Financing Strategy and its Optimization for Small and Medium-Sized Agricultural Machinery Manufacturers Under Government-Enterprise Financing Platform

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Abstract. A government-led, state-owned enterprise-built government-enterprise financing platform had emerged to solve the problem of complex financing for small and medium-sized agricultural machinery enterprises. This study considered a two-tier supply chain consisting of capital-constrained agricultural machinery manufacturers and distributors. Exploring the operational strategies of financial institutions and agricultural machinery manufacturers under the government-enterprise financing platform. This paper obtained the optimal decision through the model solution, parameter sensitivity analysis, and the optimal choice was derived by comparing the traditional bank financing model (Model B) and the government-enterprise platform financing model (Model G). The results showed the following: First, the optimal decisions of members in the agricultural machinery supply chain vary with different financing models. Second, in both financing models, supply chain members' revenues were positively correlated with product success rates, and changes in initial capital did not affect the returns of distributors. Still, they were positively related to manufacturers only when product success exceeded a certain threshold. Third, when manufacturers' initial capital and government subsidies were low, and the production costs were relatively high, model G was more suitable for the whole agricultural machinery supply chain.

Keywords: Supply chain, Small and medium-sized agricultural machinery manufacturers, Government-enterprise financing platform, Bank financing.

1 Introduction

With the development of the economy and society, the level of agriculture in China is also moving towards mechanization and automation. Developing agricultural machinery and cooperatives has provided farmers with great convenience during harvesting, increasing their income and making their lives more prosperous. However, at the beginning of the COVID-19 epidemic, the agricultural supply chain was almost wholly lost, and the agricultural supply chain had a high risk of disruption. Through the government's macro-control, the situation has improved[1]. However, the upstream small and medium-sized agricultural machinery manufacturers are facing the double blow of insufficient raw materials and production funds due to insufficient government attention or subsidies.

In general, the distribution of crops has a solid regional nature. Different types of agricultural machinery are needed to operate different crops and geographic environments. Because of this,

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many small and medium-sized agricultural machinery manufacturers have emerged. Against this background, agricultural cooperatives have gradually emerged in rural China. The cooperatives purchase some agricultural machinery and equipment from local agricultural machinery manufacturers and lease them to farmers at no or low cost[2]. In fact, for Chinese farmers, family-owned agricultural machinery is even more critical than outsourced machinery[3]. Therefore, the role of small and medium-sized agricultural machinery manufacturers in China's agricultural development cannot be ignored. However, financing difficulties, slow financing, and other problems prevail in small and medium-sized agricultural machinery enterprises, which can only be forced to reduce or interrupt production. This has dealt a blow to the development of local agriculture.

Currently, the main problems faced by the agricultural machinery industry in finance and insurance are: firstly, the industry has poor cash flow and a lack of cyclical funds; secondly, the industry has few financing channels and high financing costs. Thirdly, the industry's ability to resist risks is relatively weak. To solve this problem, the Government and the agricultural machinery industry are also actively seeking measures. In recent years, most agricultural machinery enterprises in developing countries are still mainly financed by banks and financial institutions[4]. However, bank financing requires a certain amount of credit, and for agricultural machinery enterprises with low credit, banks may set a relatively high interest rate. The high interest rate may cause agricultural machinery companies to have more losses. To avoid such situations and minimize losses, small and medium-sized enterprises with limited capital will produce with minimum orders or choose to interrupt the production of their product[5]. Therefore, how manufacturers facing financial constraints can adopt financing strategies to complete their production has become the focus of current agricultural machinery supply chain research. Therefore, this paper will study the financing strategies of small and medium-sized agricultural machinery manufacturers. Moreover, propose three main research questions:

1. Under what conditions would introducing a government-enterprise platform be preferable to traditional bank lending?

2. How can supply chain members make the best operational decisions when introducing a platform (mode G) built by a government-enterprise partnership?

3. Under what scenario would choosing Mode G result in the best profitability and efficiency for the entire supply chain?

To address these issues, we designed an agricultural machinery supply chain consisting of upstream agricultural machinery manufacturers (Replace with "manufacturer A (he)" in the following), distributors (she), and a typical agricultural machinery cooperative or farms. The government takes the lead, and the state-owned enterprise builds a relevant farm machinery financing platform to provide funds to manufacturer A, who needs them to facilitate stable transactions throughout the farm machinery supply chain. When faced with financial constraints, manufacturer A can finance itself through traditional banks and government-enterprise platforms.

This paper contributes to the literature: first, many studies have examined the integration of operations and manufacturer financing. The model of financing for undercapitalized agricultural machinery enterprises by building a supply chain financing platform under the cooperation of government and state-owned enterprises is proposed. Currently, most joint guarantees for government and enterprises are for the government and enterprises to guarantee for individuals such as farmers. There are industry restrictions for undercapitalized enterprises, which generally only exist in the agriculture category of industries. At present, there are many online platforms for financing in the literature. However, there is not enough research on the joint establishment of financing platforms by the government and state-owned enterprises. Second, the issue of financing model selection for agricultural machinery manufacturers is studied. The applicable scenarios under different financing models are analyzed by combining the characteristics of the agricultural machinery industry. In the existing literature, there are few studies on the applicable scenarios of financing based on industry characteristics. This study concludes that the government-enterprise platform can, to a certain extent, solve the problem of financing difficulties for small and medium-sized agricultural machinery manufacturers in the face of various unexpected situations and ensure the stability of the agricultural machinery supply chain. The managerial insights we have drawn will also provide better lessons for the agricultural machinery manufacturing industry.

