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Research on Ordering Strategy of Capital-Limited Retailers under Stochastic Market Demand

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Abstract : Under the condition of capital constraint on retailer, the retailers can effectively alleviate the funds shortage by delay payments and financing to third party financial institutions. This method will improve the profit of retailer and the performance of the csupply chain. Newsboy model under conditions of permissible delay payments, considers the capital structure of the company in the study of financing problems, and research two-stage supply chain system consisting of suppliers and retailers. An optimal order strategy model of the retailer is constructed, and the Analytical solution of this model is obtained. Then, this paper obtains a series of useful management conclusions through sensitivity analysis.

Key Words : capital structure; the newsboy model; optimal ordering strategy; financial supply chain

1. INTRODUCTION

With the acceleration of the global economic integration process, competition among enterprises has become increasingly fierce. In order to obtain excess returns in the fierce competition and to be healthy and sustainable, many companies are investing in products, technology, and management in the future or in the future to improve their competitiveness. However, many enterprises in China are faced with insufficient funds in the daily operation and management process, especially the small and medium-sized enterprises that account for more than 90% of the total number of enterprises in China ^[1]. The lack of funds will directly affect the daily operation of the company.

Management, research and development, etc., hinder the further development of the company. At the same time, Gelsomino (2014) ^[2], Hofmann (2013) ^[3], Liu (2015) ^[4] and other research found that through the process of supply chain finance, capital flow, logistics, procurement, distribution and other processes

Harmonic management can effectively improve the overall efficiency of the supply chain. Therefore, for academic and practical circles, supply chain financing in the current market environment is an urgent problem to be solved.

At present, the financing models of SMEs in China mainly include internal financing and external financing. The internal financing is mainly for enterprises to use the deferred payment or the advanced payment method to the downstream enterprises in the supply chain to obtain short-term funds from within the supply chain; the external financing is mainly for the enterprises to use the debt financing or equity financing methods to third-party financial institutions outside the supply chain. Get funding ^[5-7]. Huang (2011) ^[8] and other related research through theory and evidence found that for China's enterprises, these two different financing methods have greater substitution. According to the " 2013 China Enterprise Credit Risk Status Survey Report" issued by the International Credit Insurance and Credit Management Service Coface Group, it has become a relatively wide payment method through the sale of sales by enterprises, and the proportion of total transactions has been from 2007. in the 54.1% rise to 2011 years of 89.5%, accounting for cash on delivery style, it has grown from 2007 in 45.9% reduction to 2011 years of 10.5%. As can be seen from the above data, the internal financing

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model has been widely adopted by many companies in China. The modes of external financing of enterprises to third-party financial institutions outside the supply chain are: accounts receivable financing, inventory financing, prepayment financing, and strategic relationship financing^[9]. Lu Qihui et al (2012)^[10], Arya et al. (2013)^[11] studied the financing decision-making problem of financially constrained retailers from the perspective of accounts receivable financing. Buzacott et al. (2004)^[12] studied the optimal ordering strategy for financially constrained retailers using asset collateral financing.

In the supply chain model that allows for delayed payments, it is generally assumed that the retailer has sufficient ability to pay to repay the supplier's payment when the credit period expires. Shaikh et al (2016)^[13], etc. from multiple angles Research on the ordering of retailers that allow deferred payments. In fact, in real life, due to various factors, many retailers may not be able to pay the full amount of the payment when the credit period expires. At this point, the retailer's business reputation will be greatly impacted, and its upstream supply chain enterprises may also be affected to a certain extent, and even cause greater losses to the entire supply chain. At this point, retailers urgently need to finance third-party financial institutions. However, affected by the scale of business operations, credit, collateral, interest rates and other factors, many small and medium-sized enterprises in China are unable or unwilling to obtain loans from commercial banks at a higher cost. They also hope to obtain funds through equity financing.

