

Research on Financing Strategies of Small, Medium and Micro Manufacturing Enterprises in Different Life Cycle Stages

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Abstract

Consider a two-level supply chain consisting of a single manufacturer and a single retailer. Among them, manufacturers can choose to produce traditional products or green products. When manufacturers choose to produce traditional products, they have sufficient funds, but when manufacturers choose to produce green products, they face financial constraints, which can be solved by bank loans or borrowing from retailers (internal financing). Based on this background, this paper studies the financing strategies of small, medium and micro manufacturing enterprises in different life cycle stages, and draws the following conclusions: (1) Wholesale price and retail price are equal under the bank loan financing model and the internal financing model, and both are larger than the wholesale price and retail price under the non-financing model; (2) The green input level is equal under the bank loan financing model and the internal financing model; (3) The optimal decision of manufacturers is to choose bank loans or internal financing, the optimal decision of retailers is to choose internal financing, and for manufacturers and retailers, the choice of no financing model is the worst decision. In addition, this paper also analyzes the effects of changes in expected output and expected price on participants' decisions and profits.

Keywords

Green Supply Chain; Financing Strategy; Capital Constraints.

1. Introduction

In recent years, the problem of global warming has intensified, and the environmental pollution caused by China's rapid economic development has become more and more serious. Therefore, energy conservation and emission reduction, environmental protection and green development have become urgent [1-2]. As one of the major countries in the world, China is also actively undertaking the corresponding social responsibility. Since the 18th National Congress of the CPC, China has adhered to the concept that clear waters and green mountains are gold and silver mountains, unswervingly followed the path of ecological priority and green development, and promoted the comprehensive green transformation of economic and social development, and made great achievements. The white paper "China's Green Development in the New Era" released by The State Council Information Office in 2023 points out that China continues to build a green manufacturing system. China will continue to improve green factories, green parks, green supply chains, green product evaluation standards, guide enterprises to innovate green product design, use green and low-carbon environmental protection processes and equipment, optimize the spatial layout of enterprises, industries and infrastructure in parks, and accelerate the construction of green industrial chain supply chains. During the period of promoting the green transformation of traditional industries, small and medium-sized manufacturing enterprises, as an important pillar of China's real economy, play a pivotal role. The fifth meeting of the Financial and Economic Commission of the CPC Central Committee emphasized that "China's manufacturing industry ranks first in the world and is the

only country with all industrial categories in the world", "China should give full play to the entrepreneurial spirit and artisan spirit, and cultivate a number of" specialized and new "small and medium-sized enterprises", so small and medium-sized manufacturing enterprises need to conform to the trend of The Times and achieve green development [3]. However, in the process of green development, China's small and medium-sized manufacturing enterprises have to invest a lot of production costs in the early stage, and they are faced with financial constraints, which seriously hinders the rapid development of small and medium-sized manufacturing enterprises themselves [4]. At this stage, in order to solve the problem of capital constraints, enterprises generally choose external financing or internal financing to solve the financial pressure. For example, Zhongneng Chemical, Gree Electric Appliances and other manufacturing enterprises solved the fund problem in production and operation by using pre-sale financing [5].

At present, domestic and foreign literatures on the problem of capital constraints facing enterprises mainly focus on external financing and internal financing. Guo Jinson and Zhou Yongwu [6] built a supply chain financing decision-making model under two models of loan financing and prepayment financing of financial institutions, aiming at the fund constraints of manufacturers with dual channels of fair preference, and studied the influence of manufacturers' fair preference on supply chain profits and members' decision-making. Hao Zhaowei et al. [7] studied the issue of option contract coordination supply chain under the circumstance that retailers have limited funds, default risk and suppliers provide commercial credit. Wang Wenli and Luo Jianwen [8] studied the optimal production and financing decisions of suppliers and manufacturers under the prepayment financing model, considering that suppliers facing financial constraints ease the financial pressure through the internal financing model of manufacturers providing prepayment, and analyzed the impact of suppliers' own funds and price discounts on supply chain financing performance. Jin et al. [9] considered three financing strategies: single bank financing, trade credit bank financing, and bank financing guaranteed by suppliers, and made a comparative analysis of the equilibrium decision results under the three financing strategies. Zhao and Huchzermeier[10] took into account two financing models of retailers offering advance payment discounts and purchaser-supported purchase order financing to reduce the financial pressure on suppliers, and analyzed retailers' preference for the two financing models. Xing and Zhongkai[11] studied the optimal decision-making problem of suppliers and retailers under the two financing models of trade credit and bank credit, and further analyzed the double marginalization problem under different financing models.

