Game model of green financial supply chain based on government subsidy analysis

NAN XIE1,2, HAITAO HE1,2, AND YEZI TONG1,2
1Business School, Hunan Normal University, Changsha, Hunan, China
2Hunan Key Laboratory of Macroeconomic Big Data Mining and its Application, Business School, Hunan Normal University, Changsha, Hunan, China

Corresponding author: Nan Xie (e-mail:xienan@hunnu.edu.cn).

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ABSTRACT Rural Revitalization is not only the necessary way to achieve common prosperity, but also an important strategy to promote China’s sustainable development. However, under the centralized administrative management system such as China, it is still lacking that the impact research of central fiscal policy on local government behavior and market behavior in the game theory. Therefore, This paper consider the existence of two local governments with different Rural Revitalization strategies and a channel structure composed of two manufacturers (township enterprises) and two retailers (E-commerce platforms). Each retailer sells only one manufacturer’s products, and the two manufacturers can choose different sales channels and financing modes. This paper analyzes the three-party four stage Stackelberg game among manufacturers, retailers and local governments under the same conditions of central government project subsidies. The study finds that township enterprises will choose online retail for product sales in the presence of consumer preferences. The central government’s project subsidy policy has a significant positive impact on both the product demand volume and the improvement of product greenness. Although, this policy is very important for the Rural Revitalization, under the lending mode of e-commerce platforms, government subsidies and excessively high loan interest rate of e-commerce platform will damage the utility of consumers and products Innovativeness. Therefore, the combination of the central government’s project subsidy and the control of loan interest rate is the policy combination to realize the better development of township enterprises.

INDEX TERMS Government subsidies; Local government; Rural Revitalization; Supply chain management; Stackelberg model

I. INTRODUCTION

Government subsidies are effective strategies to promote industrial development in many countries. As a country with centralized administrative system, in addition to the regular distribution channels of the financial system, China adopts the project system that an institutional arrangement for resource allocation in the form of special funds from top to bottom according to the intention of the central government [1]. This institutional arrangement promotes the central and local governments, enterprises and consumers to participate in a major national strategy. Thus, it has achieved China’s action style of "concentrating power on major events". But at the same time, the project system has also formed a kind of "project power" outside the original administrative system. This power cooperates with the original administrative system and constitutes a more powerful state power. This kind of "project power" is generally controlled by central ministries and commissions to formulate unified project subsidy standards, while local governments have different endowments. Therefore, in the same national strategy, the strategic implementation effects of different regions under the jurisdiction of local governments are very different.

The implementation of the Rural Revitalization Strategy is a major decision and deployment for the sustainable development of the 19th National Congress of the Communist Party of China(CPC). It is the general focus of the work of
"agriculture, rural areas and farmers" in the new era [2]. Over the past three years since the implementation of the Rural Revitalization Strategy, the top-level design of Rural Revitalization has been continuously strengthened. The CPC Central Committee and the State Council have issued the opinions on the implementation of the Rural Revitalization Strategy, issued the strategic plan for Rural Revitalization (2018–2022), issued the regulations of the Communist Party of China on rural work, and promulgated and implemented the law of the people’s Republic of China on the promotion of Rural Revitalization. It has built the "four beams and eight pillars" of the institutional framework and policy system for Rural Revitalization. In this context, how does the central government formulate effective project subsidy policies? How will local governments, manufacturers (township enterprises) and retailers (e-commerce platforms) respond to the subsidy policies of the central government? How can the Rural Revitalization Strategy achieve long-term industrial prosperity? How do township enterprises with widespread capital constraints borrow to produce? This will become an urgent problem for us to explore how to develop township enterprises quickly and well under the background of Rural Revitalization Strategy.

As one of the conventional influence means of the government on enterprises, subsidy is the transfer of free funds provided by the government to microeconomic subjects in a certain period of time according to political or economic purposes [3]. Studies have discussed the impact of government subsidies on enterprise product innovation [4]– [10], but there is no consistent conclusion on the implementation effect of government innovation subsidy policy [11]– [18]. On the one hand, government subsidies reduce the R & D costs and risks of enterprises, make the R & D of enterprises profitable, and then stimulate enterprises to spend more on R & D. Bai [11] believes that the subsidies of the Chinese government have significantly promoted the technological innovation of enterprises, but the factors such as the enterprise’s own knowledge stock, enterprise scale, industrial technology level and property right type will have varying degrees of impact on the policy effect. Li et al [16] believe that selective industrial policies only encourage enterprises’ strategic innovation, enterprises increase the "quantity" of innovation in order to "seek support", and the "quality" of innovation has not been significantly improved. On the other hand, it is dangerous for the government to choose winners and support them instead of market competition. Yuan et al [17] believe that if there is a phenomenon of enterprise political connection, political resources will exacerbate the extensive development of enterprises, hinder the independent innovation of enterprises, and ultimately not beneficial to improve the quality of economic growth. The reason why scholars draw the opposite conclusion is the heterogeneity of governments at all levels [19]– [20]. In fact, governments at all levels have dual motives of "altruism" and "self-interest". "Altruism" is to serve the society and the people; "Self-interest" is to seek the interests of units, departments and individuals [21]. Therefore, the influence of local governments on regional markets and enterprises under their jurisdiction can not be ignored. In order to ensure the effective transmission of financial subsidy policies to local enterprises, the central government must ensure the maximization of the interests of local governments.

In addition, the production of enterprises is not only affected by the government, but also by their own capital constraints. Because enterprises do not exist in isolation, scholars further put forward the concept of supply chain finance [22]– [25]. Hu et al [24] believe that supply chain finance is a branch of supply chain management. Yan et al [25] further divided supply chain finance into three financing models: accounts receivable (accounts receivable financing [26]– [27]), advance receipt (future cargo right financing is also called confirmed warehouse financing [28]– [29]) and inventory (financing warehouse financing [30]) and considered that supply chain finance can effectively alleviate the financing difficulties of small and medium-sized enterprises in China. In recent years, with the rapid development of modern information technology represented by the Internet, especially mobile payment, social network, search engine and cloud computing, it has had a fundamental impact on human financial model [31]. A large number of e-commerce platforms have been born in society, such as "Alibaba", "Meituan", "Jingdong", etc. In view of this phenomenon, the academic circles have produced many "Internet plus" supply chain finance related research results [32]– [33].