The rest of the paper is structured as follows: Section 2 reviews the relevant literature. Section 3 presents our proposed model, and then we obtain equilibrium analysis in section 4. Section 5 performs parameters analysis. Section 6 performs a numerical analysis. Finally, section 6 concludes the whole paper.

2 Literature Review

In recent years, due to the rapid modernization of agriculture and the emergence of agricultural and farm machinery cooperatives. The increased emphasis on agricultural development by the government, the implementation of land transfer policies, and the improvement of subsidies for various types of agricultural machinery have meant rapid development of the agricultural industry and have also attracted a great deal of interest from academics in the field of operations and supply chains.

Based on modern science and technology, blockchain and cold chain technologies are used in agricultural supply chains. Cao et al.[6] analyzed the problems based on financing risk, counterparty risk, and lack of consumer trust that arose in traditional agricultural supply chains using blockchain technology and concluded that, in most cases, blockchain technology could effectively solve these problems. Bhatia and Chaudhuri's[7] research from the transaction cost economics perspective confirms the above view. At the same time, solving the financing problems of the agricultural industry from the perspective of the government and society has been the concern of many scholars, and they conducted extensive research. Villalba et al.[8] argue that smallholder farmers in developing countries lack long-term sources of credit, that traditional banks, microfinance, and cooperatives cannot address the entire financing gap, and that agricultural value chain finance that leverages social capital to meet financial needs is essential. Wu et al.[9] study the targets of subsidies for selling agricultural products on live-streaming channels; they argue that subsidies to suppliers of agricultural products are more conducive to supply chain sustainability than subsidies to live-streamers. Wang and Chen[10] study agricultural supply chain financing in developing economies with capital constraints focusing on financing models in which reputable intermediary platforms provide loans directly to farmers or act as guarantors when farmers' creditworthiness is insufficient to obtain bank loans. Van et al.[11] study financing options in agricultural procurement supply chains and demonstrate that soft contracts will likely result in better coordination across the agricultural supply chain. Ganbold [12] uses a quantitative data analysis approach; it was concluded that Government subsidies have minimal impact on agricultural machinery production and technology levels, but they will incentivize farmers to invest in agricultural machinery and increase crop yields. It is also beneficial for the revenue of agricultural machinery enterprises. However, in Aymeric's study[13], government subsidies only play a positive role in some scenarios. For example, subsidized insurance brings welfare benefits only to those farmers located in the driest areas. It is also confirmed in this paper's study that subsidies play a more significant positive role in agricultural machinery enterprises when they face financial constraints.

The development of agriculture cannot be achieved without agricultural machinery in the area of agricultural machinery supply chains; numerous scholars have studied the production and operational aspects of agricultural machinery supply chains. The current literature on agricultural machinery supply chains focuses on two main research types: 1. After-sales service and recycling of agricultural machinery products. Staus and Becker[14] (2012) and Luo and Zhang[15] (2016) have studied in detail the comprehensive services of agricultural machinery products after they reach consumers, primarily for service dispatching research, with an emphasis on market research. 2. Production planning, decision-making, and application of agricultural machinery. Increasing the use of agricultural machinery products in agricultural production would substantially increase crop yields[16]. Guilherme et al.[17] study the application of digitalization in agricultural machinery manufacturing through a literature review. From the production point of view, it can expand production and improve performance. From the marketing point of view, it can pinpoint the market and increase profits. However, the cost of applying digitization is high, and few manufacturers have adopted it. Sharmistha and Ravi[18] propose a sustainable agricultural machine product design scheme with guidelines to improve manufacturers' profits, reduce environmental pollution, and improve social benefits by changing the design of agricultural machine products. The above literature is based on decisions made by farm machinery manufacturers when they have sufficient funds for production. Agricultural machinery manufacturers can easily fall into insufficient funds, and the supply chain is broken occasionally. Therefore, our study will focus on financing upstream agricultural machinery manufacturers in the supply chain to fill the gap in the research literature on agricultural machinery supply chain finance.

In summary, little research has been done on agricultural supply chain finance, with most scholars only studying the relationship between farmers, government, and buyers before producing agricultural products. However, the study of agribusinesses upstream of the agricultural supply chain has been neglected. Therefore, many small and medium-sized agricultural machinery manufacturers face financing difficulties. In this paper, we perform mathematical modeling based on two different financing strategies to analyze the profit function of members in the supply chain and derive corresponding management insights.

3 Model Description, Assumptions, and Building

This paper constructs a secondary supply chain consisting of upstream agricultural machinery manufacturers (M) and downstream distributors (R). Government-led, state-owned enterprises build relevant agricultural machinery financing platforms to provide funds for small and medium-sized agricultural machinery manufacturers needing capital to promote the stability of the whole agricultural machinery supply chain transactions. Agricultural machinery manufacturers can finance their operations through traditional banks and government-enterprise platforms when facing financial constraints. Agricultural machinery manufacturers decide the amount of financing based on the orders provided by downstream dealers combined with available funds. Under the bank financing model, the farm machinery enterprise applies for a loan directly from the bank. Under the government-enterprise platform financing mode, as shown in Figure 1. First, the enterprise applies for financing requests to the platform. After receiving the enterprise's financing application, the platform will evaluate whether it is an agricultural machinery and agriculture-related enterprise. After passing the assessment, the platform will verify the order with the downstream dealers to avoid false financing of upstream agricultural machinery manufacturers and reduce the financing risk. When the financing of the agricultural machinery manufacturer is completed, it produces agricultural machinery products according to the order. It delivers them to the downstream dealers, who sell them to the cooperatives or farmers in need. This study intends to explore the impact of the two financing models on the decision-making of agricultural machinery supply chain members. The parameters involved in the study are harmonized for ease of description, as shown in Table 1.