However, most of the existing literature has not studied the financing strategies of micro, small and medium-sized enterprises with financial constraints, but as an important participant of the main body of the market economy, micro, small and medium-sized enterprises are of great research value. At present, more and more scholars have begun to pay attention to the financing problems of the supply chain of small and medium-sized enterprise under capital constraints. For example, Zhao Rui [12] and other scholars have studied the budget formulation and budget execution of upstream enterprises in the supply chain under the financial constraints of retailers, considering that small and medium-sized enterprise in China are facing the dilemma of insufficient funds. LAN Chuanxiao [13] studied the supply chain financing strategies of small and medium-sized enterprise suppliers with insufficient funds due to green investment, considering the participation of different government subsidy models in green credit, and explored the optimal decisions of suppliers, manufacturers and the government itself under different government subsidy models. From the perspective of supply chain, Zhang Wenji [14] studied the supply chain investment and financing portfolio strategy of core enterprises, considering that upstream small and medium-sized enterprise have insufficient environmental protection funds while downstream core enterprises have sufficient funds.

The above studies have ignored the situation that the financing strategies of enterprises in different life cycle stages are different. According to existing studies, the life cycle of an enterprise exists objectively and has an important impact on its financing strategy [15-16]. However, these studies do not consider the impact of different life cycle stages on supply chain financing strategies, especially on small, medium and micro manufacturing enterprises. Therefore, this paper considers the supply chain of small, medium and micro manufacturing enterprises with financial constraints, and constructs a two-level supply chain model consisting of a single manufacturer and a single retailer. Among them, the manufacturer is the dominant player in the Stackelberg game. The manufacturer can choose to produce traditional products or green products. The production of traditional products has sufficient funds, but the production of green products will face financial constraints, and the manufacturer can choose to solve the financial constraints through bank loans or internal financing. Based on the above background, this paper studies the financing strategies of small, medium and micro manufacturing enterprises in different life cycle stages.

2. Model Description and Assumptions

2.1. Model Description

Consider a two-level supply chain consisting of a single manufacturer and a single retailer, where the manufacturer sells the product with production cost c to the retailer at the wholesale price w , and the retailer sells the product to the customer at the retail price p . In order to stimulate product demand, manufacturers can choose whether to produce green products. This paper assumes that the manufacturer has sufficient funds to produce traditional products, while the manufacturer will have financial constraints to produce green products, which can be solved by bank loans or internal financing from retailers. Therefore, this paper specifically considers the following three scenarios: (1) manufacturers only produce traditional products, that is, no financing model; (2) Manufacturers only produce green products and bear the cost of producing green products by borrowing from banks, that is, bank loan model (3) Manufacturers only produce green products and bear the cost of producing green products by borrowing from retailers, that is, internal financing. Based on this, this paper mainly studies the financing strategy selection of small, medium and micro manufacturing enterprises in different life cycle stages.

2.2. Model Assumptions

Table 1. Symbols and their meanings

Symbols	Meaning	Symbols	Meaning
a	Market size	ϵ	Random factor of the output
r	Bank rate ($0 < r < 1$)	δ^2	Variance of ϵ
c	Production cost of traditional products	ξ	Random factor of market price
e	Green input level	u_1	Mean of ϵ
w_i	Wholesale price under the Chain i	u_2	Mean of ξ
q_i	Production input under the chain i	π_M^g	Profit of the manufacturer
*	Optimal value	π_R^g	Profit of the retailer
$i \in \{1,2,3\}, g \in \{A, B, C\}$		$\{A, B, C\}$	$\{\text{Chain 1, Chain 2, Chain 3}\}$

The model construction in this paper is based on the following assumptions:

(1) The price of the product is affected by the production input, the random factor of the output, the green input level, and the market price randomness, this is $p = a - (q + \epsilon) + e + \xi$. Where

the mean of ε and ξ is equal to u_1 and u_2 , respectively, and the variance of u_1 and u_2 is equal to δ^2 and 0. a is the market demand scale, q is the production input, e is the green input level, and the green input cost is $C(e) = e^2$.

(2) The manufacturer is the dominant player in Stackelberg game, and the retailer is the follower.

(3) The interest rate paid by the manufacturer for internal financing with the retailer is the same as the interest rate paid by the manufacturer for choosing a bank loan.

All the symbols covered in this article and their meanings are shown in Table 1.

3. Model Analysis

This section mainly analyzes the optimal decision of manufacturer pricing, green input level, production input, and the optimal expected profit of manufacturer and retailer under the three models. Firstly, the optimal decision of manufacturer and retailer under the non-financing model is analyzed, then the optimal decision of manufacturer and retailer under the bank loan model is analyzed, and finally the optimal decision of all parties under the internal financing model is analyzed.