In the related research on inventory management, Li et al. (2005)^[22] conducted a research on the multi-stage inventory financing problem with financial constraints based on the newsboy model, pointing out that retailers must achieve the goal of maximizing long-term profit in the future. carried out to a third party financial institution financing to address the plight of insufficient funds; Yang et al (2017)^[23] for the first time takes into account the equity financing model for the retailer, and the establishment of a 1 suppliers and 2 two component supply retailers The chain system has obtained the optimal ordering strategy.

Based on the models of Yang et al. (2017)^[23] and Li et al. (2005)^[22], this paper incorporates the company's capital structure problem into the newsboy model that allows for delayed payments, considering two suppliers consisting of suppliers and retailers. The level supply chain system, research retailers may face the total cost in four different situations in the future, analyze the possible financing model of the retailer, construct an optimal ordering strategy model of the retailer, and obtain the analytical solution of the model. In addition, this model is further discussed through numerical examples, and the influence of factors such as bond financing ratio and capital on retailer's profit and order quantity is analyzed by parameter sensitivity.

2. MODEL DESCRIPTION AND ASSUMPTIONS

2.1 Model description

Based on the newsboy model, this paper integrates third-party financing institutions into a two-tier supply chain system composed of suppliers and retailers based on the supply chain financial business, and this financing institution can provide debt financing or equity financing. The model consists of 1 supplier and 1 retailer. The supplier has sufficient funds, assuming that the initial capital of the retailer is zero, the sales income is used to pay the purchase price on the credit expiration date, and the retailer's sales income prior to the credit expiration date cannot pay the full payment, and the retailer facing the insufficient funds can be on debt financing or equity financing. Before the start of each sales cycle, retailers order products from suppliers to meet the stochastic demand of the market.

2.2 Variable definitions and assumptions

Suppose the retailer orders a quantity of Q from the supplier at a price c for one order cycle. Throughout the sales cycle, the retailer sells the merchandise to consumers at the price p , and the inventory cost per unit of merchandise is h . If the retailer does not complete the sale of all merchandise at the end of the period, and there

is still some inventories, then according to the newsboy model supplier will repurchase these merchandise at the price u . It is assumed that the retailer is unable to pay off the full payment at the credit expiration date, at this time, the retailer can finance with bonds, obtaining the loan from the third-party financial institution at the interest rate of r , or finance with equity.

3. MODEL ANALYSIS

3.1 Model construction

Retailers may face the following four situations throughout the sales cycle:

case 1: The retailer purchases goods that are larger than market demand, and the retailer's sales revenue cannot pay the full payment. that is, $x < Q$, $px < cQ$. At this time, the total market demand satisfies $x \in (0, \beta Q]$. Among them, $\beta = c/p$, β represents a critical value, obviously $0 < \beta < 1$, otherwise the retailer will not sell such goods. In this case, the total cost of the retailer mainly includes product cost and financing cost. Due to a random market demand faced by retailers, and the density function of market demand is $f(x)$, so the total funding gap of retailers is $g_1(y) = \int_0^{\beta Q} (cQ - px) f(x) dx$.

The expected value of the total cost of the retailer is:

$$f_1(Q) = \int_0^{\beta Q} [(c - u + h)(Q - x) + \alpha(cQ - px)r] f(x) dx \tag{1}$$

case 2: The retailer purchases goods that are larger than the market demand, and the retailer's sales revenue can pay the full payment, that is, $x < Q$, $px > cQ$. At this time, the total market demand satisfies $x \in (\beta Q, Q]$. Among them, $\beta = c/p$, β represents a critical value, obviously $0 < \beta < 1$, otherwise the retailer will not sell such goods. In this case the total cost of the retailer mainly includes the cost of the product, and the expected function of the total cost is:

$$f_2(Q) = \int_{\beta Q}^Q (c - u + h)(Q - x) f(x) dx \tag{2}$$

Case 3: The retailer purchases less than the market demand, and retailer's sales revenue can pay the full payment, that is, $x > Q$, $px > cQ$. At this time, the total market demand satisfies $x \in (Q, +\infty)$. Under this circumstance, the retailer's sales revenue can fully pay the full payment, and there is no need to borrow or finance from a third-party financial institution. The total cost at this time mainly includes the cost of stock-out. Because in real life, retailers always try to avoid the shortage of goods, and also to simplify the model, this article assumes that the retailer's stock-out loss is B in the event of stock-out.