To facilitate the study, the following assumptions are made about the model based on the above questions:

(1) When $\eta < cq$, the manufacturer is capital constrained and requires financing.

(2) Assuming that the financing environment is favorable, the bank will grant loans to agricultural machinery manufacturers, i.e., the bank will agree to the financing request of the agricultural machinery manufacturing company, but the bank will set a higher interest rate in order to ensure that it breaks even.

(3) Assume that the retail price p decreases linearly with q the number of orders: $p = a - bq$. where a is the capacity of the entire consumer market for agricultural machinery products and b is the price sensitivity of the product to the number of orders. Market demand has instability, such as the quality of the product itself, the applicability of the product, the effectiveness of advertising, and so on. It is difficult to define the impact of these factors on order quantity, product pricing, etc., in the modeling process. Therefore, this paper assumes that demand follows a two-point distribution. In order to simplify the analysis, there are also more and more studies for operation and finance using a two-point distribution function to represent the market demand, similar to CHOD [15]. The demand function for agricultural machinery products is:

$$d = \begin{cases} q & successful\, rate = \beta \\ 0 & failure\, rate = 1 - \beta \end{cases}; \quad (1)$$

That is, the farm machinery manufacturer will repay the loan in full with probability β, but not with probability $1 - \beta$.

(4) It is assumed that if the product fails in the market, the agricultural machinery manufacturer goes bankrupt directly, and the downstream dealers have no sales revenue. Moreover, regardless of which method of financing is used, the government subsidy for each farm machinery product

is the same.

(5) It is assumed that introducing this financing platform will not affect the cost of the whole supply chain. Since the introduction of the platform increases and reduces the cost simultaneously, and the operation process of the platform's construction is not the focus of this paper's research, this part is ignored when establishing the platform's benefit function.

(6) Assume that all financial institutions are in a perfectly competitive capital market.

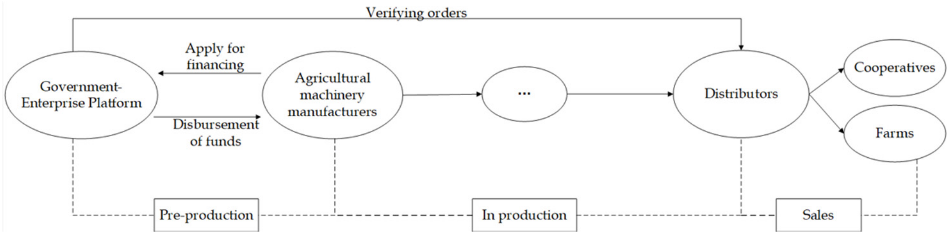

Figure 1. Platform financing operation process chart.

Table 1. Parameter symbols and their meanings.

Symbol	Meaning
c	Production cost per unit product
$i, (i = B, G)$	Observation (B is bank financing; G is platform financing)
w^i	Product wholesale price
p	Retail price
η	Manufacturer's initial capital
q^i	Number of dealers' orders
a	The capacity of agricultural machinery products consumer market
b	The price of the product is sensitive to the price of orders
$\beta, (0 \leq \beta \leq 1)$	Product success rate
$L, (L = cq - \eta)$	Loan quota
$j, (j = M, R)$	Lowering (M is a manufacturer; R is a dealer)
g	Government subsidy
$r^i, (r^B > r^G)$	Financing interest rate
f	The recycling price after product failure
π_j^i	Expected profit
λ_1	Government risk-sharing ratio
λ_2	State-owned enterprise risk ratio

Establishing and operating a government-enterprise financing platform will incur certain costs[20]. However, it will bring a lot of convenience and benefits to the agricultural machinery enterprises in need of financing, so here we assume that introducing this financing platform will not affect the cost of the whole supply chain. Since the introduction of the platform increases and decreases costs, and the process of building the platform itself is not the focus of this study, this part is ignored in the construction of the revenue function of the platform.

In Model B, manufacturer A faces capital shortages and needs total production financing from banks. The manufacturer's initial capital is η and sets a wholesale price w, after which it will receive orders from downstream distributors. Moreover, he will produce agricultural machinery at a total cost of cq. Therefore, he borrows from the bank $cq-\eta$. The manufacturer's initial capital is η. The sales profit is $w^B q$, and with a probability of β repay the bank the principal and interest $L(1+r^B)$. In summary, the profit function of the farm machinery manufacturer in model B is:

$$\pi_M^B = -\eta + \beta(qw^B - L(1+r^B) + qg), \tag{2}$$

where g is the government subsidy for each agricultural machinery product. qg is the total subsidy received by the manufacturer A.