3.1. No Financing Model

In the no-financing model, the manufacturer only produces traditional products, at which time the manufacturer has sufficient funds and does not need financing. Stackelberg game is played between the manufacturer and the retailer, that is, the manufacturer first decides the wholesale price of the product w_1 , and the retailer then decides its production input q_1 based on the manufacturer's decision. The expected profit of the manufacturer and the retailer can be expressed as follows:

$$\begin{cases} \pi_M^A = (w_1 - c)(q_1 + u_1) \\ \pi_R^A = (a - q_1 + u_2 - w_1)(q_1 + u_1) - u_1 q_1 - u_1^2 - \delta^2 \end{cases} \quad (1)$$

Under the non-financing model, using the inverse derivation method to solve equation (1), the optimal wholesale price w_1^* and the optimal production input q_1^* of the manufacturer and retailer can be obtained as follows:

$$\begin{cases} w_1^* = \frac{1}{2}(a + c + u_2) \\ q_1^* = \frac{1}{4}(a - c - 4u_1 + u_2) \end{cases} \quad (2)$$

The manufacturer's optimal profit π_M^{A*} and the retailer's optimal profit π_R^{A*} are:

$$\begin{cases} \pi_M^{A*} = \frac{1}{8}(a - c + u_2)^2 \\ \pi_R^{A*} = \frac{1}{16}[(a - c + u_2)^2 - 16\delta^2] \end{cases} \quad (3)$$

Corollary 1 Under the non-financing model : ① q_1^* decreases with the increase of u_1 , and w_1^* , π_M^{A*} , π_R^{A*} are not affected by u_1 ; ② $w_1^*, q_1^*, \pi_M^{A*}, \pi_R^{A*}$ increased with the increase of u_2 .

Proof : All the proofs in this article are detailed in the appendix.

From Corollary 1, we can see that: (1) production input is inversely proportional to expected output, while wholesale prices, manufacturers' and retailers' expected profits are not affected by expected output. From this conclusion, it can be seen that the larger the expected output is, the smaller the production input will be. This is because the actual output of the manufacturer is certain, and the expected output will not affect the wholesale price and actual output, so the expected profit of the manufacturer and retailer will not be affected by the expected output. (2) Wholesale prices, production inputs, and the expected profits of manufacturers and retailers are all directly proportional to expected prices. From this conclusion, it can be seen that when the expected price increases, the demand for traditional products in the market increases, and both manufacturers and retailers will raise their own prices to achieve better profits.

3.2. Bank Loan Model

Under the bank loan model, the manufacturer only produces green products. At this time, the manufacturer has the problem of capital constraint, and the manufacturer solves the financing problem through bank loan. The Stackelberg game is played between the manufacturer and the retailer, that is, the manufacturer first determines the wholesale price w_2 and the green input level e_2 , and then the retailer determines its production input q_2 according to the manufacturer's decision. The expected profit of the manufacturer and the retailer can be expressed as follows:

$$\begin{cases} \pi_M^B = (w_2 - c)(q_2 + u_1) - (1+r)e_2^2 \\ \pi_R^B = (a - q_2 + e_2 + u_2 - w_2)(q_2 + u_1) - u_1q_2 - u_1^2 - \delta^2 \end{cases} \quad (4)$$

Under the bank loan model, using the inverse derivation method to solve equation (4), the optimal wholesale price w_2^* , the optimal green input level e_2^* and the optimal production input q_2^* of the manufacturer and retailer can be obtained as follows:

$$\begin{cases} w_2^* = \frac{4a(1+r) + c(3+4r) + 4(1+r)u_2}{7+8r} \\ e_2^* = \frac{a-c+u_2}{7+8r} \\ q_2^* = \frac{2(a-c+u_2)(1+r) - (7+8r)u_1}{7+8r} \end{cases} \quad (5)$$

The manufacturer's optimal profit π_M^{B*} and the retailer's optimal profit π_R^{B*} are:

$$\begin{cases} \pi_M^{B*} = \frac{(1+r)(a-c+u_2)^2}{7+8r} \\ \pi_R^{B*} = \frac{4(a-c+u_2)(1+r)^2 - (7\delta+8r\delta)^2}{(7+8r)^2} \end{cases} \quad (6)$$

Corollary 2 Under the bank loan model : ① q_2^* decreases with the increase of u_1 , and $w_2^*, \pi_M^{B*}, \pi_R^{B*}$ are not affected by u_1 ; ② $w_2^*, q_2^*, \pi_M^{B*}, \pi_R^{B*}$ increased with the increase of u_2 .