Case 4 : The goods purchased by the retailer are less than the market demand, and the retailer's sales revenue cannot pay the full payment, that is, $x > Q$, $px < cQ$, which means that the price of the products sold by the retailer is much less than that of the Wholesale price from the supplier, obviously this situation is unreasonable, so this situation cannot appear in the real world.

For this retailer, the funding gap faced in the next cycle is:

$$g(Q) = \int_0^{\beta Q} (cQ - px) f(x) dx \tag{3}$$

Assume that the proportion of debt financing planned by the retailer in the future is α , which means that the amount of future debt financing is αg and the amount of equity financing is $(1 - \alpha)g$. The expected cost of future debt financing by retailers can be expressed as:

$$C(Q) = \alpha \int_0^{\beta Q} (cQ - px) r f(x) dx \tag{4}$$

Therefore, the retailer's expected total profit is:

$$\pi(Q) = (1-\theta) \left[\int_0^Q px f(x) dx - \int_0^Q (c-u+h)(Q-x) f(x) dx - B - \alpha \int_0^{\beta Q} (cQ-px) r f(x) dx \right] \tag{5}$$

Among them, $\theta = \frac{(1-\alpha)g}{M}$ is the ratio of financing amount to total retail capital (M) in the equity financing model.

In the face of debt financing and equity financing, listed companies in China are more inclined to equity financing [24-27]. Due to the impact of financing costs and other external factors, so the proportion of financing when using equity financing is generally higher. This article assumes equity financing ratio is not less than 20%, i.e. $\theta > 20\%$. At the same time, in order to simplify the calculation process, this paper assumes that the goods sold by the retailer are commodities that are in the product life cycle, so it can be assumed that the density function of the demand random variable is $f(x) = \begin{cases} kx, x \in [0, X] \\ 0, \text{其他} \end{cases}$, where $k = 2/X^2$, X is the largest market demand obtained by retailers according to previous experience.

3.2 Optimal solution

In this paper, the retailer's order strategy model will be analyzed and solved. Simplify and organize formula (5):

$$\pi(Q) = \left[1 - \frac{kp(1-\alpha)\beta^3 Q^3}{6M} \right] \left[\frac{pkQ^3}{3} - \frac{(c-u+h)kQ^3 - \alpha rkp\beta^3 Q^3}{6} - B \right] \tag{6}$$

Let $D_1 = \frac{pk}{3} - \frac{(c-u+h)k - \alpha rkp\beta^3}{6}$, $D_2 = \frac{(1-\alpha)kp\beta^3}{6M}$, and substitute into equation (6) to get:

$$\pi(Q) = (D_1 + D_2 B) Q^3 - D_1 D_2 Q^6 - B \tag{7}$$

Find the first derivative of equation (7):

$$\frac{d\pi(Q)}{dQ} = 3(D_1 + D_2 B) Q^2 - 6D_1 D_2 Q^5 \tag{8}$$

Let $\frac{d\pi}{dQ} = 0$, you can get the stagnation point of equation: $Q = \left(\frac{D_1 + BD_2}{2D_1 D_2} \right)^{\frac{1}{3}}$ \tag{9}

he second order of equation (6) will continue to be solved below to determine whether equation (9) is the optimal solution for this problem.

$$\frac{d^2\pi(Q)}{dQ^2} = 6(D_1 + D_2 B) Q - 30D_1 D_2 Q^4 \tag{10}$$

In real life, retailers are generally in the buyer's market. Through effective inventory control, the probability of out-of-stock situation is relatively low. Even if it is faced with a certain degree of out-of-stock situation, its shortage cost is generally not particularly large. Therefore, this paper assumes that the retailer's shortage cost to total capital ratio is lower than its gross profit margin, namely: $B/M < (p-c)/c$.

