2r+4d^2-16r-16\right)(r+\gamma)}$	$\frac{\begin{pmatrix}ad^2r\gamma+2ad^2\gamma+2adr\gamma-2adr \\ -8a\gamma+\beta d^2ru+2\beta d^2u-2\beta drtu \\ -8\beta u+d^2kru^2+2d^2ku^2 \\ +2dkrt^2u^2-8kru^2-8ku^2\end{pmatrix}}{d^2r^2+4d^2r+4d^2-16r-16}$	$\frac{a\gamma+\beta u+kru^2+ku^2}{2(r+1)}$
w_{k-S}^{HL*}	$\frac{(1-\gamma)\left(a-a\gamma+\beta tu+kt^2u^2\right)}{2(1+r-\gamma)}$	$\frac{\begin{pmatrix}ad^2r\gamma-ad^2r+2ad^2\gamma-2ad^2+2adr\gamma \\ -8a\gamma+8a-\beta d^2rtu-2\beta d^2tu+2\beta dru \\ +8\beta tu-d^2krt^2u^2-2d^2kt^2u^2-2dkru^2 \\ +8krt^2u^2+8kt^2u^2\end{pmatrix}}{16-d^2r^2-4d^2r-4d^2+16r}$	$\frac{\begin{pmatrix}(1-\gamma)(-ad^2r\gamma+ad^2r-2ad^2\gamma \\ +2ad^2+2adr\gamma+8ar\gamma-8ar+8a\gamma \\ -8a+\beta d^2rtu+2\beta d^2tu+2\beta dru-8\beta rtu \\ -8\beta tu+d^2kr^2t^2u^2+3d^2krt^2u^2+2d^2kt^2u^2 \\ -2dkr^2u^2-2dkru^2-8krt^2u^2-8kt^2u^2)\end{pmatrix}}{(r-\gamma+1)(d^2r^2+4d^2r+4d^2-16r-16)}$	$\frac{a-a\gamma+\beta tu+krt^2u^2+kt^2u^2}{2(r+1)}$
q_{k-L}^{HL*}	$\frac{\begin{pmatrix}ad\gamma-ad+2a\gamma-\beta dtu \\ +2\beta u+dkt^2u^2-2ku^2\end{pmatrix}}{2\left(4-d^2\right)}$	$\frac{\begin{pmatrix}adr\gamma-adr+2ad\gamma-2ad+4ar\gamma \\ +4a\gamma-\beta drtu-2\beta dtu+4\beta ru \\ +4\beta u+dkr^2t^2u^2+3dkrt^2u^2 \\ +2dkt^2u^2-4kru^2-4ku^2\end{pmatrix}}{16r+16-d^2r^2-4d^2r-4d^2}$	$\frac{(r+1)\begin{pmatrix}-adr\gamma+adr-2ad\gamma+2ad \\ -4a\gamma+\beta drtu+2\beta dtu-4\beta u \\ -dkrt^2u^2-2dkt^2u^2+4kru^2+4ku^2\end{pmatrix}}{d^2r^2+4d^2r+4d^2-16r-16}$	$\frac{\begin{pmatrix}ad\gamma-ad+2a\gamma-\beta dtu+2\beta u \\ +dkrt^2u^2+dkt^2u^2-2kru^2-2ku^2\end{pmatrix}}{2(4-d^2)}$
q_{k-S}^{HL*}	$\frac{\begin{pmatrix}ad\gamma+2a\gamma-2a+\beta du \\ -2\beta tu-dku^2+2kt^2u^2\end{pmatrix}}{2(d^2-4)}$	$\frac{\begin{pmatrix}(r+1)(adr\gamma+2ad\gamma+4a\gamma \\ -4a+\beta dru+2\beta du-4\beta u \\ -dkru^2-2dku^2+4kru^2+4ku^2)\end{pmatrix}}{d^2r^2+4d^2r+4d^2-16r-16}$	$\frac{\begin{pmatrix}adr\gamma+2ad\gamma+4ar\gamma-4ar \\ +4a\gamma-4a+\beta dru+2\beta du \\ -4\beta rtu-4\beta tu-dkr^2u^2-3dkru^2 \\ -2dku^2+4krt^2u^2+4kt^2u^2\end{pmatrix}}{d^2r^2+4d^2r+4d^2-16r-16}$	$\frac{\begin{pmatrix}ad\gamma+2a\gamma-2a+\beta du-2\beta tu \\ -dkru^2-dku^2+2krt^2u^2+2kt^2u^2\end{pmatrix}}{2(d^2-4)}$
π_{k-L}^{HL*}	$\frac{\begin{pmatrix}ad\gamma-ad+2a\gamma-\beta dtu \\ +2\beta u+dkt^2u^2-2ku^2\end{pmatrix}^2}{4(d^2-4)^2}$	$\frac{\begin{pmatrix}(adr\gamma-adr+2ad\gamma-2ad \\ +4ar\gamma+4a\gamma-drtu-2\beta dtu \\ +4\beta ru+4\beta u+dkr^2t^2u^2 \\ +3dkrt^2u^2+2dkt^2u^2-4kru^2-4ku^2)^2\end{pmatrix}}{(d^2r^2+4d^2r+4d^2-16r-16)^2}$	$\frac{\begin{pmatrix}(r+1)^2(-adr\gamma+adr-2ad\gamma \\ +2ad-4a\gamma+\beta drtu+2\beta dtu-4\beta u \\ -dkrt^2u^2-2dkt^2u^2+4kru^2+4ku^2)^2\end{pmatrix}}{(d^2r^2+4d^2r+4d^2-16r-16)^2}$	$\frac{\begin{pmatrix}(ad\gamma-ad+2a\gamma-\beta dtu+2\beta u \\ +dkrt^2u^2+dkt^2u^2-2kru^2-2ku^2)^2\end{pmatrix}}{4(d^2-4)^2}$
π_{k-S}^{HL*}	$\frac{\begin{pmatrix}ad\gamma+2a\gamma-2a+\beta du \\ -2\beta tu-dku^2+2kt^2u^2\end{pmatrix}^2}{4(d^2-4)^2}$	$\frac{\begin{pmatrix}(r+1)^2(adr\gamma+2ad\gamma+4a\gamma \\ -4a+\beta dru+2\beta du-4\beta tu \\ -dkru^2-2dku^2+4krt^2u^2+4kt^2u^2)^2\end{pmatrix}}{(d^2r^2+4d^2r+4d^2-16r-16)^2}$	$\frac{\begin{pmatrix}(adr\gamma+2ad\gamma+4ar\gamma-4ar \\ +4a\gamma-4a+\beta dru+2\beta du \\ -4\beta rtu-4\beta tu-dkr^2u^2-3dkru^2 \\ -2dku^2+4krt^2u^2+4kt^2u^2)^2\end{pmatrix}}{(d^2r^2+4d^2r+4d^2-16r-16)^2}$	$\frac{\begin{pmatrix}(ad\gamma+2a\gamma-2a+\beta du-2\beta tu \\ -dkru^2-dku^2+2krt^2u^2+2kt^2u^2)^2\end{pmatrix}}{4(d^2-4)^2}$
π_{k-M}^{HL*}	π_{TT-M}^{HL*}	π_{TB-M}^{HL*}	π_{BT-M}^{HL*}	π_{BB-M}^{HL*}