Proof : All the proofs in this article are detailed in the appendix.

From Corollary 2, we can see that: (1) production input is inversely proportional to expected output, while wholesale price, green input level, and expected profit of manufacturers and retailers are not affected by expected output. From this conclusion, it can be seen that the actual output of manufacturers in the supply chain is certain, and the higher the expected output, the smaller the production input, while the wholesale price, green input level, and the expected profit of manufacturers and retailers are not affected by the expected output because the actual output of green products produced by manufacturers is certain. (2) Wholesale prices, green input levels, production inputs, and the expected profits of manufacturers and retailers are all proportional to the expected prices. From this conclusion, it can be seen that the higher the expected price indicates that consumers are more willing to buy green products at a higher price. At this time, manufacturers will increase the production input of green products and increase the green input level of products, so as to sell at a higher wholesale price, which makes manufacturers and retailers expect to increase profits.

3.3. Internal Financing Model

Under the internal financing model, the manufacturer only produces green products. At this time, the manufacturer has the problem of financial constraint, and the manufacturer solves the financing problem by internal financing from the retailer. At the same time, assume that the periodic interest rate of the retailer's loan to the manufacturer is the same as the periodic interest rate of the bank's loan, that is, the opportunity cost is re_3^2 . The Stackelberg game is played between the manufacturer and the retailer, that is, the manufacturer first determines the wholesale price w_3 and green input level e_3 , and then the retailer produces input q_3 according to the manufacturer's decision. The expected profit of the manufacturer and the retailer can be expressed as follows:

$$\begin{cases} \pi_M^C = (w_3 - c)(q_3 + u_1) - (1+r)e_3^2 \\ \pi_R^C = (a - q_3 + e_3 + u_2 - w_3)(q_3 + u_1) - u_1q_3 - u_1^2 - \delta^2 + re_3^2 \end{cases} \quad (7)$$

Under the internal financing model, using the inverse derivation method to solve equation (7), the optimal wholesale price w_3^* , the optimal green input level e_3^* and the optimal production input q_3^* of the manufacturer and retailer can be obtained as follows:

$$\begin{cases} w_3^* = \frac{4a(1+r) + c(3+4r) + 4(1+r)u_2}{7+8r} \\ e_3^* = \frac{a-c+u_2}{7+8r} \\ q_3^* = \frac{2(a-c+u_2)(1+r) - (7+8r)u_1}{7+8r} \end{cases} \quad (8)$$

The manufacturer's optimal profit π_M^{C*} and the retailer's optimal profit π_R^{C*} are:

$$\begin{cases} \pi_M^{C*} = \frac{(1+r)(a-c+u_2)^2}{7+8r} \\ \pi_R^{C*} = \frac{(a-c+u_2)^2(4+9r+4r^2) - (7\delta+8r\delta)^2}{(7+8r)^2} \end{cases} \quad (9)$$

Corollary 3 Under the internal financing model : ① q_3^* decreases with the increase of u_1 , and $w_3^*, \pi_M^{C*}, \pi_R^{C*}$ are not affected by u_1 ; ② $w_3^*, q_3^*, \pi_M^{C*}, \pi_R^{C*}$ increased with the increase of u_2 .

Proof : All the proofs in this article are detailed in the appendix.

From Corollary 3, we can see that: (1) production input is inversely proportional to expected output, while wholesale price, green input level, and expected profit of manufacturers and retailers are not affected by expected output. This is because when the expected output increases, the actual consumer demand for green products does not change, so its wholesale prices, green input levels, manufacturers and retailers expect profits will not change, and production inputs will decrease. (2) Wholesale prices, green input levels, production inputs, and the expected profits of manufacturers and retailers are all proportional to the expected prices. It can be seen that with the increase of the expected price, its wholesale price and production input will increase, which gives the manufacturer financing motivation and will increase the investment in the green input level of the product, thus increasing the expected profit of the manufacturer and retailer.

Proposition 1: ① $w_3^* = w_2^* > w_1^*$; ② $e_3^* = e_2^*$; ③ $q_3^* = q_2^* > q_1^*$.

Proof : All the proofs in this article are detailed in the appendix.