Nature 1 : If the retailer's shortage cost as a percentage of total capital is lower than its gross profit margin, that is: $B/M < (p-c)/c$, the Equation (9) is the optimal solution to the original problem.

Proof: Through the above, we know that $0 < \beta < 1$ and the retailer's interest rate r for debt financing from third-party financial institutions satisfies $0 < r < 1$, therefore the following inequality hold $(1 - \alpha r \beta^3) > 1 - \alpha > B \beta^3 (1 - \alpha) / M$. In order to get a higher profit, The retailer must require that the sum of the selling price and the buyback price of the goods is greater than the sum of the cost paid to the supplier and the cost of the inventory, that is: $p + u > c + h$. Therefore, it can be seen that the following inequality holds:

$$2p + \frac{Bp\alpha\beta^3}{M} > (c-u+h) + \alpha r p \beta^3 + \frac{Bp\beta^3}{M} \tag{11}$$

Substitute D_1, D_2 into the above equation, and simplify it: $D_1 > D_2 B$. From the above, we know it has the following relationship: $(5\theta - 1)D_1 > D_2 B$, that is, it satisfies $5D_1 D_2 Q^3 > D_1 + D_2 B$. Combined with formula (10), we can know $\frac{d^2 \pi(Q)}{dQ^2} < 0$. Therefore, equation (9) is the optimal solution to the problem.

4. NUMERICAL EXAMPLES AND PARAMETER SENSITIVITY ANALYSIS

4.1 Numerical examples

Through the analysis of relevant numerical examples, this paper will further elaborate the proposed optimal ordering strategy model. At the beginning of the period, the retailer uses deferred payment to obtain the goods from the supplier and pays the full payment at the credit expiration date. If the retailer's sales revenue is unable to pay the full payment before the credit expiration date, the retailer facing insufficient funds can conduct debt financing or equity financing. At the same time, in order to solve the worries of retailers and increase the enthusiasm of retailers to place order, suppliers will buyback the remaining commodities of retailers at a certain price according to the newsboy model. The relevant parameters are as follows: $c = 5$, $u = 3$, $h = 2$, $X = 3e + 5$, $p = 15$, $r = 0.1$, $M = 1e + 5$, $B = 1e + 4$, $\alpha = 0.3$. Under the framework of the optimal ordering strategy model proposed in this paper, according to the formula (7) and formula (9), the retailer's optimal order quantity in the interest-sales cycle is $1.8e+5$, and the corresponding profit to this order quantity is $2.7e+5$.

4.2 Parameter sensitivity analysis

In this section, based on the retailer's optimal ordering strategy model proposed above, relevant data in the numerical examples will be used to consider the impact of such parameters as debt financing ratio, retail capital, sales price, purchase price, cost price proportional coefficient on the retailer's optimal order quantity and profit respectively.

Figure 1 and Figure 2 respectively consider the relationship between debt financing ratio, order quantity and profit. As can be seen from figure 1 and figure 2, as the other parameters kept constant in the case, the ratio of debt financing factor increases, the optimal order quantity of retailers gradually increases, so does the profit. This is because according to the formula 5, with the increase of the proportional coefficient of debt financing, the total profits of retailers also show an increasing trend.

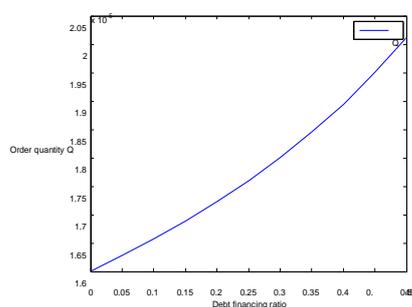


Figure 1. Relationship between debt financing ratio and order quantity

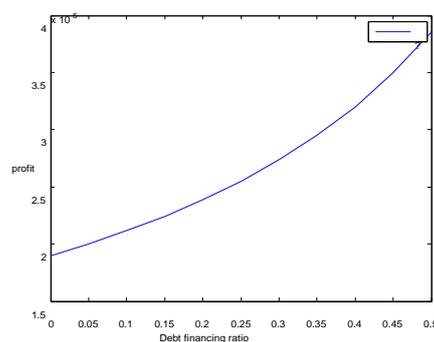


Figure 2. Relationship between debt financing ratio and profit

Figures 3 and 4 consider the relationship between retailer capital, order quantity, and profit respectively. It can be seen from Figure 3 and Figure 4 that, with the other parameters unchanged, as the retailer's capital increases, its optimal order quantity and profit gradually increase. This is because the more capital the retailer has, the smaller the proportion of the same amount of capital in the financing from the third-party financial