$$\gamma^{HL}=\frac{\begin{bmatrix}2ad^2r^2+16ad^2r+16ad^2-64ar-64a-3\beta d^3r^2u-10\beta d^3ru-8\beta d^3u+2\beta d^2r^2tu+16\beta d^2rtu+16\beta d^2tu+8\beta dr^2u \\ +40\beta dru+32\beta du-64\beta rtu-64\beta tu+3d^3kr^2u^2+10d^3kru^2+8d^3ku^2-10d^2kr^2t^2u^2-24d^2krt^2u^2-16d^2kt^2u^2 \\ -8dkr^2u^2-40dkru^2-32dku^2+32kr^2t^2u^2+96krt^2u^2+64kt^2u^2\end{bmatrix}}{a(d+2)\left(3d^2r^2+10d^2r+8d^2-4dr^2-4dr-32r-32\right)}$$

According to Lemma 2, market forces are the key factors affecting retailers' financing choices.When the market power of retailers R_S is relatively strong, retailers R_S will choose trade credit financing immediately. As its market power declines, interest rates on trade credit financing rise, leading to higher financing costs.So retailers R_S will turn to bank financing at lower interest rates to solve their own funding problems.

3.1.3. Only R_L Profit Models for Purchasing High Quality Products (Scenarios LH)

Suppose the wholesale price set by the manufacturer is w_{k-i}^{LH}, and the quantity of products ordered by the retailer and at the same time are q_{k-L}^{LH} and q_{k-S}^{LH} . π_{k-L}^{LH} , π_{k-S}^{LH} and π_{k-M}^{LH} are respectively the profit function of retailer and manufacturer under the financing choice of scenario, then:

$$\begin{cases}\pi_{k-L}^{LH}=(\gamma a-q_{k-L}^{LH}-dq_{k-S}^{LH}+\beta tu)q_{k-L}^{LH}-w_{k-L}^{LH}q_{k-L}^{LH}(1+\varphi_k)\\ \pi_{k-S}^{LH}=\left((1-\gamma)a-q_{k-S}^{LH}-dq_{L-k}^{LH}+\beta u\right)q_{k-S}^{LH}-w_{k-S}^{LH}q_{k-S}^{LH}(1+\phi_k)\\ \pi_{k-M}^{LH}=w_{k-L}^{LH}q_{k-L}^{LH}(1+\varphi_k)+w_{k-S}^{LH}q_{k-S}^{LH}(1+\phi_k)-ku^2q_{k-S}^{LH}-k(tu)^2q_{k-L}^{LH}\end{cases} \tag{3}$$