As can be seen from proposition 1: (1) The manufacturer chooses the lowest wholesale price of traditional products under the non-financing model, while the wholesale price of green products under the bank loan model is equal to that under the internal financing model. On the one hand, manufacturers bear the green input cost of green products when producing green products, and in order to increase profits, they will increase the price of green products. On the other hand, the price of green products in the market is generally higher than that of traditional products. In the internal financing model, the periodic interest of the retailer's loan to the manufacturer is equal to the periodic interest of the bank loan model, so the wholesale price under the two models is equal. (2) The level of green input under the manufacturer's internal financing model is equal to that under the bank loan model. This is because the cyclical interest borne by the manufacturer under the two models is the same, so the green input level of the product under the two models is also equal. (3) The production input under the internal financing model is equal to that under the bank loan model, while the production input under the non-financing model is the smallest. This is because the cyclical interest, wholesale price and product green input level borne by the manufacturer under the internal financing model and the bank loan model are the same, so the production input amount under the two models is also the same. Compared with traditional products, customers are more willing to buy green products due to the enhancement of customers' environmental awareness. Therefore, the traditional product production input under the non-financing model is the least.

Proposition 2: ① $\pi_M^{C*} = \pi_M^{B*} > \pi_M^{A*}$; ② $\pi_R^{C*} > \pi_R^{B*} > \pi_R^{A*}$.

Proof : All the proofs in this article are detailed in the appendix.

As can be seen from proposition 2: (1) The expected profit obtained when the manufacturer chooses internal financing is equal to the expected profit obtained when the manufacturer chooses bank loan, and both are greater than the expected profit of the manufacturer when producing traditional products. This is because the processing cost, wholesale price and production input of green products borne by the manufacturer under the internal financing

model and the bank loan model are the same, so the expected profit of the manufacturer under the two models is the same. In the non-financing model, the production input and wholesale price of traditional products are smaller than the other two models, so the manufacturer's expected profit is the smallest. (2) The retailer's expected profit is the largest when the manufacturer chooses internal financing, followed by the retailer's expected profit when the manufacturer chooses bank loan, and the retailer's expected profit is the least when the manufacturer produces traditional products. This is because under the internal financing model, the retailer borrowings to the manufacturer and obtains the periodic interest generated by the loan. Therefore, the expected profit of the retailer under the internal financing model is greater than that under the bank loan model. In the non-financing model, the demand and price of traditional products are lower than that of green products, so the retailer has the smallest expected profit.

4. Model Comparison

In order to enhance the readability of this study, this section uses MATLAB to analyze the change rules of wholesale price, product green input level, production input, and expected profit of manufacturers and retailers under the three models, and further verify the conclusions of corollary 1 to 3, proposition 1 and proposition 2. Therefore, on the premise of not affecting the conclusion, without losing the generality, the values of relevant parameters are taken as $a = 100, c = 2, r = 0.5, \delta = 2$.