Some scholars also study enterprise production from the perspective of market driven, combine consumer awareness with government subsidies, and analyze it under the framework of supply chain [34]– [38]. Based on consumer demand preference, Yang et al [34] discussed the driving factors and timing of green technology innovation in different government subsidies. Under the two subsidy policy choices of consumer subsidy and manufacturer subsidy, Subrata Saha et al [37] established a three-stage game model in a centralized and decentralized environment to obtain a fair understanding of the favorable environment for government subsidies to consumers or manufacturers. Liu et al [38] introduced the power structure of the supply chain into the transnational green supply chain model, and analyzed the impacts of tariffs, power structure and consumers’ green preference on the green supply chain decision-making. Although they have government subsidies and various model functions to express the production of green products, they have never added the local government as a special participant into the game model.

In conclusion, under the background of rural revitalization, the factors affecting enterprise production have been highly valued by academic and theoretical circles. Existing studies have laid a good foundation for this research, but most of them are based on the supply chain analysis framework, without considering the resource competition between local governments and the market competition between enterprises under the jurisdiction of local governments [39]– [41]. And
the government is not divided into two levels of central and local governments, less consideration of the "Internet plus" empowerment of products, less involving two sources of corporate funding, namely, government subsidies and borrowing. The contribution of this paper is based on the consumer’s demand preference. It constructs a Stackelberg model including market follower 1 and market leader 2, which respectively produce low-Innovativeness products 1 and high-Innovativeness products 2. It systematically analyzes the effects of central government subsidies, good consumer demand preference, enterprise channel selection, loan mode and loan interest rate on product pricing, market share, the impact of enterprise profits and social welfare at the central and local levels, so as to clarify its mechanism of Rural Revitalization.

II. PROBLEM DESCRIPTION AND MODEL ASSUMPTIONS

A. PROBLEM DESCRIPTION

Table 1 shows the parameters involved in this research and their meanings.

The local government mainly has two rural revitalization strategies: positive and negative. Local governments that adopt negative Rural Revitalization Strategy (set as government 1) often do not pay attention to the implementation of Rural Revitalization Strategy because of their own unique reasons. The local government (set as government 2) that adopts the active rural revitalization strategy, besides carrying out the regular local government rural revitalization management measures, also actively helps the township enterprises, actively builds up the upstream and downstream supply chain system of the township enterprises, and promotes the supporting activities such as featured product network promotion, etc., to promote the township enterprises within its jurisdiction to obtain the central government subsidy more likely, and to improve the green degree of the products. Furthermore, The local government can have an external impact on the township enterprises under its jurisdiction through financial means. This external impact includes not only the explicit impact, but also the implicit impact hidden in the "hidden rules".

Township enterprises mainly have two retail strategies: traditional retail and e-commerce platform online retail. Among them, the traditional retail mode chooses to sell products directly. Township enterprises sell Rural Revitalization products at wholesale prices \( w_1 \) sold to consumers, banks provide loans to township enterprises with capital gap, and the loan interest rate is \( r_b \). As shown in the Fig.1.

In the online retail mode, there is a secondary supply chain composed of an e-commerce and a township enterprise. The e-commerce platform provides two financing modes, bank lending and e-commerce lending, for township enterprises with insufficient funds. After placing orders, the e-commerce platform plays a game with township enterprises through wholesale price contracts to maximize profits. After completing the process from production to sales, the local government has an external impact on township enterprises through financial means, so as to maximize local social welfare. Under the bank loan mode, township enterprises can apply to the bank for loans for production with the help of the credit of the e-commerce platform and the order of the e-commerce. After the goods are sold at the retail price and the funds are returned, the e-commerce platform not only evaluates the credit of township enterprises and the order of the e-commerce, but also deducts the loan principal and interest, and then the profits are distributed by the e-commerce platform and township enterprises. Under the e-commerce lending mode, township enterprises can apply for loans to small loan companies set up by the e-commerce platform. After reviewing the relevant information, the e-commerce platform will evaluate the credit of township enterprises and issue loans to township enterprises. When the goods are sold and the funds are returned, the e-commerce platform not only obtains its due profits, but also deducts the loan principal and interest of township enterprises, and the rest is owned by township enterprises [42].

As shown in Fig.2 and Fig.3, this paper constructs a scenario in which the e-commerce platform provides two lending modes for township enterprises with capital gap under the background of Rural Revitalization Strategy. Based on the description of the classical newsboy model by [43], this
paper intends to model the income of each node enterprise under different models:

1. Under the bank lending model, township enterprises can apply for loans from banks for production with the help of the credit of e-commerce platform and the orders of e-commerce.

2. Under the e-commerce lending model, the e-commerce platform orders products according to the market demand, and township enterprises and e-commerce platforms are centralized. When making decisions, there is no shortage of funds.

Based on the perspective of government project subsidies, this paper discusses the four stage Stackelberg game model between competitive local governments implementing different Rural Revitalization management strategies and competitive township enterprises adopting different retail channels and supply chain financing under the same subsidy conditions of the central government. It is assumed that all market participants of local government 1 adopting negative Rural Revitalization management strategy are followers and all market participants of local government 2 adopting positive Rural Revitalization management strategy are leaders, As shown in the fig. 4.

The first stage: the two local governments determine the optimal external influence coefficient on township enterprises. The second stage: township enterprises 2 determine the optimal green degree of their products. The third stage: the two township enterprises choose their own optimal wholesale price. The fourth stage: the two e-commerce platforms select their respective optimal retail prices.

B. MODEL ASSUMPTIONS

Under the condition of not changing the essence of the problem, some complicated conditions are simplified, and the following assumptions are made for the model with reference to [36] [37] [38] [44] [45] [46]:

1. China’s central government takes economic development as its first priority, and the development of enterprises under the jurisdiction of local governments and their taxation are crucial to the promotion of local government officials. Therefore, this article sets the revenue of the local government as the sum of the revenue of the enterprises within its jurisdiction and the revenue of the external influence of the government on the township enterprises. The central government utility is the total social welfare, which is set as the sum of the local government revenue and the consumer utility and the interest earned from the bank loan, less the project subsidy paid by the government to the township enterprises.