Regardless of the financing model, distributors will always receive sales proceeds when the product is brought to market successfully. If the product fails, the distributor immediately orders agricultural machinery from another manufacturer. This paper focuses on financing and supply chain operations and does not examine the issue of the distributor choosing another manufacturer to purchase the product if it fails. Therefore, in both models, the distributor's profit function is:

$$\pi_R^j = \beta q(p - w^j).\ j = B, G. \tag{3}$$

Under Model B, the conventional bank gains the entire principal and interest sum $L(1+r^B)$ of the loaned funds with probability β, and loses the loan principal L with probability $1-\beta$. The bank's profit function is given by:

$$\pi_B = \beta L r^B - (1-\beta)(L-f). \tag{4}$$

The first part of the above equation is the expectation that the farm machinery manufacturer will repay all its capital, and the second part is the expectation of the difference between the principal lost by the bank and the total value of unsold farm machinery products in the event of the manufacturer's insolvency.

Secondly, manufacturer A in Model G is financed through the government-enterprise financing platform. After receiving an order from a distributor and deciding on a production decision, the agricultural machinery manufacturer applies to the platform for a financing amount of L. After the platform has been approved, it verifies the order and the relevant information of manufacturer A with the downstream distributor, and the funds reach the manufacturer's account immediately after the verification is completed. As a result, the manufacturer will give the distributor a discount on the wholesale price to seek maximum help from the distributor in the financing review stage. The wholesale price set by the manufacturer of the agricultural machinery in Model G, $w^G < w^B$. Similarly, the profit function for the agricultural machinery manufacturer in Model G is:

$$\pi_M^G = \beta[qw^G + qg - L(1+r^G)] - \eta. \tag{5}$$

The above equation is like (2). The difference is that the wholesale price and the financing rate are less than Mode B. Agricultural machinery products can generate revenue when invested successfully. Conversely, the manufacturer goes bankrupt.

In the case of government-enterprise platforms, a lower interest rate is set for agricultural machinery companies needing financing because of government and state-owned enterprise guarantees. Similarly, the platform also takes β and $1-\beta$ the probability of gain or loss. However, the difference is due to a risk-sharing mechanism whereby if the product fails, the funds lost by the platform will be shared. The profit function for the platform is:

$$\pi_G = \beta L r^G - (1-\beta)[L(1-\lambda_1-\lambda_2) - f]. \quad (6)$$

where λ_1, λ_2 represents the proportion of risk borne by the government and state-owned enterprises. The latter part of (6) represents the expectation of losses borne by the platform.

Finally, the decision scenarios of the agricultural machinery manufacturer, the retailer, and the financing institution as leader, follower, and sub-follower are analyzed based on the Stackelberg game model in the two financing models mentioned above.

4 Equilibrium Analysis

In this section, we use the inverse solution method to derive the equilibrium solutions for the two financing models, the traditional financing model and the government-enterprise platform financing model, as follows.

4.1 Traditional Financing Models

In Model B, the agricultural machinery manufacturer first decides on the wholesale price, the distributor decides on the number of orders and sets the retail price, and the bank finally decides on its interest rate.

In the highly competitive capitalist market, banks set interest rates to break even to obtain a financing profit equivalent to the risk-free rate profit.

$$\beta L r_B^* - (1-\beta)L = L r^B. \quad (7)$$

In the above equation, the left-hand side is the bank's profit function in default risk, and the right-hand side is the bank's profit in the absence of any risk. The bank uses this to determine the interest rate to guarantee its return, and the bank's optimal interest rate is $r_B^* = \frac{r^B+1-\beta}{\beta}$.

Lemma 1. (1) In Model B, the bank's optimal interest rate, the wholesale price of the product, and the number of orders for the product are:

$$r_B^* = \frac{r^B+1-\beta}{\beta}, w_B^* = \frac{\beta(a-g)+c(1+r^B)}{2\beta},\ and\ q_B^* = \frac{\beta(a+g)-c(1+r^B)}{4b\beta}.$$

(2) Under Model B, the expected profits of the agricultural machinery manufacturer, the distributor and the commercial bank are as follows:

$$\pi_W^{B*} = \frac{(c(1+r^B)-(a+g)\beta)^2+r^B\eta 8b\beta}{8b\beta},\ \pi_R^{B*} = \frac{(c(1+r^B)-(a+g)\beta)^2}{16b\beta}, and\ \pi_B^* = \frac{-c^2r^B(1+r^B)+c(a+g)r^B\beta-4b\beta(f(-1+\beta)+r^B\eta)}{4b\beta}.$$

The specific solution process is as follows: based on the derivative calculation of the profit function for the manufacturer and the distributor. First, the second order derivative of q^B in π_R^B is obtained as $\frac{d^2\pi_R^B}{d(q^B)^2} = -2b\beta$. The function has an extreme value of q^{B}, so that $q^B = \frac{a-w_B}{2b}$ is brought into the manufacturer's profit formula π_W^B. The second order derivative of w_B yields $\frac{d^2\pi_W^B}{d(w_B)^2} = -\frac{\beta}{b}$, there is an optimal wholesale price w_B^*. Similarly, substituting the optimal wholesale price into the distributor's profit function π_R^B, the optimal number of orders can be obtained q_B^*.

4.2 Financing Model for Government-Enterprise Platforms

In model G, the manufacturer A, the distributor, and the government enterprise platform determine the wholesale price, retail price, and interest rate, respectively. The equilibrium decisions obtained are as follows.