institutions through equity financing, and the smaller the amount of capital that needs to be distributed to the third-party financial institutions during profit sharing.

Therefore, its profit and optimal order quantity increase with the increase of capital. This is consistent with reality.

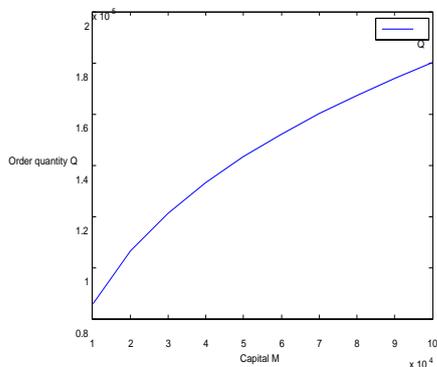


Figure 3. Relationship between retail capita and order quantity

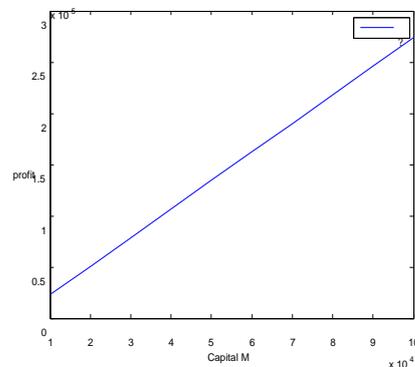


Figure 4. Relationship between retail capital and profit

Figures 5 and 6 consider the relationship between retailer sales price, order quantity, and profit, respectively. It can be seen from Figure 5 and Figure 6 that, while keeping other parameters unchanged, as the retailer's sales price increases, its optimal order quantity and profit gradually increase. This is because the higher the sales price of the retailer and the greater the profit, the other factors remain unchanged. This property can also be confirmed from equation (6).

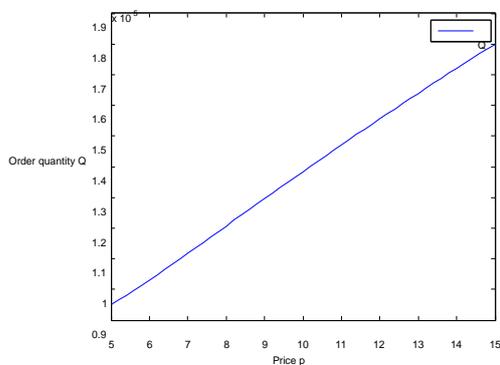


Figure 5. retailer sales price and order quantity relationship

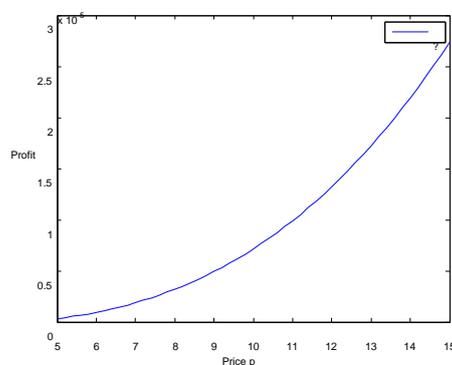


Figure 6. retailer sales price and profit relationship

Figures 7 and 8 consider the relationship between retailer purchase price and order quantity and profit, respectively. It can be seen from Figure7 and Figure8 that with the other parameters unchanged, the optimal order quantity and profit of the retailer have a significant decrease with the increase of the purchase price of the retailer. This is consistent with the reality. This is because, with other factors unchanged, the higher the retailer's purchase price, the lower the profit. At the same time, this property can also be confirmed from equation (6).