2. Assuming that the standard for the central government to approve rural revitalization projects is the greenness of their products. \( g_{1}, g_{2} \) indicates the green level of township enterprises of government 1 and government 2. It is assumed that only local government 2 can obtain the project subsidy from the central government, and township enterprises 2 needs product innovation in order to improve the product greenness [36]–[38]. It is assumed that the upfront one-time cost payments by township enterprises 2 is \( \frac{1}{2} g_{2}^{2} \).

3. Assuming that the central government subsidizes the cost of Rural Revitalization products, and the subsidy rate is \( t \), the government’s cost subsidy for unit Rural Revitalization products is \( t g_{i} c_{i} \), (i = 1, 2).

4. The local government can have an external impact on the township enterprises under its jurisdiction through financial means. This external impact includes not only the explicit impact, but also the implicit impact hidden in the “hidden rules”. Moreover, e-commerce platforms are generally large national platforms, and it is difficult for local governments to have an influence on them. For the convenience of calculation, this paper assumes that this externality only affects the production cost of township enterprises, sets \( s \) as the externality impact coefficient of local governments on township enterprises, and the total impact income is
With the participation of the central government, in order to obtain more project subsidies, the external impact of local government 2 will be less than that of local government 1.

(5) Assuming that the products of Township Enterprises 1 are low-green products and are not subsidized; Township Enterprises 2 is a high-green product and receives subsidies.

(6) Assuming that consumer preferences in the market are heterogeneous, some consumers are willing to pay high prices for high-green products under the Rural Revitalization Strategy, while others do not care whether they are high-green products under the Rural Revitalization Strategy [44].

Use $h$ to express consumers’ support for high-green products for Rural Revitalization. Every additional unit of consumer support indicates that consumers are willing to pay a certain fee $k$ ($k$ is the payment coefficient of consumers’ preference for environmental protection).

(7) $h$ denotes consumers’ satisfaction with the environment of the products, represents the types of consumers, and obeys uniform distribution: $h \sim [h_1, h_2]$. $h_1$ indicates that there is no difference between Product 1 and Product 2, $h_2$ indicating that consumers have extremely high environmental satisfaction and are extremely inclined to purchase Product 2. Generally speaking, township enterprises can gain high popularity in the market and win consumers’ preference for their products by obtaining project subsidies. Therefore, $tg_2$ is used in the pricing model to show the product preferences. When $p_1 + k(h - h_1) + tg_2 = p_2$, the type of $h$ consumers were willing to buy the products of Township Enterprise 2. That is $h_3$, there is a consumer of this type who has no difference in purchasing the products of the rural enterprise 2 and the products of the rural enterprise 1.

$$h_3 = \frac{p_2 - p_1 - tg_2}{k} + h_1$$  \hspace{1cm} (1)

(8) Assuming that the market demand is known, the market capacity is 1, the market demand for products of township enterprises 2 under the jurisdiction of government 2 is $q_2$. The market demand for products of township enterprises under the jurisdiction of government 1 is $q_1 = 1 - q_2$.

(9) The consumer utility of buying a township enterprise product 1 is:

$$U_1 = (U_0 - p_1)q_1$$ \hspace{1cm} (2)

(10) The consumer utility of buying a township enterprise product 2 is:

$$U_2 = (U_0 - p_2 + k(h_2 - h_1) + tg_2)q_2$$ \hspace{1cm} (3)

(11) High greenness product market demand for $q_2$, low greenness product market demand for $q_1 = 1 - q_2$.

$$q_2 = \int_{h_1}^{h_2} \frac{1}{h_2 - h_1} dh = 1 - \frac{h_3 - h_1}{h_2 - h_1} = 1 - \frac{p_2 - p_1 - tg_2}{k(h_2 - h_1)}$$ \hspace{1cm} (4)

This paper uses the reverse induction method to solve it, starting from the third or fourth stage, ending at the first stage, and then substituting the optimal value back from the first stage.

C. MODEL PARAMETERS

The parameters involved in this model are summarized as follows: In order to distinguish the parameters under the three modes, the subscript $z$ is used to refer to the traditional retail mode, the subscript $b$ is used to refer to the bank lending mode, the subscript $e$ is used to refer to the e-commerce lending mode. Product 1 refers to the low-green products, and Product 2 refers to the high-green products.

$p_1, p_2$: retail price per unit product for Products 1 and 2;

$q_1, q_2$: market demand for Products 1 and 2, $q_1 + q_2 = 1$;

$w_1, w_2$: the wholesale price per unit product for Products 1 and 2;

$c_1, c_2$: unit manufacturing cost of products 1 and 2;

$h$: Consumers’ satisfaction with the environment of the products, representing the types of consumers, obeying uniform distribution: $h \sim [h_1, h_2]$. $h_1$ indicates that there is no difference between Product 1 and Product 2, $h_2$ indicating that consumers have extremely high degree of environmental satisfaction and are extremely inclined to purchase Product 2.

$k$: The payment coefficient of consumers’ environmental preference, which represents the fees that consumers are willing to pay for each unit of green degree added to the products.

$g$: product greenness. In order to distinguish other similar products, township enterprises 2 need to improve the product greenness 2 and carry out product innovation. The one-time research and development cost they pay is $\frac{1}{2}tg_2^2$.

$t$: The subsidy rate set for the central government. If the subsidy for central government projects depends on the greenness of the products, the amount of subsidy for each unit of products by the central government to the township enterprise 2 is $c_2tg_2$.

$r_b$: the loan interest rate set by the bank;

$r_e$: loan interest rate set by e-commerce platform;

$s$: local government’s external influence coefficient on township enterprises.

III. MODEL SOLVING

As shown in the fig.5, in case (a), the game equilibrium of product price and demand between consumers and township enterprises
enterprises is obtained first. After determining the product price and demand, the optimal green degree is determined on the basis of maximizing the profit of the township enterprise. Finally, through the judgment of the local government on the optimal green degree and product market conditions, the optimal externality coefficient for township enterprises is determined on the basis of profit maximization, and the determined optimal externality coefficient is replaced.