Lemma 2. (1) In model G, the optimal interest rate, the optimal wholesale price and the optimal number of orders for the government enterprise platform are:

$$r^{G^*} = r^G, w_G^* = \frac{a-g+c(1+r^G)}{2}, \text{ and } q_G^* = \frac{a+g-c(1+r^G)}{4b};$$

(2) Under Model G, the expected profits of the manufacturer A, distributor and commercial bank are as follows:

$$\pi_M^{G^*} = \frac{(a+g-c(1+r^G))^2\beta+(-1+\beta+r^G\beta)8b\eta}{8b}, \pi_R^{G^*} = \frac{(a+g-c(1+r^G))^2\beta}{16b} \text{ and } \pi_G^* = \frac{r^G\beta\left(c\left(a+g-c(1+r^G)\right)-4b\eta\right)+(1-\beta)(4bf-(c(-a+c-g+cr^G)+4b\eta)(-1+\lambda_1+\lambda_2))}{4b}.$$

The government-enterprise platform exists risk-sharing so that it can decide interest rate firstly, and $r^G < r^B$. Similarly, the sequence of decisions for other members of the supply chain is as follows: after the agricultural machinery manufacturer decides on the wholesale price, the distributor decides on the order quantity and the retail price. The solution process is similar to Lemma 1.

4.3 Comparison of Equilibrium Decisions under Different Financing Models

Corollary 1. It is known that $\beta \in [0,1]$, for more straightforward calculation and comparison, take $\beta = 1$. When $\beta = 1$, the manufacturer A will not go bankrupt, and the product produced can be successfully marketed. From this can obtain the following: $w_B^* > w_G^*$, $q_B^* < q_G^*$.

The reason for the above corollary to taking $\beta = 1$ is explained as follows: when β is taken to be the maximum, the wholesale price set by the manufacturer A is the lowest in model B; the wholesale price in model G is independent of the change in β. When $\beta = 1$ holds, the whole of $\beta \in [0,1]$ all holds. The management insight is as follows: In model G, when the manufacturer A applies for a loan from the platform, the platform needs to verify the relevant orders with the downstream distributor and know the information of the upstream enterprise. Manufacturer A should give the distributor a preferential wholesale price to get financing successfully. Once the distributor has received the discount, she should try to facilitate financing in the platform verification process. Distributors should increase the number of orders to profit from low wholesale prices. The increase in the number of orders will also increase the manufacturer's profit, allowing the manufacturer to repay the loan more aggressively and quickly for the platform. As a result, manufacturer A will enjoy lower margins when using Mode G financing and reduce its wholesale price accordingly. If the downstream distributor increases the number of orders, it will be a win-win for both parties!

Corollary 2. For initial capital η, production costs c, government subsidies g, there is a critical point (η_1, c_1, g_1), when $\eta < \eta_1$, $c > c_1$, and $g < g_1$, $\pi_M^{G^*} > \pi_M^{B^*}$. For distributor, there is always $\pi_R^{G^*} > \pi_R^{B^*}$. That is, when the initial capital of the farm machinery manufacturer and the subsidies are low, and production costs are high. The supply chain members have higher expected profits when they choose Mode G than Mode B.

From Corollary 2, manufacturer A will always choose Mode G for financing when the capital held by the manufacturer is low, production costs are high, and government subsidies for agricultural machinery are relatively low. As a follower of the agricultural machinery supply chain, the distributor will be happy for the upstream agricultural machinery manufacturer to choose Mode G financing. Because it is clear from Corollary 1 that when the manufacturer chooses financing mode G, it will give the distributor a lower wholesale price compared to mode B, the distributor will want the manufacturer A to choose mode G regardless of the manufacturer's business situation. For manufacturer A, when η decreases and c increases, the number of loans increases, and agricultural machinery manufacturers can benefit more from low-interest rates. However, when government subsidies g is very high, the economic benefits of subsidies may be higher than the benefits of low interest rates. At this time, both financing models can be beneficial to manufacturer A. Nevertheless, this is unlikely to be the case in reality. Agricultural machinery products are often accompanied by a lower subsidy amount, so the manufacturer A benefits far more from the low-interest rate effect than the subsidy. In summary, when initial capital, subsidies, and production costs are low, manufacturer A and distributor profits are higher under model G than model B. Therefore, applying government-enterprise financing platforms creates value for undercapitalized agricultural machinery supply chains and improves the stability of agricultural machinery supply chains. Agricultural machinery manufacturers with higher production costs and low initial capital for agricultural machinery products are more suitable for this model.

The management insight is as follows: In model G, when the manufacturer A applies for a loan from the platform, the platform needs to verify the relevant orders with the downstream distributor and know the information of the upstream enterprise. Manufacturer A should give the distributor a preferential wholesale price to get financing successfully. Once the distributor has received the discount, she should try to facilitate financing in the platform verification process. Distributors should increase the number of orders to profit from low wholesale prices. The increase in the number of orders will also increase the manufacturer's profit, allowing the manufacturer to repay the loan more aggressively and quickly for the platform. As a result, manufacturer A will enjoy lower margins when using Mode G financing and reduce its wholesale price accordingly. If the downstream distributor increases the number of orders, it will be a win-win for both parties!

5 Model Parameters Analysis

5.1 Effect of Product Success on Equilibrium Solutions

Based on the effect of β on the equilibrium decision, the following proposition is derived:

Proposition 1. In model B, r^{B^*} and w_B^* decrease as β increases. Only when $\frac{c(1+r^{B^*})}{2(a+g)} < \beta \leq 1$, q_B increases with β increasing. In model G, the variation of r^{G^*}, w_G^*, q_G^* is independent of β, and the above parameters remain constant regardless of the variation of β.