Table 4. Optimal wholesale price, order quantity and profit of retailers in LH scenario under Nash game

k	TT	TB	BT	BB
w_{k-L}^{LH*}	$\frac{\gamma(av+\beta tu+kt^2u^2)}{2(r+\gamma)}$	$\frac{\left(\begin{array}{l}-\gamma(-ad^2r\gamma-2ad^2\gamma+2adr\gamma\\-2adr+8ar\gamma+8a\gamma-\beta d^2rtu\\-2\beta d^2tu-2\beta dru+8\beta rtu+8\beta tu\\+d^2(-k)r^2t^2u^2-3d^2krt^2u^2-2d^2kt^2u^2\\+2dkr^2u^2+2dkru^2+8krt^2u^2+8kt^2u^2)\end{array}\right)}{\left(d^2r^2+4d^2r+4d^2-16r-16\right)(r+\gamma)}$	$\frac{\left(\begin{array}{l}ad^2r\gamma+2ad^2\gamma+2adr\gamma-2adr\\-8a\gamma+\beta d^2ru+2\beta d^2u-2\beta dru\\-8\beta u+d^2kru^2+2d^2ku^2\\+2dkru^2-8kru^2-8ku^2\end{array}\right)}{d^2r^2+4d^2r+4d^2-16r-16}$	$\frac{a\gamma+\beta tu+krt^2u^2+kt^2u^2}{2(r+1)}$
w_{k-S}^{LH*}	$\frac{(1-\gamma)\left(a-a\gamma+\beta u+ku^2\right)}{2\left(1+r-\gamma\right)}$	$\frac{\left(\begin{array}{l}ad^2r\gamma-ad^2r+2ad^2\gamma-2ad^2\\+2adr\gamma-8a\gamma+8a-\beta d^2ru-\\2\beta d^2u+2\beta drtu+8\beta u-d^2kru^2\\-2d^2ku^2-2dkrt^2u^2+8kru^2+8ku^2\end{array}\right)}{-d^2r^2-4d^2r-4d^2+16r+16}$	$\frac{\left(\begin{array}{l}(1-\gamma)(-ad^2r\gamma+ad^2r-2ad^2\gamma\\+2ad^2+2adr\gamma+8ar\gamma-8ar+8a\gamma\\-8a+\beta d^2ru+2\beta d^2u+2\beta drtu-8\beta ru\\-8\beta u+d^2kr^2u^2+3d^2kru^2+2d^2ku^2\\-2dkr^2t^2u^2-2dkrt^2u^2-8kru^2-8ku^2)\end{array}\right)}{(r-\gamma+1)(d^2r^2+4d^2r+4d^2-16r-16)}$	$\frac{a-a\gamma+\beta u+kru^2+ku^2}{2(r+1)}$
q_{k-L}^{LH*}	$\frac{\left(\begin{array}{l}ad\gamma-ad+2a\gamma-\beta du\\+2\beta tu+dku^2-2kt^2u^2\end{array}\right)}{2\left(4-d^2\right)}$	$\frac{\left(\begin{array}{l}adr\gamma-adr+2ad\gamma-2ad\\+4ar\gamma+4a\gamma-\beta dru-2\beta du\\+4\beta rtu+4\beta tu+dkr^2u^2+3dkru^2\\+2dku^2-4krt^2u^2-4kt^2u^2\end{array}\right)}{16r+16-d^2r^2-4d^2r-4d^2}$	$\frac{(r+1)\left(\begin{array}{l}-adr\gamma+adr-2ad\gamma+2ad\\-4a\gamma+\beta dru+2\beta du-4\beta tu\\-dkru^2-2dku^2+4krt^2u^2+4kt^2u^2\end{array}\right)}{d^2r^2+4d^2r+4d^2-16r-16}$	$\frac{\left(\begin{array}{l}ad\gamma-ad+2a\gamma-\beta du+2\beta tu\\+dkru^2+dku^2-2krt^2u^2-2kt^2u^2\end{array}\right)}{2(4-d^2)}$
q_{k-S}^{LH*}	$\frac{\left(\begin{array}{l}ad\gamma+2a\gamma-2a+\beta dtu\\-2\beta u-dkt^2u^2+2ku^2\end{array}\right)}{2(d^2-4)}$	$\frac{\left(\begin{array}{l}(r+1)(adr\gamma+2ad\gamma+4a\gamma-4a\\+\beta drtu+2\beta dtu-4\beta u-dkrt^2u^2\\-2dkt^2u^2+4kru^2+4ku^2)\end{array}\right)}{d^2r^2+4d^2r+4d^2-16r-16}$	$\frac{\left(\begin{array}{l}adr\gamma+2ad\gamma+4ar\gamma-4ar\\+4a\gamma-4a+\beta drtu+2\beta dtu-4\beta ru\\-4\beta u-dkr^2t^2u^2-3dkrt^2u^2\\-2dkt^2u^2+4kru^2+4ku^2\end{array}\right)}{d^2r^2+4d^2r+4d^2-16r-16}$	$\frac{\left(\begin{array}{l}ad\gamma+2a\gamma-2a+\beta dtu-2\beta u\\-dkrt^2u^2-dkt^2u^2+2kru^2+2ku^2\end{array}\right)}{2(d^2-4)}$
π_{k-L}^{LH*}	$\frac{\left(\begin{array}{l}ad\gamma-ad+2a\gamma-\beta du\\+2\beta tu+dku^2-2kt^2u^2\end{array}\right)^2}{4(d^2-4)^2}$	$\frac{\left(\begin{array}{l}(adr\gamma-adr+2ad\gamma-2ad\\+4ar\gamma+4a\gamma-\beta dru-2\beta du\\+4\beta rtu+4\beta tu+dkr^2u^2+3dkru^2\\+2dku^2-4krt^2u^2-4kt^2u^2)^2\end{array}\right)}{(d^2r^2+4d^2r+4d^2-16r-16)^2}$	$\frac{\left(\begin{array}{l}(r+1)^2(-adr\gamma+adr-2ad\gamma\\+2ad-4a\gamma+\beta dru+2\beta du-4\beta tu\\-dkru^2-2dku^2+4krt^2u^2+4kt^2u^2)^2\end{array}\right)}{(d^2r^2+4d^2r+4d^2-16r-16)^2}$	$\frac{\left(\begin{array}{l}(ad\gamma-ad+2a\gamma-\beta du+2\beta tu\\+dkru^2+dku^2-2krt^2u^2-2kt^2u^2)^2\end{array}\right)}{4(d^2-4)^2}$
π_{k-S}^{LH*}	$\frac{\left(\begin{array}{l}ad\gamma+2a\gamma-2a+\beta dtu\\-2\beta u-dkt^2u^2+2ku^2\end{array}\right)^2}{4(d^2-4)^2}$	$\frac{\left(\begin{array}{l}(r+1)^2(adr\gamma+2ad\gamma+4a\gamma-4a\\+\beta drtu+2\beta dtu-4\beta u-dkrt^2u^2\\-2dkt^2u^2+4kru^2+4ku^2)^2\end{array}\right)}{(d^2r^2+4d^2r+4d^2-16r-16)^2}$	$\frac{\left(\begin{array}{l}(adr\gamma+2ad\gamma+4ar\gamma-4ar\\+4a\gamma-4a+\beta drtu+2\beta dtu-4\beta ru\\-4\beta u-dkr^2t^2u^2-3dkrt^2u^2\\-2dkt^2u^2+4kru^2+4ku^2)^2\end{array}\right)}{(d^2r^2+4d^2r+4d^2-16r-16)^2}$	$\frac{\left(\begin{array}{l}(ad\gamma+2a\gamma-2a+\beta dtu-2\beta u\\-dkrt^2u^2-dkt^2u^2+2kru^2+2ku^2)^2\end{array}\right)}{4(d^2-4)^2}$
π_{k-M}^{LH*}	π_{TT-M}^{LH*}	π_{TB-M}^{LH*}	π_{BT-M}^{LH*}	π_{BB-M}^{LH*}