The main difference between scenario (b) and scenario (a) is that there are e-commerce platforms as the body between the township enterprises and consumers, thus transforming the game process between consumers and township enterprises in scenario (a) into the game process between consumers and e-commerce platforms and between e-commerce platforms and township enterprises in scenario (b).

Scenario (c) compared with scenario (b), the main difference is the transfer of the borrowing objects of the township enterprises, which is because in reality, township enterprises generally borrow from e-commerce platforms. Through further analysis, this paper finds out the rationality of this situation and its negative impact on the implementation of the rural revitalization strategy.

A. TRADITIONAL RETAIL MODEL

1) Stage 3: Two Township Enterprises Choose Their Optimal Retail Prices

In this decision-making process, the township enterprises make products through loans from banks and achieve maximize profits.

For product 1 with low greenness, the profit function of township enterprise 1 is:

$$\pi_{1z}^-(p_{1z}) = (p_{1z} - c_1(1 + r_b))q_{1z} - c_1q_{1z}s_{1z}$$  \hspace{1cm} (5)

For product 2 with high greenness, the profit function of township enterprise 2 is:

$$\pi_{2z}^-(p_{2z}) = p_{2z}q_{2z} - ((1 - tg_{2z})c_2q_{2z} + \frac{1}{2}g_{2z}^2)(1 + r_b) - c_2q_{2z}s_{2z}$$  \hspace{1cm} (6)

If we substitute the formula $q_{1z}$ and $q_{2z}$ into $\pi_{1z}^-(p_{1z})$ and $\pi_{2z}^-(p_{2z})$, the first derivative of $p_{1z}$ and $p_{2z}$, we can get $p_{1z}^*$ and $p_{2z}^*$.

$$p_{1z}^* = \frac{1}{4}(3c_1(1 + r_b + s_{1z}) + c_2(s_{2z} + (1 - tg_{2z})(1 + r_b)) + 2k(h_2 - h_1) - tg_{2z})$$  \hspace{1cm} (8)

$$p_{2z}^* = \frac{1}{2}(c_1(1 + r_b + s_{1z}) + c_2(s_{2z} + (1 - tg_{2z})(1 + r_b)) + 2k(h_2 - h_1) + tg_{2z})$$  \hspace{1cm} (9)

Substituting $p_{1z}^*$ and $p_{2z}^*$ into Equation (4) to obtain $q_{1z}^*$ and $q_{2z}^*$:

$$q_{1z}^* = \frac{1}{4k(h_2 - h_1)}(c_2(s_{2z} + (1 - tg_{2z})(1 + r_b)) - c_1(1 + r_b + s_{1z}) + 2k(h_2 - h_1) - tg_{2z})$$  \hspace{1cm} (10)

$$q_{2z}^* = \frac{1}{4k(h_2 - h_1)}(c_1(1 + r_b + s_{1z}) - c_2(s_{2z} + (1 - tg_{2z})(1 + r_b)) + 2k(h_2 - h_1) + tg_{2z})$$  \hspace{1cm} (11)

At this time, $k > 0$, $h_2 > h_1$ satisfy the constraint condition that the second derivative is less than 0.

2) Stage 2: Township Enterprises 2 Determine Optimal Product Green Degree

In this decision-making process, the township enterprises 2 in order to seize the market and maximize their own profit, thus determining the optimal product green degree. For product 2 with high greenness, the profit function of township enterprises 2 is:

$$\pi_{2z}^-(g_{2z}) = p_{2z}q_{2z} - ((1 - tg_{2z})c_2q_{2z} + \frac{1}{2}g_{2z}^2)(1 + r_b) - c_2q_{2z}s_{2z}$$  \hspace{1cm} (12)

If we substitute the formula $q_{1z}^*$ and $q_{2z}^*$, $p_{1z}^*$ and $p_{2z}^*$ into $\pi_{2z}^-(g_{2z})$, the first derivative of $g_{2z}$, we can get $g_{2z}^*$.

Because the formula is too complex, this paper substitutes the values of non-critical parameters. order $r_b = 0.06$, $c_1 = 2$, $c_2 = 3$, $h_1 = 0$, $h_2 = 1$, $U_0 = 4$.

$$g_{2z}^* = \frac{209t(100k + 100s_{1z} - 150s_{2z} - 53)}{10600k - 43681t^2}$$  \hspace{1cm} (13)

The constraint condition is that the second derivative is less than 0.

$$\frac{\partial^2 \pi_{2z}^-(g_{2z})}{\partial^2 g_{2z}} = \frac{43681t^2}{10000k} - \frac{53}{50} < 0$$  \hspace{1cm} (14)

3) Stage 1: the two local governments determine the optimal external impact coefficient on township enterprises.

In this decision-making, the local government exerts an external influence on the township enterprises through financial means such as taxation to maximize the revenue of the local government. In reality, consumers who buy products come from all regions of the country, and local governments cannot count the utility of consumers. Therefore, local governments generally only pay attention to the benefits of the enterprises under their jurisdiction. We assume that in all models, the local government only pays attention to the profit of the enterprises under its jurisdiction when making decisions, and does not take the consumer utility as its own decision-making basis.