β increases mean the market is less risky, and the manufacturer A is less likely to default on loan repayments. Thus, in Model B, an increase in product success makes the bank lower its interest rate, and manufacturer A lowers the wholesale price to seek more orders correspondingly.

Interestingly, the volume of orders does not always increase with β increasing. Because β is lower, it is proven that the agricultural machinery manufacturer produces faulty agricultural machinery that is unsuitable for the current market. The distributor will reduce the order volume or even request the manufacturer to terminate the contract for product problems. Only when $\frac{c(1+r^B)}{2(a+g)} < \beta \leq 1$, it means that the product is suitable for the current market and the quality of the product is high, the distributor will increase the order quantity to seek more profit. In model G, the β's increase or decrease does not affect the decision-making of supply chain members, as there are guarantees from the government and state-owned enterprises, and the platform is more confident in the $R\&D$ (Research and Development) level of the manufacturer A, as are the distributor.

From these results, the following management insights emerge from this paper. First, financial institutions providing funding in Models B and G should respond to β the decline in raising and keeping interest rates constant. Secondly, agricultural machinery manufacturers facing a larger β should reduce their wholesale prices to seek more orders, regardless of the model. However, when β is smaller in Mode B, the manufacturer A should increase the wholesale price to ensure profitability. Thirdly, when β increases, whichever financing model is used, distributors should increase the wholesale price to increase the number of orders. The above results show that the business decisions of manufacturers and financial institutions differ under Mode B and Mode G, while the business decisions of distributors are the same under both modes.

Proposition 2. Under the Model B or Model G, the expected profit $\pi_M^{B^*}$, $\pi_R^{B^*}$, π_B^*, $\pi_M^{G^*}$, $\pi_R^{G^*}$, and π_G^* all increase as the success rate of the product β increases.

The above study found that as long as the product success rate β increases, the expected profits of financial institutions, manufacturer A, and distributor increase regardless of the financing method used, consistent with this paper's expected results. Therefore, it is paramount that agricultural machinery manufacturers strive to improve their research and development, and the entire agricultural machinery supply chain will benefit if agricultural machinery products are successfully launched into the market.

From the distributor's perspective, consumers have high demands for spare parts in the agricultural machinery market because of the enormous losses in the operation of farm machinery products and the short duration of farm harvest. Therefore, we believe that consumers have a low sensitivity to the price of farm machinery parts but a slightly higher sensitivity to the price of expensive farm machinery products. The following management insights were obtained: Distributors can adopt the sales method of selling parts at the original retail price and selling products at reduced prices to attract more demand, thus creating more profit for the whole supply chain.

5.2 Effect of Initial Funding on Equilibrium Solutions

The impact of η values on equilibrium decisions and expected profits for both financing models leads to the following proposition:

Proposition 3. When the manufacturer's initial capital η changes, the equilibrium decision in model B, r^{B*}, w_B^*, and q_B^*, and the equilibrium decision in model G, r^{G*}, w_G^*, and q_G^* all remain unchanged.

It is clear from Proposition 6 that, regardless of the financing model used, when the initial funding η changes, it does not affect financial institutions, manufacturer A, and distributor to make equilibrium decisions. Unlike related studies based on the paperboy model, this paper uses a two-point distributed demand model. In the case of the paper, market demand is treated as a continuous variable, and the threshold for bankruptcy is related to the initial capital and subsequent decisions made by the firm. In contrast, this paper focuses on studying the manufacturer's choice of financing method. The manufacturer's bankruptcy threshold is set as a constant threshold (β) to simplify the model. Regardless of the amount of initial capital, agricultural machinery manufacturers will still go for financing. The cost of agricultural machinery products generally accounts for 40-50% of pricing. In front of cost, manufacturers do not use the amount of initial capital to determine their decisions. Therefore, in this paper, the change in the initial capital of manufacturer A does not affect the equilibrium decision.

Proposition 4. In Model B, the members of the agricultural machinery supply chain expect profits $\pi_M^{B^*}$, $\pi_R^{B^*}$, and π_B^* increase, remain constant, and decrease, respectively, as the initial capital η of manufacturer A increases. In Model G, however, when the initial capital η increases, the $\pi_R^{G^*}$ does not change, and π_G^* increases. In the expected profit of the agricultural machinery manufacturer $\pi_M^{G^*}$, there is a threshold value in β_1. When $\beta > \beta_1$, $\pi_M^{G^*}$ increases as the initial capital η increase.

The following results follow Proposition 7 above. First, regardless of the type of financing used, when the initial capital changes, the distributor's profit remains unchanged. Secondly, in Model B, as η increases, the expected profits of manufacturer A and the bank increase and decrease, respectively. Finally, in model G, there is a threshold value that allows the farm machinery manufacturer to make a higher β profit. Similarly, the expected profit of the government enterprise platform increases as η.