According to the optimal solution of each parameter in Table 4, the financing subgame equilibrium of retailers under Nash game scenario is analyzed, as shown in Lemma 3:

Lemma 3. Nash Game: when $\gamma\in(0.5,\gamma^{LH})$,all retailers chose trade credit financing; when $\gamma\in(\gamma^{LH},1)$,retailers R_L chose trade credit financing and retailers R_S chose bank financing.

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$$\gamma^{LH}=\frac{\left[\begin{array}{l}2ad^2r^2+16ad^2r+16ad^2-64ar-64a-3\beta d^3r^2tu-10\beta d^3rtu-8\beta d^3tu+2\beta d^2r^2u+16\beta d^2ru+16\beta d^2u+8\beta dr^2tu+\\40\beta drtu+32\beta dtu-64\beta ru-64\beta u+3d^3kr^2t^2u^2+10d^3krt^2u^2+8d^3kt^2u^2-10d^2kr^2u^2-24d^2kru^2-16d^2ku^2-8dkr^2t^2u^2\\-40dkrt^2u^2-32dkt^2u^2+32kr^2u^2+96kru^2+64ku^2\end{array}\right]}{a(d+2)\left(3d^2r^2+10d^2r+8d^2-4dr^2-4dr-32r-32\right)}$$

3.1.4. Profit Model of All Retailers Purchasing Low-quality Products (Scenario LL)

Suppose the wholesale price set by the manufacturer is w_{k-i}^{LL} , and the quantity of products ordered by the retailer and at the same time are q_{k-L}^{LL} and q_{k-S}^{LL} . π_{k-L}^{LL} , π_{k-S}^{LL} and π_{k-M}^{LL} are respectively the profit function of retailer and manufacturer under the financing choice of scenario, then:

$$\begin{cases}\pi_{k-L}^{LL}=(\gamma a-q_{k-L}^{LL}-dq_{k-S}^{LL}+\beta tu)q_{k-L}^{LL}-w_{k-L}^{LL}q_{k-L}^{LL}(1+\varphi_k)\\ \pi_{k-S}^{LL}=\left((1-\gamma)a-q_{k-S}^{LL}-dq_{k-L}^{LL}+\beta tu\right)q_{k-S}^{LL}-w_{k-S}^{LL}q_{k-S}^{LL}(1+\phi_k)\\ \pi_{k-M}^{LL}=w_{k-L}^{LL}q_{k-L}^{LL}(1+\varphi_k)+w_{k-S}^{LL}q_{k-S}^{LL}(1+\phi_k)-k(tu)^2(q_{k-L}^{LL}+q_{k-S}^{LL})\end{cases} \tag{4}$$