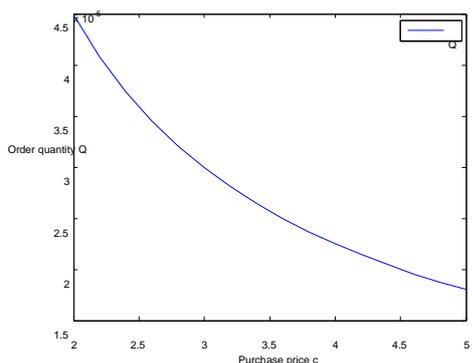


Figure 7. Relationship between retailer purchase price and profit

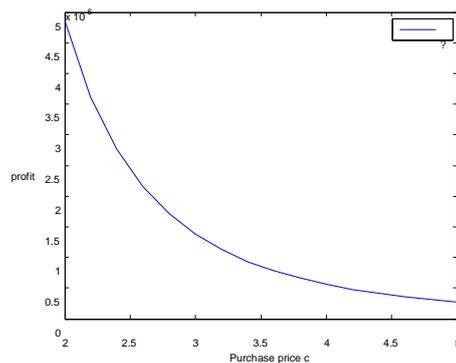


Figure 8. Relationship between retailer purchase and order quantity

Figures 9 and 10 will analyze the relationship between the retailer cost price ratio (incoming price / sale price) and the order quantity and profit. It can be seen from Figure 9 and Figure 10 that, with the other parameters unchanged, as the retailer cost and sales price ratio coefficient increase, the optimal order quantity and profit are greatly reduced. This is because, with other factors unchanged, the greater the retailer's cost-price ratio coefficient means that the retailer's profit margin is smaller, so the order quantity and profit are less.

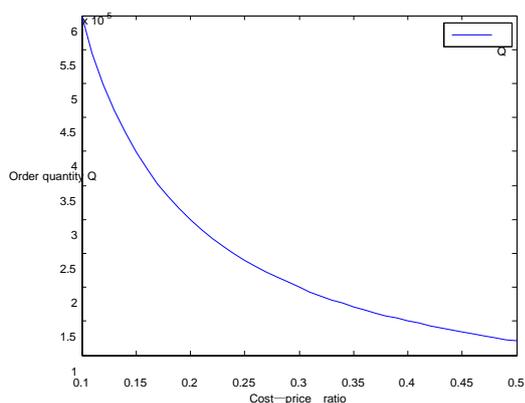


Figure 9. Relationship between retailer cost-price ratio and the and order

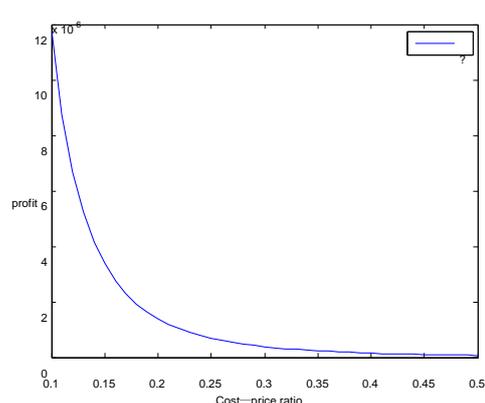


Figure 10. Relationship between the cost-price ratio profit of retailer

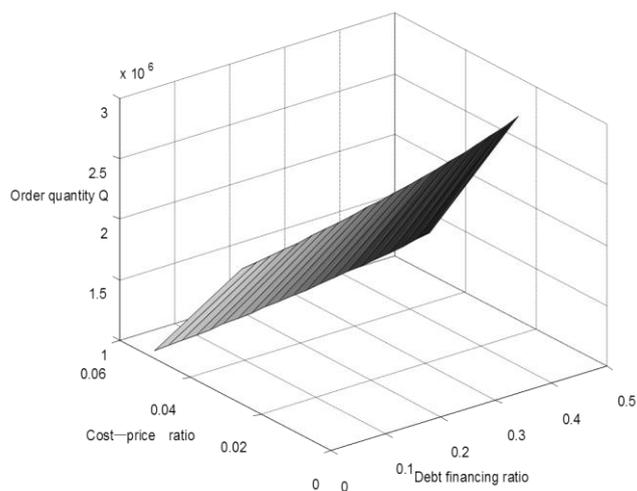


Figure 11. Relationship between cost-price ratio, debt financing ratio and order quantity