An interesting phenomenon can be observed from the η analysis of the expected profit impact of each supply chain member. In the two financing models, the η impacts the expected profits of the manufacturer A and the financial institutions differently. The reasons for this may be as follows: for the agricultural machinery manufacturer, the more money it borrows, the more interest it has to pay. The phenomenon is "the interest-increasing effect of the loan" (A). Similarly, the repayment of debt after the bankruptcy of an agricultural machinery manufacturer is often limited, the phenomenon is known as "the limited liability effect" (B) (Kouvelis and Zhao. 2016). Because $r^B > r^G$, when the manufacturer A uses mode B financing, the more money it borrows, the more interest it has to pay and the higher the interest rate $(A > B)$. When the agricultural machinery manufacturer uses this model, the fewer funds borrowed, the better. Conversely, the interest rate in model G is lower, and the farm machinery manufacturer has to pay back less interest. At this point, the risk of bankruptcy from lower levels of β is significant $(B > A)$. In model B, the η increases, the $\pi_M^{B^*}$ increase. In model G, the manufacturer's expected profit $\pi_M^{B^*}$ increases only in a higher β .

For financial institutions, in Model B, the bank sets a higher interest rate to break even. The more the manufacturer A borrows, the greater the profit for the bank. Therefore, the bank wants a lower η to make more profit. The government-enterprise financing platform is more lenient to the agricultural machinery manufacturer. It gives a lower interest rate because of the risk-sharing. When the initial asset η increases, the platform must bear more losses from the manufacturer's bankruptcy. Although the existence of sharing mechanism, the government-enterprise platform is more willing to lend to companies that hold relatively more capital for manufacturers at risk of bankruptcy. Therefore, for agricultural machinery manufacturers with less initial capital, the government-enterprise platform should strengthen supervision and audit to avoid a default to the greatest extent.

6 Numerical Analysis

In this section, we perform a numerical analysis of the theoretical model developed above. Since obtaining the required data from companies is difficult, this paper will refer to other academic papers for parameter design: Li et al.[21] and try to design relevant parameters to validate our results. We use the following fundamental parameter values for our analysis. $a = 10, b = 1, r^B = 0.05, f = 2, g = 0.5, \lambda_1 + \lambda_2 = 0.6$. Then analyzed the impact of β, c, η on the financing model.

6.1 Product Success Rate β Impact on Expected Profit

In this subsection, we analyze how product success rate β affects the expected profitability of agricultural machinery supply chain members. This paper assumes that $c = 4, r^G = 0.01, \eta = 0$. The model is analyzed numerically to derive the impact on the decision maker's expected profit in the interval $\beta \in [0.4, 1]$. As shown in Figure 2, regardless of the model, the parameter β increases the profits of all decision-makers in the agricultural machinery supply chain. Moreover, when the product success rate β is relatively high, the profits of manufacturer A, distributor, and the whole supply chain under mode G are always greater than those of mode B. Our corresponding parameter values and images verify that in Corollary 2, when the initial capital of the manufacturer, government subsidies are deficient, and production costs are relatively high, the choice of mode G by manufacturer A and distributor is always better than mode B. The higher the success rate of the product, the greater the probability that the manufacturer will make a profit on the sale of the product and the greater the probability of repaying the loan to the financial institution. In a high success rate, low-interest rate scenario, the manufacturer A is more profitable, as in Model G. Conversely, high-interest rates reduce profits, as in Model B. For distributors a higher β means a lower risk of manufacturer bankruptcy and a higher probability of order fulfillment. In model G, where the wholesale price of the agricultural machinery manufacturer is lower, the distributor will enjoy increased profits from the low wholesale price. Finally, we compared the profits of external financial institutions as well and found that regardless of β no matter how it varies, the profits of commercial banks in Model B are always higher than those of the government-enterprise financing platform in Model G. Because of the presence of lower interest rates, even at higher β under, the profits of the government-enterprise financing platforms remain low. It can be seen that the profits of the platforms show a slow upward trend of around 0. On the one hand, it reflects that solving the financing problem of small and medium-sized agricultural machinery enterprises requires significant investment from government departments, which should support the development of the agricultural machinery industry at a lower profit. On the other hand, agricultural machinery enterprises are also required to strengthen innovation.

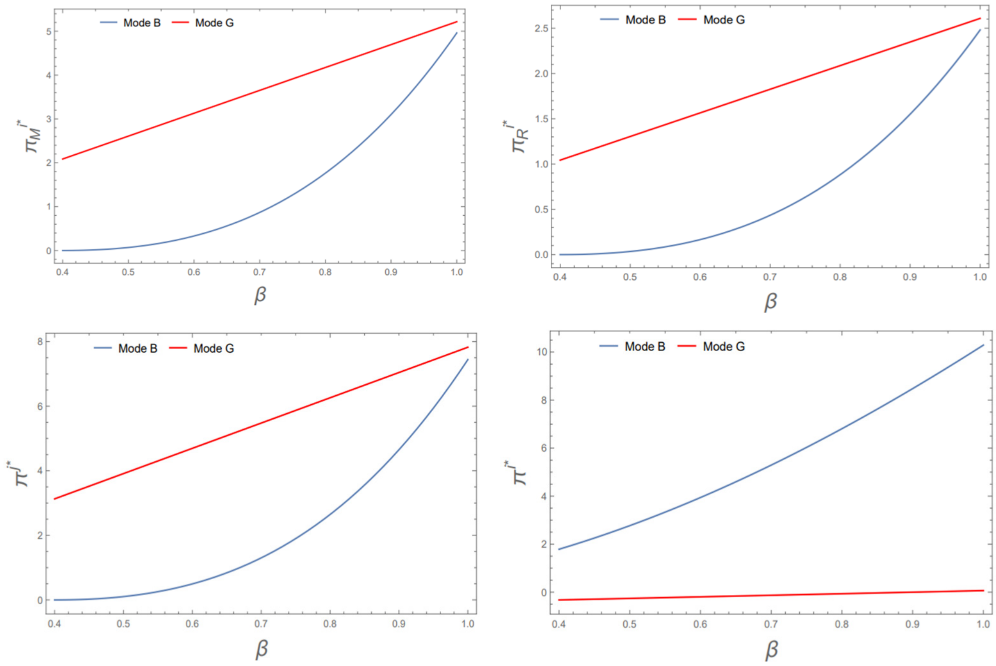

Figure 2. β impact on expected profit.