Table 5. Optimal wholesale price, order quantity and profit of retailers in LL scenario under Nash game

k	TT	TB	BT	BB
w_{k-L}^{LH*}	$\frac{\gamma(av+\beta tu+kt^2u^2)}{2(r+\gamma)}$	$\frac{\left(\begin{array}{l}-\gamma(-ad^2r\gamma-2ad^2\gamma+2adr\gamma\\-2adr+8ar\gamma+8a\gamma-\beta d^2rtu\\-2\beta d^2tu-2\beta dru+8\beta rtu+8\beta tu\\+d^2(-k)r^2t^2u^2-3d^2krt^2u^2-2d^2kt^2u^2\\+2dkr^2u^2+2dkru^2+8krt^2u^2+8kt^2u^2)\end{array}\right)}{\left(d^2r^2+4d^2r+4d^2-16r-16\right)(r+\gamma)}$	$\frac{\left(\begin{array}{l}ad^2r\gamma+2ad^2\gamma+2adr\gamma-2adr\\-8a\gamma+\beta d^2ru+2\beta d^2u-2\beta dru\\-8\beta u+d^2kru^2+2d^2ku^2\\+2dkru^2-8kru^2-8ku^2\end{array}\right)}{d^2r^2+4d^2r+4d^2-16r-16}$	$\frac{a\gamma+\beta tu+krt^2u^2+kt^2u^2}{2(r+1)}$
w_{k-S}^{LH*}	$\frac{(1-\gamma)\left(a-a\gamma+\beta u+ku^2\right)}{2\left(1+r-\gamma\right)}$	$\frac{\left(\begin{array}{l}ad^2r\gamma-ad^2r+2ad^2\gamma-2ad^2\\+2adr\gamma-8a\gamma+8a-\beta d^2ru-\\2\beta d^2u+2\beta drtu+8\beta u-d^2kru^2\\-2d^2ku^2-2dkrt^2u^2+8kru^2+8ku^2\end{array}\right)}{-d^2r^2-4d^2r-4d^2+16r+16}$	$\frac{\left(\begin{array}{l}(1-\gamma)(-ad^2r\gamma+ad^2r-2ad^2\gamma\\+2ad^2+2adr\gamma+8ar\gamma-8ar+8a\gamma\\-8a+\beta d^2ru+2\beta d^2u+2\beta drtu-8\beta ru\\-8\beta u+d^2kr^2u^2+3d^2kru^2+2d^2ku^2\\-2dkr^2t^2u^2-2dkrt^2u^2-8kru^2-8ku^2)\end{array}\right)}{(r-\gamma+1)(d^2r^2+4d^2r+4d^2-16r-16)}$	$\frac{a-a\gamma+\beta u+kru^2+ku^2}{2(r+1)}$
q_{k-L}^{LH*}	$\frac{\left(\begin{array}{l}ad\gamma-ad+2a\gamma-\beta du\\+2\beta tu+dku^2-2kt^2u^2\end{array}\right)}{2\left(4-d^2\right)}$	$\frac{\left(\begin{array}{l}adr\gamma-adr+2ad\gamma-2ad\\+4ar\gamma+4a\gamma-\beta dru-2\beta du\\+4\beta rtu+4\beta tu+dkr^2u^2+3dkru^2\\+2dku^2-4krt^2u^2-4kt^2u^2\end{array}\right)}{16r+16-d^2r^2-4d^2r-4d^2}$	$\frac{(r+1)\left(\begin{array}{l}-adr\gamma+adr-2ad\gamma+2ad\\-4a\gamma+\beta dru+2\beta du-4\beta tu\\-dkru^2-2dku^2+4krt^2u^2+4kt^2u^2\end{array}\right)}{d^2r^2+4d^2r+4d^2-16r-16}$	$\frac{\left(\begin{array}{l}ad\gamma-ad+2a\gamma-\beta du+2\beta tu\\+dkru^2+dku^2-2krt^2u^2-2kt^2u^2\end{array}\right)}{2(4-d^2)}$
q_{k-S}^{LH*}	$\frac{\left(\begin{array}{l}ad\gamma+2a\gamma-2a+\beta dtu\\-2\beta u-dkt^2u^2+2ku^2\end{array}\right)}{2(d^2-4)}$	$\frac{\left(\begin{array}{l}(r+1)(adr\gamma+2ad\gamma+4a\gamma-4a\\+\beta drtu+2\beta dtu-4\beta u-dkrt^2u^2\\-2dkt^2u^2+4kru^2+4ku^2)\end{array}\right)}{d^2r^2+4d^2r+4d^2-16r-16}$	$\frac{\left(\begin{array}{l}adr\gamma+2ad\gamma+4ar\gamma-4ar\\+4a\gamma-4a+\beta drtu+2\beta dtu-4\beta ru\\-4\beta u-dkr^2t^2u^2-3dkrt^2u^2\\-2dkt^2u^2+4kru^2+4ku^2\end{array}\right)}{d^2r^2+4d^2r+4d^2-16r-16}$	$\frac{\left(\begin{array}{l}ad\gamma+2a\gamma-2a+\beta dtu-2\beta u\\-dkrt^2u^2-dkt^2u^2+2kru^2+2ku^2\end{array}\right)}{2(d^2-4)}$
π_{k-L}^{LH*}	$\frac{\left(\begin{array}{l}ad\gamma-ad+2a\gamma-\beta du\\+2\beta tu+dku^2-2kt^2u^2\end{array}\right)^2}{4(d^2-4)^2}$	$\frac{\left(\begin{array}{l}(adr\gamma-adr+2ad\gamma-2ad\\+4ar\gamma+4a\gamma-\beta dru-2\beta du\\+4\beta rtu+4\beta tu+dkr^2u^2+3dkru^2\\+2dku^2-4krt^2u^2-4kt^2u^2)^2\end{array}\right)}{(d^2r^2+4d^2r+4d^2-16r-16)^2}$	$\frac{\left(\begin{array}{l}(r+1)^2(-adr\gamma+adr-2ad\gamma\\+2ad-4a\gamma+\beta dru+2\beta du-4\beta tu\\-dkru^2-2dku^2+4krt^2u^2+4kt^2u^2)^2\end{array}\right)}{(d^2r^2+4d^2r+4d^2-16r-16)^2}$	$\frac{\left(\begin{array}{l}(ad\gamma-ad+2a\gamma-\beta du+2\beta tu\\+dkru^2+dku^2-2krt^2u^2-2kt^2u^2)^2\end{array}\right)}{4(d^2-4)^2}$
π_{k-S}^{LH*}	$\frac{\left(\begin{array}{l}ad\gamma+2a\gamma-2a+\beta dtu\\-2\beta u-dkt^2u^2+2ku^2\end{array}\right)^2}{4(d^2-4)^2}$	$\frac{\left(\begin{array}{l}(r+1)^2(adr\gamma+2ad\gamma+4a\gamma-4a\\+\beta drtu+2\beta dtu-4\beta u-dkrt^2u^2\\-2dkt^2u^2+4kru^2+4ku^2)^2\end{array}\right)}{(d^2r^2+4d^2r+4d^2-16r-16)^2}$	$\frac{\left(\begin{array}{l}(adr\gamma+2ad\gamma+4ar\gamma-4ar\\+4a\gamma-4a+\beta drtu+2\beta dtu-4\beta ru\\-4\beta u-dkr^2t^2u^2-3dkrt^2u^2\\-2dkt^2u^2+4kru^2+4ku^2)^2\end{array}\right)}{(d^2r^2+4d^2r+4d^2-16r-16)^2}$	$\frac{\left(\begin{array}{l}(ad\gamma+2a\gamma-2a+\beta dtu-2\beta u\\-dkrt^2u^2-dkt^2u^2+2kru^2+2ku^2)^2\end{array}\right)}{4(d^2-4)^2}$
π_{k-M}^{LH*}	π_{TT-M}^{LH*}	π_{TB-M}^{LH*}	π_{BT-M}^{LH*}	π_{BB-M}^{LH*}