4.1. Comparison of Optimal Wholesale Price, Green Input Level and Production Input

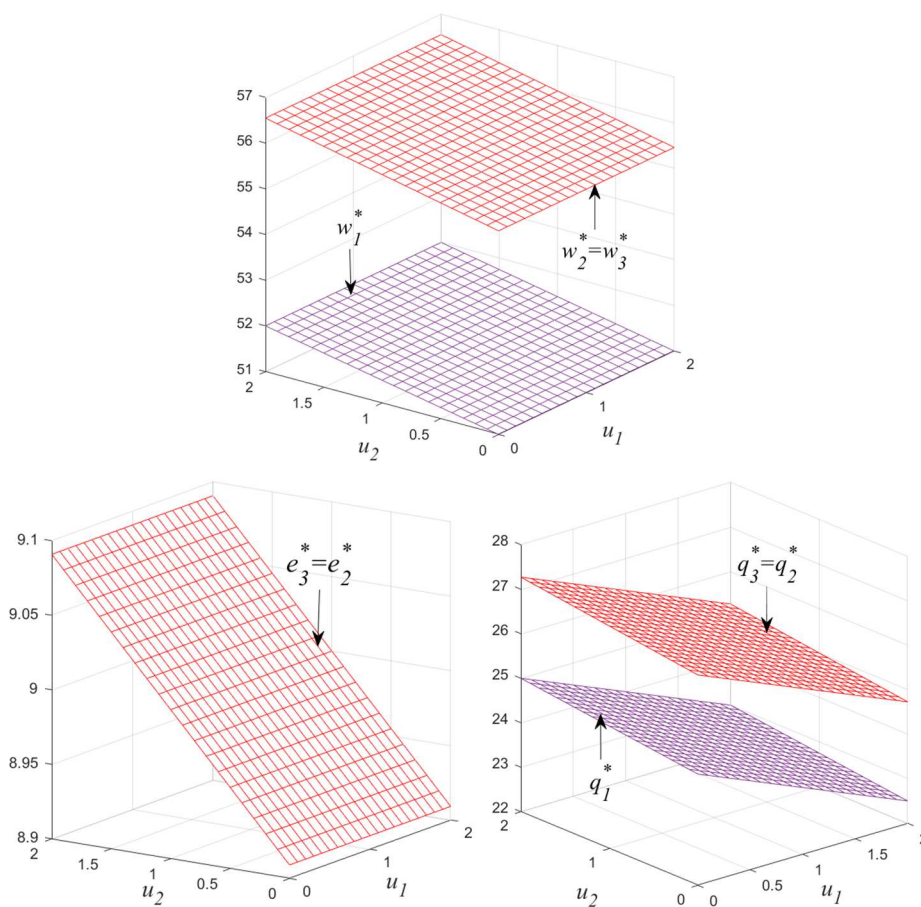


Figure 1. Impact of u_1 and u_2 on wholesale price, green input level and production input under the three models.

Figure 1 shows that: (1) The wholesale price when the manufacturer chooses bank loan is equal to the wholesale price when the manufacturer chooses internal financing, and the wholesale price is the smallest when the manufacturer chooses no financing, that is, $w_1^* < w_2^* = w_3^*$; (2) The green input level when the manufacturer chooses internal financing is equal to the green input level when the bank loans, that is, $e_2^* = e_3^*$; (3) The production input of the product when the manufacturer chooses internal financing is equal to the production input of the product when the manufacturer chooses bank loan, while the production input of the product without financing is the smallest, that is, $q_1^* < q_2^* = q_3^*$. According to Figure 1, it can also be found that under the three models, the production input decreases with the increase of the expected output u_1 , the wholesale price and green input level are not affected by the expected output u_1 , and the wholesale price, green input level and product output increase with the increase of the expected price u_2 .

4.2. Comparison of Optimal Expected Profit

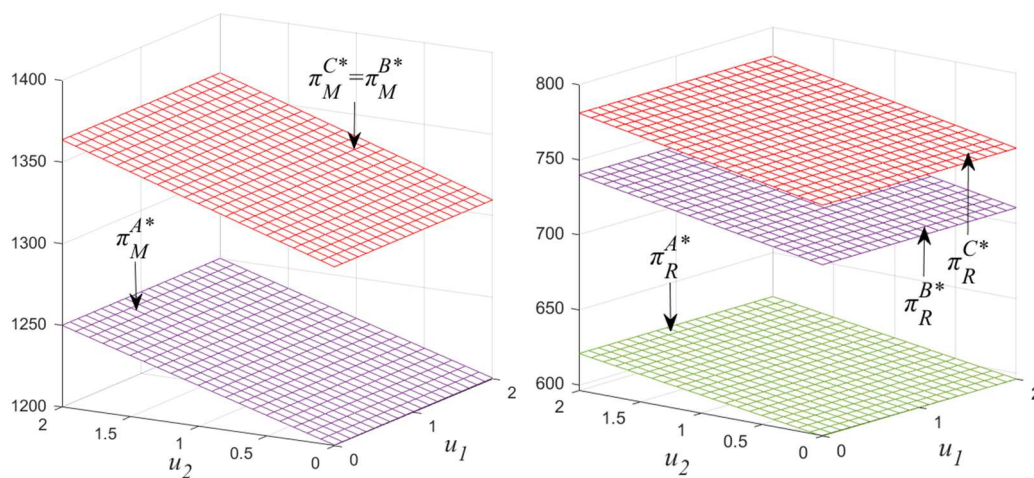


Figure 2. Impact of u_1 and u_2 on manufacturers and retailers expect profits under the three models.

It can be seen from Figure 2 that the expected profit obtained by the manufacturer when it chooses internal financing is equal to that obtained when it chooses bank loan, while the expected profit obtained without financing is the smallest, that is, $\pi_M^{A*} < \pi_M^{B*} = \pi_M^{C*}$. When the retailer chooses internal financing, the expected profit is the largest, followed by the expected profit when choosing bank loan, and the expected profit without financing is the smallest, that is, $\pi_R^{A*} < \pi_R^{B*} < \pi_R^{C*}$. The expected profit of manufacturers and retailers under the three models is not affected by the expected output u_1 , while the expected profit of manufacturers and retailers under the three models increases with the increase of the expected price u_2 .

From the above analysis, it can be seen that the manufacturer's choice of internal financing strategy is beneficial to both manufacturers and retailers. At the same time, whether the manufacturer chooses internal financing strategy or bank loan financing strategy, the expected profit obtained by the manufacturer is the same, and both are greater than the expected profit of the manufacturer under the non-financing model.