6.2 Initial Capital η Impact on Expected Profit

The graph below illustrates the initial capital η of the manufacturer's impact on the expected profits of members in the supply chain. This paper assumes $\beta = 0.8$ that the values of other parameters are as above. As shown in Figure 3, when the initial funding η increases, the banks' profits decrease in Mode B, while the earnings of the government and corporate financing platforms increase in Mode G. The larger η, the lower the bank's profit. Because the lower the amount the manufacturer finances, the lower the bank's return from the high-interest rate. The profit of the government-enterprise financing platform is lost when η is particularly low, because the manufacturer may default, and the low-interest rate of the platform puts it at high risk. The adverse effects of low-interest rates are only diminished when initial funding increases. For the agricultural machinery manufacturer, the interest-increasing effect of loans is greater when model B is chosen. The negative impact of high-interest rates on the manufacturer's profit is greater, so the less the loan, the more the profit. In Mode B, π_M^{j*} increases as η. In Mode G, with more initial capital, the agricultural machinery manufacturer enjoys less benefit from the low-interest rate effect than the limited liability effect of bankruptcy, so the manufacturer's profits are declining. This is only possible if $\beta > \beta_1$, in Mode G, the profit curve of the manufacturer rises only when the product success rate is high. And as η the increase in the distributor's expected profit does not change in any way. Changes in η do not affect agricultural machinery manufacturer's decisions on wholesale prices, and the distributor's profit does not change as long as the wholesale price does not change. Furthermore, the graph below shows that when the manufacturer chooses mode G, the profit of each member of the supply chain and the supply chain as a whole is higher than that of mode B. Therefore, no matter how η changes, Mode G is the most favorable choice for agricultural machinery manufacturers. It is a "win-win" financing strategy.

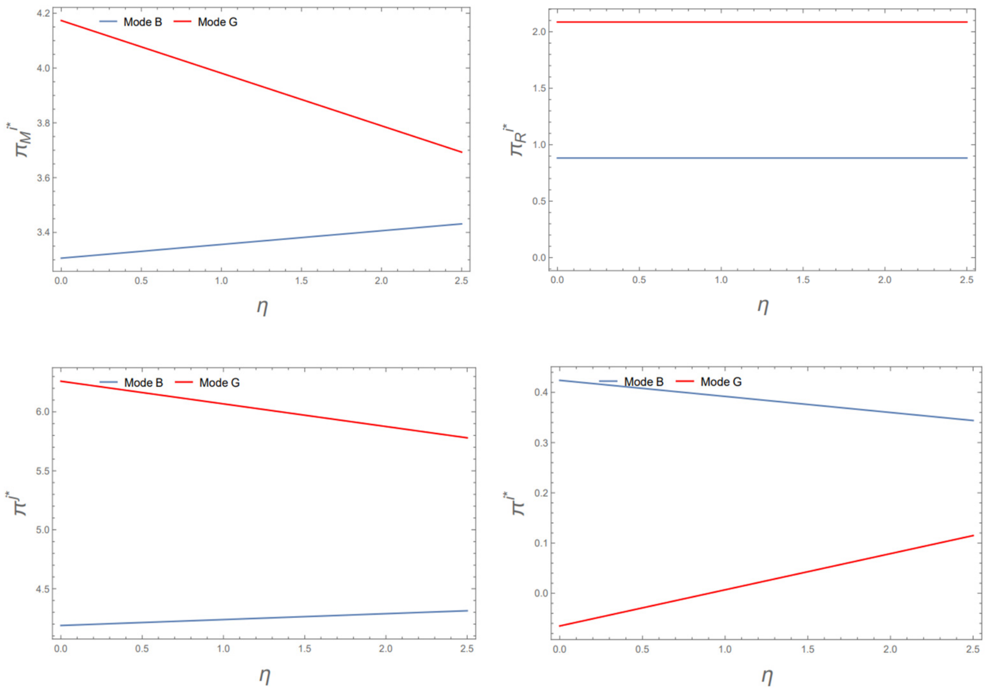

Figure 3. η impact on expected profit.

7 Conclusion

(1) The optimal interest rate and wholesale price under Model G are always lower than Model B, while the optimal order quantity is higher than Model B.

(2) In model B, as the product success rate increases, the optimal wholesale price and the bank's interest rate decreases. The optimal number of orders increases only when the product success rate takes on a larger value. Differently, the product success rate does not affect the change of the optimal value in model G.

(3) With the increase of initial capital, the willingness of small and medium-sized agricultural machinery manufacturers to choose model G has weakened, and the willingness to choose model B realizes a weak increase.

(4) When $\eta < \eta_1$, $c > c_1$, and $g < g_1$, the optimal profits of agricultural machinery manufacturers and dealers under model G are greater than model B to realize a "win-win" situation.

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