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For low greenness product 1, the profit function for government 1 is:

\[ \pi_{1Gz}^{t}(s_{1z}) = \pi_{1r}^{t} + c_{1}s_{1z} \]  

(15)

For product 2 with high greenness, the profit function of government 2 is:

\[ \pi_{2Gz}^{t}(s_{2z}) = \pi_{2r}^{t} + c_{2}s_{2z} \]  

(16)

Substituting \( q_{1s}^{*} \) and \( g_{2s}^{*} \) into \( \pi_{1Gz}^{t}(s_{1z}) \) and \( \pi_{2Gz}^{t}(s_{2z}) \), find the first derivative of \( s_{1z}^{*} \) and \( s_{2z}^{*} \), respectively:

\[ s_{1z}^{*} = \frac{[5618000k^{2} - 926037200k t^{2} + 14887700k + 3816059522t^{4} - 122699929 t^{2}]/[5300 (21200k - 131043 t^{2})]}{1} \]

(17)

\[ s_{2z}^{*} = \frac{[5618000k^{2} - 694527900k t^{2} - 14887700k + 1908029761t^{4} + 122699929 t^{2}]/[7950 (21200k - 131043 t^{2})]}{1} \]

(18)

The constraint condition is that the second derivative is less than 0.

\[ \frac{\partial^{2} \pi_{1G}^{t}(s_{1z})}{\partial s_{1z}^{2}} = - \frac{168540000k - 926037200k t^{2}}{(16000k - 43681 t^{2})^{2}} < 0 \]  

(19)

\[ \frac{\partial^{2} \pi_{2G}^{t}(s_{2z})}{\partial s_{2z}^{2}} = - \frac{11925 (21200k - 131043 t^{2})}{2 (7950k - 43681 t^{2})^{2}} < 0 \]  

(20)

Then, the three-stage optimal Stackelberg game equilibrium between the two parties under the traditional retail model is obtained \( s_{1z}^{*} \) and \( s_{2z}^{*} \) by combining the obtained generations with \( q_{1s}^{*} \) and \( g_{2s}^{*} \), respectively:

\[ P_{1} = \frac{w_{1b} + w_{2b} + 2(k_{2} - h_{1}) + g_{2b} b}{2} \]  

(25)

Substituting \( p_{1b}^{*} \) and \( p_{2b}^{*} \) into Equation (4) to obtain \( q_{1b}^{*} \) and \( q_{2b}^{*} \):

\[ q_{1b}^{*} = \frac{w_{2b} - w_{1b} + 2(k_{2} - h_{1}) - g_{2b} b}{4k(k_{2} - h_{1})} \]  

(26)

\[ q_{2b}^{*} = \frac{w_{1b} - w_{2b} + 2(k_{2} - h_{1}) + g_{2b} b}{4k(k_{2} - h_{1})} \]  

(27)

2) Stage 3: Two Township Enterprises Choose Their Optimal Wholesale Prices

In this decision-making process, due to the limitation of their own funds, township enterprises take the e-commerce platform as the core enterprise and provide order vouchers to banks to borrow loans.

For product 1 with low greenness, the profit function of township enterprise 1 is:

\[ \pi_{1r}^{b}(w_{1b}) = (w_{1b} - c_{1}(1 + r_{b}))(1 + b_{1})q_{1b}^{*} \]

(28)

For product 2 with high greenness, the profit function of township enterprise 2 is:

\[ \pi_{2r}^{b}(w_{2b}) = (w_{2b} - c_{2}(1 + r_{b}))(1 + b_{2})q_{2b}^{*} \]

(29)

Substituting \( p_{1b}^{*} \) and \( p_{2b}^{*} \), \( q_{1b}^{*} \) and \( q_{2b}^{*} \) into \( \pi_{1r}^{b}(w_{1b}) \) and \( \pi_{2r}^{b}(w_{2b}) \), and find the first derivative of \( w_{1b} \) and \( w_{2b} \), respectively, yields \( w_{1b}^{*} \) and \( w_{2b}^{*} \):

\[ w_{1b}^{*} = \frac{1}{4} (3c_{1}(1 + r_{b} + s_{1b}) + c_{2}(s_{2b} + 1 - g_{2b} t)(1 + r_{b})) + 10k(h_{2} - h_{1}) - g_{2b} b t \]  

(30)

\[ w_{2b}^{*} = \frac{1}{2} (c_{1}(1 + r_{b} + s_{1b}) + c_{2}(s_{2b} + 1 - g_{2b} t)(1 + r_{b})) + 6k(h_{2} - h_{1}) + g_{2b} b t \]  

(31)

3) Stage 2: Township Enterprises 2 Determine Optimal Product Green Degree

In this decision-making process, the township enterprises 2 in order to seize the market and maximize their own profit, thus determining the optimal product green degree.

For product 2 with high greenness, the profit function of township enterprise 2 is:

\[ \pi_{2r}^{b}(g_{2b}) = w_{2b} - (1 - g_{2b})c_{2}q_{2b} + \frac{1}{2} g_{2b}^{2}(1 + r_{b}) - c_{2}q_{2b} s_{2b} \]  

(32)

Substituting \( p_{1b}^{*} \) and \( p_{2b}^{*} \), \( q_{1b}^{*} \) and \( q_{2b}^{*} \), \( w_{1b}^{*} \) and \( w_{2b}^{*} \) into \( \pi_{2r}^{b}(g_{2b}) \), and find the first derivative of \( g_{2b} \), yields \( g_{2b}^{*} \).
Because the formula is too complex, this paper substitutes the values of non-critical parameters: order $r_b = 0.06$, $c_1 = 2$, $c_2 = 3$, $h_1 = 0$, $h_2 = 1$, $U_0 = 4$.

$$g_{2b} = \frac{209 \times 300 k + 100 s_{1b} - 150 s_{2b} - 53}{42400 k - 43681 t^2}$$ (33)

The constraint condition is that the second derivative is less than 0.

$$\frac{\partial^2 \pi_{1G}(g_{2b})}{\partial^2 g_{2b}} = \frac{43681 t^2}{40000 k} - \frac{53}{50} < 0$$ (34)

4) Stage 1: the two local governments determine the optimal external impact coefficient on township enterprises

In this decision-making, the local government adopts financial means such as taxation to the township enterprises, which has an external impact on the enterprises under its jurisdiction and maximizes its own revenue. Similarly, when the local government makes decisions, it only pays attention to the profit of the enterprises under its jurisdiction and does not take the utility of consumers as its decision-making basis.