According to the optimal solution of each parameter in Table 5, the financing subgame equilibrium of retailers under Nash game scenario is analyzed, as shown in Lemma 4:

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Lemma 4. Nash Game: when $\gamma \in (0.5, \gamma^{LL})$,all retailers chose trade credit financing; when $\gamma \in (\gamma^{LL}, 1)$,retailers R_L chose trade credit financing and retailers R_S chose bank financing.

$$\gamma^{LL} = \frac{\begin{bmatrix} 2ad^2r^2 + 16ad^2r + 16ad^2 - 64ar - 64a - 3\beta d^3r^2tu - 10\beta d^3rtu - 8\beta d^3tu + 2\beta d^2r^2tu + 16\beta d^2rtu + 16\beta d^2tu + 8\beta dr^2tu \\ +40\beta drtu + 32\beta dtu - 64\beta rtu - 64\beta tu + 3d^3kr^2t^2u^2 + 10d^3krt^2u^2 + 8d^3kt^2u^2 - 10d^2kr^2t^2u^2 - 24d^2krt^2u^2 - 16d^2kt^2u^2 \\ -8dkr^2t^2u^2 - 40dkrt^2u^2 - 32dkt^2u^2 + 32kr^2t^2u^2 + 96krt^2u^2 + 64kt^2u^2 \end{bmatrix}}{a(d+2)\left(3d^2r^2 + 10d^2r + 8d^2 - 4dr^2 - 4dr - 32r - 32\right)}$$

3.2. Supply Chain Financing Decision Analysis

After obtaining the optimal income of each member of the supply chain and the selection conditions of each financing strategy, we analyze the financing decision of the supply chain.For the threshold expression of market power in Lemma 1-4, we can get the following relation. As lemma 5 shows:

Lemma 5. Nash game: If, exists $k \in (0, k_1]$, $\gamma^{HL} < \gamma^{LL} < \gamma^{HH} < \gamma^{LH}$. If, exists $k \in (k_1, \bar{k})$, $\gamma^{LH} < \gamma^{HH} < \gamma^{LL} < \gamma^{HL}$, $k_1 = \dfrac{\beta\left(3d^2r^2 + 10d^2r + 8d^2 + 4dr^2 + 4dr - 32r - 32\right)}{(t+1)u\left(3d^2r^2 + 10d^2r + 8d^2 - 4dr^2 - 4dr - 16r^2 - 48r - 32\right)}$.