5. Conclusion

This paper focuses on a two-level supply chain consisting of a single manufacturer and a single retailer, in which the manufacturer can choose to produce traditional products or green products, and the retailer sells according to the products produced by its manufacturer. When manufacturers produce traditional products, they have sufficient funds and do not need

financing. When manufacturers choose to produce green products, they will face the problem of financial constraints. They can choose bank loans or internal financing to solve the problem of financial constraints. In the framework of manufacturer-led Stackelberg game, this paper studies the financing strategy choice and product type choice of supply chain. Through the full text analysis, the following conclusions can be drawn:

(1) The wholesale price of the product when the manufacturer chooses bank loan is equal to the wholesale price when the manufacturer chooses internal financing, while the wholesale price of the product is the smallest when the manufacturer chooses no financing. This is because the cost borne by the manufacturer when choosing bank loan and the cost borne by choosing internal financing are equal, so the wholesale price under the two models is also equal. In the non-financing model, the manufacturer does not have to bear the corresponding cost of the green input level of the product, so its wholesale price is the smallest. Therefore, the wholesale price of a manufacturer is closely related to the cost of production it bears.

(2) The green input level under the internal financing model is equal to that under the bank loan model. This is because the manufacturer needs to bear the same cost under the two models, so the manufacturer has the same financing motivation.

(3) When the manufacturer chooses internal financing, the production input of the product is equal to that of the product when the manufacturer chooses bank loan, while the production input of the product is the smallest when the manufacturer chooses no financing. This is because with the enhancement of consumers' awareness of green environmental protection, they are more willing to buy green products, and the green investment level of products under the internal financing model and the bank loan model is the same. Therefore, consumers' consumption demand for green products under the two models is the same, while their consumption demand for traditional products is generally lower than that of green products. Therefore, the production input of products under the internal financing model and the bank loan model is the same and higher than that under the non-financing model.

(4) For manufacturers, it is the optimal decision to produce green products, and the financing strategy is the same whether they choose bank loans or internal financing, while it is the worst choice to produce traditional products.

(5) For retailers, it is the best decision to choose to produce green products and provide loans to manufacturers, that is internal financing strategy, while the worst decision is to choose to sell traditional products.

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Appendix

Corollary 1 proves that: According to the results of wholesale price w_1^* , product output q_1^* , manufacturer's profit π_M^{A*} and retailer's profit π_R^{A*} obtained under the non-financing model, we can obtain the first derivation of u_1 and u_2 of these results respectively:

$$\frac{\partial w_1^*}{\partial u_1} = -\frac{1}{2} < 0; \frac{\partial p_1^*}{\partial u_1} = -\frac{3}{4} < 0; \frac{\partial q_1^*}{\partial u_1} = -\frac{1}{4} < 0; \frac{\partial \pi_M^{A*}}{\partial u_1} = \frac{1}{4}(-a + c + u_1 - u_2) < 0; \frac{\partial \pi_R^{A*}}{\partial u_1} = \frac{1}{8}(-a + c + u_1 - u_2) < 0$$

$$\frac{\partial w_1^*}{\partial u_2} = \frac{1}{2} > 0; \frac{\partial p_1^*}{\partial u_2} = \frac{3}{4} > 0; \frac{\partial q_1^*}{\partial u_2} = \frac{1}{4} > 0; \frac{\partial \pi_M^{A*}}{\partial u_2} = \frac{1}{4}(a - c - u_1 + u_2) > 0; \frac{\partial \pi_R^{A*}}{\partial u_2} = \frac{1}{8}(a - c - u_1 + u_2) > 0$$

Through the above analysis, it is easy to get the conclusion of corollary 1.

Corollary 2 proves that: According to the results of wholesale price w_2^* , green input level e_2^* , product output q_2^* , manufacturer's profit π_M^{B*} and retailer's profit π_R^{B*} obtained under the bank loan model, we can obtain the first derivation of u_1 and u_2 of these results respectively:

$$\frac{\partial w_2^*}{\partial u_1} = -\frac{4(1+r)}{7+8r} < 0; \frac{\partial p_2^*}{\partial u_1} = -\frac{6(1+r)}{7+8r} < 0; \frac{\partial e_2^*}{\partial u_1} = \frac{1}{-7-8r} < 0; \frac{\partial q_2^*}{\partial u_1} = -\frac{2(1+r)}{7+8r} < 0$$