For low greenness product 1, the profit function for government 1 is:

$$\pi_{1b}(s_{1b}) = \pi_{1e} + \pi_{1r} + c_1 q_{1b} s_{1b}$$ (35)

For product 2 with high greenness, the profit function of government 2 is:

$$\pi_{2c}(s_{2b}) = \pi_{2e} + \pi_{2r} + c_2 q_{2b} s_{2b}$$ (36)

Substituting $p_{1b}^*$ and $p_{2b}^*$, $q_{1b}$ and $q_{2b}$, $w_{1b}^*$ and $w_{2b}^*$, $g_{2b}^*$ into $\pi_{1G}(s_{1b})$ and $\pi_{2G}(s_{2b})$, and find the first derivative of $s_{1b}$ and $s_{2b}$, respectively, yields $s_{1b}^*$ and $s_{2b}^*$.

$$s_{1b}^* = \frac{[505620000 k^2 - 2778111600 k t^2 + 44663100 k + 381605922 t^1 - 122699929 t^2]/[15900 (21200 k - 43681 t^2)]}{1}$$ (37)

$$s_{2b}^* = \frac{[168540000 k^2 - 1620565100 k t^2 - 14887700 k + 1908029761 t^4 + 122699929 t^2]/[23850 (21200 k - 43681 t^2)]}{1}$$ (38)

The constraint condition is that the second derivative is less than 0.

$$\frac{\partial^2 \pi_{1G}(s_{1b})}{\partial^2 s_{1b}} = -\frac{233200 (2650 k - 3971 t^2)}{(42400 k - 43681 t^2)^2} < 0$$ (39)

$$\frac{\partial^2 \pi_{2G}(s_{2b})}{\partial^2 s_{2b}} = -\frac{35775 (21200 k - 43681 t^2)}{242 (2650 k - 3971 t^2)^2} < 0$$ (40)

Then the resulting generations $s_{1b}^*$ and $s_{2b}^*$ are returned to $p_{1b}^*$ and $p_{2b}^*$, $q_{1b}$ and $q_{2b}$, $w_{1b}^*$ and $w_{2b}^*$, $g_{2b}^*$. The optimal equilibrium of the four-stage Stackelberg game involving three parties under the bank lending model is obtained.

C. E-COMMERCE LENDING MODEL

1) Stage 4: Two e-commerce platforms select their respective optimal retail prices

When a township enterprise borrows money from a small lending company set up by the e-commerce platform, the cost of setting up the capital of the e-commerce small lending company is $r_b$. Therefore, the profit function of the e-commerce platform can be expressed as:

For product 1 with low greenness, the profit function of e-commerce platform 1:

$$\pi_{1c}(p_{1c}) = (p_{1c} - w_{1c} + c_1 (r_e - r_b)) q_{1c}$$ (41)

Profit function of e-commerce platform 2 for high-green product market 2:

$$\pi_{2c}(p_{2c}) = (p_{2c} - w_{2c}) g_{2c} + ((1 - t g_{2c}) c_2 q_{2c} + \frac{1}{2} g_{2c}^2) (r_e - r_b)$$ (42)

For $p_{1c}^*$ and $p_{2c}^*$, obtaining the first derivative of $p_{1c}$ and $p_{2c}$ separately, obtained $p_{1c}^*$ and $p_{2c}^*$.

$$p_{1c}^* = \frac{1}{4} (3 w_{1c} + w_{2c} + 2 k (h_2 - h_1) + 3 c_1 (r_e - r_b)) + c_2 (1 - g_{2c} t) (r_b - r_e) - g_{2c} t$$ (43)

$$p_{2c}^* = \frac{1}{2} (w_{1c} + w_{2c} + 2 k (h_2 - h_1) + c_1 (r_e - r_b)) + c_2 (1 - g_{2c} t) (r_b - r_e) + g_{2c} t$$ (44)

Substituting $p_{1c}^*$ and $p_{2c}^*$ into equation (4) to obtain $q_{1c}^*$ and $q_{2c}^*$.

$$q_{1c}^* = \frac{1}{4} (h_2 - h_1) (w_{2c} - w_{1c} + 2 k (h_2 - h_1) - c_1 (r_b - r_e)) + c_2 (1 - g_{2c} t) (r_b - r_e) - g_{2c} t$$ (45)

$$q_{2c}^* = \frac{1}{4} (h_2 - h_1) (w_{1c} - w_{2c} + 2 k (h_2 - h_1) + c_1 (r_b - r_e)) - c_2 (1 - g_{2c} t) (r_b - r_e) + g_{2c} t$$ (46)

2) Stage 3: Two Township Enterprises Choose Their Optimal Wholesale Prices

For product 1 with low greenness, the profit function of township enterprise 1 is:

$$\pi_{1r}(w_{1c}) = (w_{1c} - c_1 (1 + r_e)) q_{1c} - c_1 q_{1c} s_{1c}$$ (47)

For product 2 with high greenness, the profit function of township enterprise 2 is:

$$\pi_{2r}(w_{2c}) = w_{2c} g_{2c} - ((1 - t g_{2c}) c_2 q_{2c} + \frac{1}{2} g_{2c}^2) (1 + r_e) - c_2 g_{2c} s_{2c}$$ (48)
Substituting $p^*_1$ and $p^*_2$, $q^*_1$ and $q^*_2$, into $\pi_1 e^c(w_{1e})$ and $\pi_2 e^c(w_{2e})$, and find the first derivative of $w_{1e}$ and $w_{2e}$, respectively, yields $w^*_{1e}$ and $w^*_{2e}$.

\[
w^*_{1e} = \frac{1}{4} (c_1 (3 + 3s_{1e} + 4r_e - r_b) + c_2 (s_{2e} + (1 - g_{2e})(1 + r_b)) + 10k (h_2 - h_1) - g_{2e} t) \tag{49}
\]

\[
w^*_{2e} = \frac{1}{2} (c_1 (1 + r_b + s_{1e}) + c_2 (s_{2e} + (1 - g_{2e})(1 - r_b + 2r_b)) + 6k (h_2 - h_1) + g_{2e} t) \tag{50}
\]

At this time, $k > 0$, $h_2 > h_1$ satisfy the second derivative is less than 0.