According to Lemma 5 and the previous lemma 1-4, the retailer's financing decision equilibrium can be analyzed and obtained.As shown in theorem 1.

Theorem 1. Nash game:

(1)Given $k \in (0, k_1]$, if $\gamma \in (0.5, \gamma^{HL})$: TT is the financing equilibrium strategy in four scenarios HH, HL, LH, LL ;if $\gamma \in (\gamma^{HL}, \gamma^{LL}]$:when LL , HH , LH scenario, TT is financing equilibrium strategy,and when HL scenario, TB is financing equilibrium strategy; if $\gamma \in (\gamma^{LL}, \gamma^{HH}]$: when HH , LH scenario, TT is financing equilibrium strategy,and when HL , LL situation, TB is financing equilibrium strategy; if $\gamma \in (\gamma^{HH}, \gamma^{LH}]$:when LH situation, TT is financing equilibrium strategy, and when HL , LL , HH scenario, TB is financing equilibrium strategy; if $\gamma \in (\gamma^{LH}, 1)$: TB is the financing equilibrium strategy.

(2)Given $k \in (k_1, \bar{k})$, if $\gamma \in (0.5, \gamma^{LH})$: TT is the financing equilibrium strategy in four scenarios HH, HL, LH, LL ;if $\gamma \in (\gamma^{LH}, \gamma^{HH}]$:when HH , LL , HL scenario, TT is financing equilibrium strategy,and when LH scenario, TB is financing equilibrium strategy; if $\gamma \in (\gamma^{HH}, \gamma^{LL}]$: when LL , HL scenario, TT is financing equilibrium strategy,and when LH , HH situation, TB is financing equilibrium strategy; if $\gamma \in (\gamma^{LL}, \gamma^{HL}]$:when HL situation, TT is financing equilibrium strategy, and when LH , LL , HH scenario, TB is financing equilibrium strategy; if $\gamma \in (\gamma^{HL}, 1)$: TB is the financing equilibrium strategy.

According to Theorem 1, the market power and product cost coefficient of retailers are the main factors affecting their financing decisions, and the different purchasing strategies of retailers also affect their financing strategies.

3.3. Supply Chain Procurement Decision and Financing Choice Balance Strategy

This section mainly analyzes the purchasing strategies of two retailers.Based on the financing decision of theorem 1, we further analyze the product purchasing strategy and financing choice equilibrium strategy of supply chain.

3.3.1. Product Procurement Decision When Product Cost Coefficient K is Small

When the product cost coefficient is small (i.e. $k \in (0, k_1]$), we compare the influence of market competition coefficient on purchasing decision, and discuss retailer's product purchasing and financing equilibrium strategy in Nash game based on retailer's financing decision, as shown in Theorem 2.

(1)When $\gamma \in (0.5, \gamma^{HL})$:if $d \in (0, d_{f1})$, then adopt the strategy for the optimal equilibrium of the supply chain, that is $HH-TT$, both retailers purchase high-quality products and choose trade credit financing method; if $d \in (d_{f1}, 1)$, then the optimal equilibrium of the supply chain is adopted, that is $HL-TT$, retailers R_L purchase high-quality products and retailers R_S purchase low-quality products, and both retailers choose trade credit financing.
(2)When $\gamma \in (\gamma^{HL}, \gamma^{HH}]$:if $d \in (0, d_{f2})$, then adopt the strategy for the optimal equilibrium of the supply chain, that is $HH-TT$, both retailers purchase high-quality products and choose trade credit financing method; if $d \in (d_{f2}, 1)$, then the optimal equilibrium of the supply chain is adopted, that is $HL-TB$, the retailer R_L chooses to purchase high-quality products and choose trade credit financing, while the retailer R_S chooses to purchase low-quality products and choose bank financing.
(3)When $\gamma \in (\gamma^{HH}, 1)$:if $d \in (0, d_{f3})$, then adopt the strategy for the optimal equilibrium of the supply chain, that is $HH-TB$, both retailers purchase high-quality products,but the retailer R_S chooses bank financing; if $d \in (d_{f3}, 1)$, then the optimal equilibrium of the supply chain is adopted, that is $HL-TB$, the retailer R_L chooses to purchase high-quality products and choose trade credit financing, while the retailer R_S chooses to purchase low-quality products and choose bank financing.

$$d_{f1} = \frac{-2a\gamma + 2a + \beta tu + \beta u - kt^2u^2 - ku^2}{a\gamma + \beta u - ku^2}$$

$$d_{f2} = \arg_d \left\{ \pi_{TT-S}^{HH*} - \pi_{TB-S}^{HL*} \right\}$$

$$d_{f3} = \frac{-2\{u[-\beta(1+t) + k(1+r)(1+t^2)u] + 2a(-1+\gamma)\}}{(2+r)[u(\beta - ku) + a\gamma]}$$