$$\frac{\partial \pi_M^{B*}}{\partial u_1} = -\frac{2(1+r)(a-c-u_1+u_2)}{7+8r} < 0; \frac{\partial \pi_R^{B*}}{\partial u_1} = -\frac{8(1+r)^2(a-c-u_1+u_2)}{(7+8r)^2} < 0$$

$$\frac{\partial w_2^*}{\partial u_2} = \frac{4(1+r)}{7+8r} > 0; \frac{\partial p_2^*}{\partial u_2} = \frac{6(1+r)}{7+8r} > 0; \frac{\partial e_2^*}{\partial u_2} = \frac{1}{7+8r} > 0; \frac{\partial q_2^*}{\partial u_2} = \frac{2(1+r)}{7+8r} > 0$$

$$\frac{\partial \pi_M^{B*}}{\partial u_2} = \frac{2(1+r)(a-c-u_1+u_2)}{7+8r} > 0; \frac{\partial \pi_R^{B*}}{\partial u_2} = \frac{8(1+r)^2(a-c-u_1+u_2)}{(7+8r)^2} > 0$$

Through the above analysis, it is easy to get the conclusion of corollary 2.

Corollary 3 proves that: According to the results of wholesale price w_3^* , green input level e_3^* , product output q_3^* , manufacturer's profit π_M^{C*} and retailer's profit π_R^{C*} obtained under the Internal financing model, we can obtain the first derivation of u_1 and u_2 of these results respectively:

$$\frac{\partial w_3^*}{\partial u_1} = -\frac{1}{2} < 0; \frac{\partial p_3^*}{\partial u_1} = -\frac{5+6r}{6+8r} < 0; \frac{\partial e_3^*}{\partial u_1} = -\frac{1}{6+8r} < 0; \frac{\partial q_3^*}{\partial u_1} = -\frac{1+r}{3+4r} < 0$$

$$\frac{\partial \pi_M^{C*}}{\partial u_1} = -\frac{(1+r)(a-c-u_1+u_2)}{6+8r} < 0; \frac{\partial \pi_R^{C*}}{\partial u_1} = -\frac{(1+r)(a-c-u_1+u_2)}{6+8r} < 0$$

$$\frac{\partial w_3^*}{\partial u_2} = \frac{1}{2} > 0; \frac{\partial p_3^*}{\partial u_2} = \frac{5+6r}{6+8r} > 0; \frac{\partial e_3^*}{\partial u_2} = \frac{1}{6+8r} > 0; \frac{\partial q_3^*}{\partial u_2} = \frac{1+r}{3+4r} > 0$$

$$\frac{\partial \pi_M^{C*}}{\partial u_2} = \frac{(1+r)(a-c-u_1+u_2)}{3+4r} > 0; \frac{\partial \pi_R^{C*}}{\partial u_2} = \frac{(1+r)(a-c-u_1+u_2)}{6+8r} > 0$$

Through the above analysis, it is easy to get the conclusion of corollary 3.

Proposition 1 proves:

$$\begin{aligned}
w_2^* - w_1^* &= \frac{a - c - u_1 + u_2}{14 + 16r} > 0; w_3^* - w_1^* = 0 \\
p_3^* - p_2^* &= -\frac{(1 + 2r)(a - c - u_1 + u_2)}{2(3 + 4r)(7 + 8r)} < 0; p_3^* - p_1^* = \frac{a - c - u_1 + u_2}{12 + 16r} > 0 \\
e_3^* - e_2^* &= \frac{a - c - u_1 + u_2}{42 + 104r + 64r^2} > 0 \\
q_3^* - q_2^* &= \frac{(1 + r)(a - c - u_1 + u_2)}{(3 + 4r)(7 + 8r)} > 0; q_2^* - q_1^* = \frac{a - c - u_1 + u_2}{28 + 32r} > 0
\end{aligned}$$

Through the above analysis, it is easy to get the conclusion of proposition 1.

Proposition 2 proves:

$$\begin{aligned}
\pi_M^{C^*} - \pi_M^{B^*} &= \frac{(1 + r)(a - c - u_1 + u_2)^2}{2(3 + 4r)(7 + 8r)} > 0; \pi_M^{B^*} - \pi_M^{A^*} = \frac{(a - c - u_1 + u_2)^2}{8(7 + 8r)} > 0 \\
\pi_R^{C^*} - \pi_R^{B^*} &= \frac{r(a - c + u_2)^2}{(7 + 8r)^2} > 0; \pi_R^{B^*} - \pi_R^{A^*} = \frac{(15 + 16r)(a - c - u_1 + u_2)^2}{16(7 + 8r)^2} > 0
\end{aligned}$$

Through the above analysis, it is easy to get the conclusion of proposition 2.