3) Stage 2: Township Enterprises 2 Determine Optimal Product Green Degree

In this decision-making process, the township enterprises 2, in order to maximize its own utility, optimizes the green degree of its own products. For product 2 with high greenness, the profit function of township enterprises 2 is:

\[
\pi_{2e}^c (g_{2e}) = w_{2e} q_{2e} - [(1 - t g_{2e}) c_2 q_{2e} + \frac{1}{2} g_{2e}^2 (1 + r_e) - c_2 g_{2e} s_{2e}] \tag{51}
\]

Substituting $p^*_1$ and $p^*_2$, $q^*_1$ and $q^*_2$, $w^*_{1e}$ and $w^*_{2e}$ into $\pi_{2e}^c (w_{2e})$, and find the first derivative of $g_{2e}$ yields $g_{2e}^*$. Because the formula is too complex, this paper substitutes the values of non-critical parameters. order $r_b = 0.06, c_1 = 2, c_2 = 3, h_1 = 0, h_2 = 1, U_0 = 4$

\[
g^*_{2e} = \frac{209 t (300 k + 100 s_{1e} - 150 s_{2e} - 53)}{-43681 t^2 + 40000 k (1 + r_e)} \tag{52}
\]

Conclusion 1: It can be seen from Equation (13)(33)(52) that, regardless of the lending model, the product green degree is positively correlated with the externality impact coefficient of local government 1 on township enterprises 1, and negatively correlated with the externality impact coefficient of local government 2 on township enterprises 2. That is, the green degree of the green products produced by the township enterprises 2 under the jurisdiction of the positive strategy local government 2 increases as the externalities imposed by the negative strategy local government 1 on the township enterprises 1 increase, and decreases as the externalities imposed by the positive strategy local government 2 on the township enterprises 2 increase.

The constraint condition is that the second derivative is less than 0.

\[
\frac{\partial^2 \pi_{2e}^c (g_{2e})}{\partial g_{2e}^2} = -\frac{43681 t^2 + 400000 k (1 + r_e)}{40000 k} < 0 \tag{53}
\]

4) Stage 1: the two local governments determine the optimal external impact coefficient on township enterprises

In this decision-making, the local government adopts financial means such as taxation to the township enterprises, which has an external impact on the enterprises under its jurisdiction and maximizes its own revenue. When local governments make decisions, they only pay attention to the profit of the enterprises under their jurisdiction, and do not take consumer utility as the basis of their own decisions.

For low greenness product 1, the profit function for government 1 is:

\[
\pi_{1e}^c (s_{1e}) = \pi_{1e}^c + \pi_{1r} e^c + c_1 q_{1e}s_{1e} \tag{54}
\]

For product 2 with high greenness, the profit function of government 2 is:

\[
\pi_{2e}^c (s_{2e}) = \pi_{2e}^c + \pi_{2r} e^c + c_2 q_{2e}s_{2e} \tag{55}
\]

By substituting $p^*_1$ and $p^*_2$, $q^*_1$ and $q^*_2$, $w^*_{1e}$ and $w^*_{2e}$, $g^*_{2e}$ into $\pi_{1e}^c (s_{1e})$ and $\pi_{2e}^c (s_{2e})$, and deriving $s_{1e}, s_{2e}$ from the optimization, we can obtain $s^*_{1e}$ and $s^*_{2e}$.

\[
s^*_{1e} = [(22500000000 r_e^3 + 67500000000 r_e^2 + 67500000000 r_e + 2250000000000 r_e^2 + 1638037500000 r_e^2 t^2 + 59625000000 r_e^2 t - 292881105000 r_e t^2 + 59625000000 r_e - 120773550000 t^2 + 198750000000 k - 57877325000 r_e^2 t^2 + 28620446150 r_e t^4 - 115754650000 r_e t^2 + 18507888617 t^4 - 57877325000 t^2] / ([1500000000 r_e^3 + 45000000000 r_e^2 t^2 + 45000000000 r_e + 15000000000 k - 43681000000 r_e t^2 - 32105350000 t^2] \tag{56}
\]

\[
s^*_{2e} = [(7500000000 r_e^3 + 225000000000 r_e^2 + 225000000000 r_e + 750000000000 r_e^2 + 141963250000 r_e^2 t^2 - 19875000000 r_e^2 t - 214473710000 r_e t^2 - 18507888617 t^4 + 25000000000000 k + 115754650000000 r_e^2 t^2 + 19080298761000 r_e t^4 + 17015933550 r_e t^2 + 89677398767 t^4 + 5440465500 t^2] / ([22500000000 r_e^3 + 67500000000 r_e + 675000000000 r_e + 22500000000000 r_e^2 + 655215000000 r_e^2 t^2 - 113679825000 r_e t^2 - 481583025000 t^2] \tag{57}
\]

Conclusion 2: Judging from the complexity of the optimal solution of the local government’s externality coefficient, the order from big to small is: e-commerce lending model, bank lending model and traditional retail model. It shows that with the transfer of product sales role from township enterprises to e-commerce, and the transfer of lending objects of township enterprises from banks to e-commerce, the local government’s management of enterprises under its jurisdiction is gradually complicated. The practical enlightenment is that with the development of technology, local governments need to keep pace with the times and manage the market in a refined way. Secondly, whether the e-commerce platform
should assume the role of capital supplier of township enterprises is still a problem to be discussed, because it brings higher costs to the management of local governments.

The constraint condition is that the second derivative is less than 0.

\[
\frac{\partial^2 \pi_G^e(s_{1e})}{\partial s_{1e}^2} = \frac{220000 (r_e + 1) (-3971 t^2 + 2500 k (r_e + 1))}{(43681 t^2 - 40000 k (r_e + 1))^2} < 0
\]  \hspace{1cm} (58)

\[
\frac{\partial^2 \pi_G^e(s_{2e})}{\partial s_{2e}^2} = \left[-225 (300000 k r_e^2 - 8736200 r_e t^2 + 600000 k r_e - 6421107 t^2 + 3000000 k)]/[242 (-3971 t^2 + 2500 k + 2500 k r_e)^2\right] < 0
\]  \hspace{1cm} (59)

Then the resulting generations \( s_{1e}^* \) and \( s_{2e}^* \) are returned to \( p_{1e}^* \) and \( p_{2e}^* \), \( q_{1e}^* \) and \( q_{2e}^* \), \( w_{1e}^* \) and \( w_{2e}^* \), \( g_{1e}^* \). The optimal equilibrium of the four-stage Stackelberg game involving three parties under the bank lending model is obtained.