For the convenience of observation, we summarized the retailers' product purchasing equilibrium strategy into a table, as shown in Table 6:

Table 6. Product procurement balancing policies

	$\gamma \in (0.5, \gamma^{HL}]$		$\gamma \in (\gamma^{HL}, \gamma^{HH}]$		$\gamma \in (\gamma^{HH}, 1)$	
R_L / R_S	H	L	H	L	H	L
H	$d \in (0, d_{f1})$	$d \in (d_{f1}, 1)$	$d \in (0, d_{f2})$	$d \in (d_{f2}, 1)$	$d \in (0, d_{f3})$	$d \in (0, d_{f3})$
L	non-existent	non-existent	non-existent	non-existent	non-existent	non-existent

3.3.2. Product Procurement Decision When Product Cost Coefficient K is Large

When the product cost coefficient is large(i.e. $k \in (k_1, \bar{k})$), we compare the influence of market competition coefficient on purchasing decision, and discuss retailer's product purchasing and financing equilibrium strategy in Nash game based on retailer's financing decision, as shown in Theorem 3.
(1)When $\gamma \in (0.5, \gamma^{LH}]$:if $d \in (0, d_{f4})$, then adopt the strategy for the optimal equilibrium of the supply chain, that is $LL-TT$, both retailers purchase low-quality products and choose trade credit financing method; if $d \in (d_{f4}, 1)$, then the optimal equilibrium of the supply chain is

adopted, that is $LH-TT$, retailers R_L purchase low-quality products and retailers R_S purchase high-quality products, and both retailers choose trade credit financing.

(2)When $\gamma \in (\gamma^{LH}, \gamma^{LL}]$:if $d \in (0, d_{f5})$, then adopt the strategy for the optimal equilibrium of the supply chain, that is $LL-TT$, both retailers purchase low-quality products and choose trade credit financing method; if $d \in (d_{f5}, 1)$, then the optimal equilibrium of the supply chain is adopted, that is $LH-TB$, the retailer R_L chooses to purchase low-quality products and choose trade credit financing, while the retailer R_S chooses to purchase high-quality products and choose bank financing.

(3)When $\gamma \in (\gamma^{LL}, 1]$:if $d \in (0, d_{f6})$, then adopt the strategy for the optimal equilibrium of the supply chain, that is $LL-TB$, both retailers purchase low-quality products, but the retailer R_S chooses bank financing; if $d \in (d_{f6}, 1)$, then the optimal equilibrium of the supply chain is adopted, that is $LH-TB$, the retailer R_L chooses to purchase low-quality products and choose trade credit financing, while the retailer R_S chooses to purchase high-quality products and choose bank financing.

$$d_{f4} = \frac{2a\gamma - 2a - \beta tu - \beta u + kt^2u^2 + ku^2}{-a\gamma - tu + kt^2u^2}$$

$$d_{f5} = \arg_d \left\{ \pi_{TT-S}^{LL*} = \pi_{TB-S}^{LH*} \right\}$$

$$d_{f6} = \frac{-2\{u[-\beta(1+t)+k(1+r)(1+t^2)u]+2a(-1+\gamma)\}}{(2+r)[tu(\beta-ktu)+a\gamma]}$$

For the convenience of observation, we summarized the retailers' product purchasing equilibrium strategy into a table, as shown in Table 7:

Table 7. Product procurement balancing policies

	$\gamma \in (0.5, \gamma^{LH}]$		$\gamma \in (\gamma^{LH}, \gamma^{LL}]$		$\gamma \in (\gamma^{LL}, 1)$	
R_L / R_S	H	L	H	L	H	L
H	non-existent	non-existent	non-existent	non-existent	non-existent	non-existent
L	$d \in (0, d_{f4})$	$d \in (d_{f4}, 1)$	$d \in (0, d_{f5})$	$d \in (d_{f5}, 1)$	$d \in (0, d_{f6})$	$d \in (d_{f6}, 1)$

4. Conclusion

The results show that if in both Nash and Stackelberg games, retailers with strong market power tend to choose trade credit financing from the perspective of financing strategies, while retailers with weak market power have more choices in financing strategies and are influenced by market forces and product purchasing strategies. From the perspective of product purchasing strategy, retailer's product purchasing strategy will be affected by product production cost, market power and market competition intensity. When the production cost coefficient of unit product is small, no matter the market competition intensity is large or small, retailers will purchase high-quality products when the market forces are not different. When the difference of market forces increases, retailers' product purchasing strategies appear differentiation with the increase of market competition intensity. When the production cost coefficient of unit product is large, retailers with higher market power will give up purchasing

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high-quality products, while retailers with lower market power will purchase high-quality products with the increase of competition intensity.

Therefore, retailers should choose appropriate financing methods to solve the problem of capital constraints in combination with their own market power, so as not to miss the good opportunity and be eliminated by the market.

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