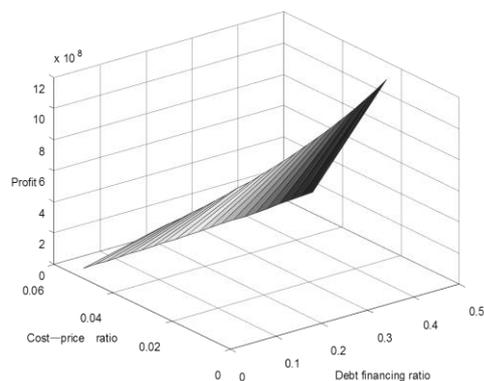


Figure 12. Relationship between cost-price ratio, debt financing ratio and profit

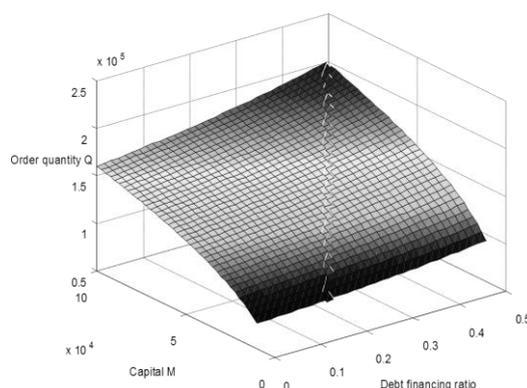


Figure 13. Relationship between capital and debt financing ratio and order quantity

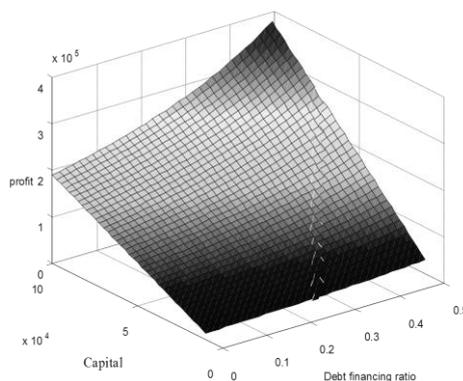


Figure 14. Relationship between capital and debt financing ratio and profit

5 CONCLUSION

In real life, most goods are faced with a buyer's market, in which case suppliers will allow retailers to purchase goods in the form of delayed payments in order to sell more products. However, due to various factors, many retailers may not be able to repay their purchases in full when the credit period expires. At this point, retailers, supply chain upstream companies, and even the entire supply chain system can suffer significant losses. To avoid this, many retailers are getting loans from third-party finance, such as commercial banks, to avoid debt defaults.

Based on the newsboy model that allows delayed payment, this paper integrates the company's capital structure problem into the financing problem in supply chain finance, considers a two-tier supply chain system

composed of suppliers and retailers, and analyzes the retailer's There may be four situations in the future sales cycle , study the cost situation in each case, and consider the issue of debt financing and equity financing that retailers may face when financing, and finally construct a retailer's optimal ordering strategy. Model and get an analytical solution for this model. Further, this model was deeply analyzed by numerical examples and parameter sensitivity analysis. The study found that with the other parameters unchanged, as the retailer's sales price, capital, debt financing ratio and other parameters increase, its order quantity and profit gradually increase; with the retailer's purchase price, cost price ratio As the coefficient increases, the order quantity and profit gradually decrease. Therefore, in order to increase profits and increase the rate of return, the retailer should increase the bond financing ratio, capital and sales price as much as possible when formulating the ordering strategy and reduce the purchase price, cost price ratio coefficient, equity financing ratio, etc.

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