### IV. NUMERICAL ANALYSIS

Considering the complexity of the formulas listed, Matlab software is used as a calculation tool to solve each formula. This paper conducts a numerical analysis on the changes and impacts of the payment coefficient of consumers' environmental preferences \( k \), the subsidy rate \( t \) determined by the central government and the loan interest rate \( r_e \), set by the e-commerce platform, in order to obtain favorable conclusions and provide reference for the decision-making of relevant government departments.

#### A. SELECTION OF CHANNEL MODEL FOR TOWNSHIP ENTERPRISES

Although local governments do not use consumer utility as a basis for decision-making, the central government will use consumer utility as a basis for assessing the promotion of local government officials. Therefore, consumer utility should be added to the profit function when judging the social welfare of local governments. The central government's utility is the total social welfare, which is set as the sum of the total local government benefits of the same product under different models, plus the interest earned on bank loans less the project subsidies paid. This is for the convenience of seeing the changing trend of social welfare of different products.

1) Comparative Analysis on the Impact of Changes in Payment Coefficient of Consumers’ Environmental Preference \( k \):

Through Matlab simulation calculation, we found that the traditional retail model and bank lending model have significant differences in price, demand, corporate income and government welfare when the payment coefficient value of consumers’ environmental preference \( k \) and the subsidy rate \( t \) determined by the central government change, which indicates that \( k \) and \( t \) are the external decision-making factors in the channel selection of township enterprises. In this paper, we fix other parameters and observe the changes of the whole supply chain when the \( k \) value and \( t \) value change. Referring to the actual situation, the values of each parameter are set as follows:

- The values of each parameter are: \( r_e = 0.08, r_0 = 0.06, c_1 = 2, c_2 = 3, h_1 = 0, h_2 = 1, U_0 = 4. \)
- We bring the parameter setting into the constraint conditions and make the product demand \( 0 < q_1 < 1, 0 < q_2 < 1 \), so that the range of \( k \) value with optimal solution is \( k > 0.5 \).

This paper makes \( k = [0.5, 2] \), two cases of \( t = 0.1 \) and \( t = 0.2 \) are discussed respectively.

As shown in Fig. 6, with the increase in the \( k \) value of consumer’s preference payment coefficient, the wholesale \( w \) value of products under the two channel models is on the rise. The wholesale price of online retail model is higher than that of traditional retail model, and the wholesale price of products decreases with the increase of central government subsidy rate \( t \). This shows that consumer support for rural revitalization can positively affect the prices of the two types of products. However, the impact mechanism of consumers’ support for rural revitalization on the product prices of the
two products is different. The increase in consumers’ support for rural revitalization products increases the effectiveness of consumers’ purchase of rural revitalization products, which in turn increases the selling price of rural revitalization products. However, the increase in the selling price of high-level rural revitalization products will also promote the selling price of low-level rural revitalization products due to the price spillover effect. In fact, the participation of the e-commerce platform will enable the township enterprises to further improve the greenness and price of commodities and increase the utility of consumers (through product promotion, information collection, data processing, etc.).

As shown in fig. 7, with the increase in the payment coefficient $k$ value of consumers’ preference for the rural revitalization environment, the demand $q$ value of product 1 shows a downward trend and the demand value of product 2 shows an upward trend under the two channel models. The decline rate of demand for product 1 in the traditional retail model is higher than the decline rate of demand for product 1 in the online retail model. The demand for product 2 in the online retail model is always higher than the demand for product 2 in the traditional retail model. The demand for product 2 increases with the increase in the subsidy rate $t$ of the central government. This indicates that the participation of the e-commerce platform can effectively increase the sales volume of Product 2.

As shown in fig. 8, with the increase of consumer’s preference payment coefficient $k$ value for rural revitalization environment, the impact coefficient $s$ value of local government on the externalities of township enterprises under the two channel models is on the rise, and the impact coefficient $s$ value under the online retail model is always higher than the $s$ value under the traditional retail model. The $s$ value of the external influence coefficient of Product 2 is always smaller than the $s$ value of Product 1, and the $s$ value decreases as the $t$ value of the central government subsidy rate increases.

As shown in fig. 9, with the increase in the $k$ value of payment coefficient of consumers’ preference for rural revitalization environment, the green value $g$ of township enterprises 2 products under the two channel models is an increasing trend. The $g$ value of Product 2 in the traditional retail mode is always lower than the $g$ value of Product 2 in the online retail mode. The increase in the $t$ value of central government subsidy rate can significantly increase the greenness of products, i.e. the central government subsidy policy for projects is effective.

As shown in Fig 10, with the increase in the $k$ value of payment coefficient of consumers’ preference for rural revitalization environment, the profit of township enterprises under the two channel models is on the rise. The profit of the township enterprise under the network retail model is always higher than that under the traditional retail model. In the online retail model, the intersection $k$ value of the income curves of the two township enterprises is 0.5. In the traditional retail model, the intersection $k$ value of the income curves of the two township enterprises is 1.5. The central
government subsidy rate $t$ has no significant impact on the income of the township enterprises.

As shown in fig. 11, with the increase in the payment coefficient $k$ value of consumers’ preference for rural revitalization environment, the total social welfare of local government 2 shows a rising trend and that of local government 1 shows a declining trend under the two channel models. For local government 1, the total social welfare under the traditional retail model is always higher than that under the online retail model. For local government 2, the total social welfare under the traditional retail model is always lower than that under the online retail model. For local government 1, the total social welfare under the traditional retail model is always lower than that under the online retail model. When the $k$ value of consumer’s environmental preference payment coefficient is less than 0.5, the local government adopts the passive rural revitalization strategy, while the township enterprises do not carry out product innovation, which hinders the transmission mechanism of the central government’s project subsidy policy. When the $k$ value of consumer’s environmental preference payment coefficient is less than 1.5, the local government adopts the passive rural revitalization strategy, while the township enterprises have the incentive to carry out product innovation to obtain subsidies. When the $k$ value of consumer’s environmental preference payment coefficient is greater than 1.7, the local government adopts the active rural revitalization strategy and the township enterprises carry out product innovation. Under the online retail model, when the $k$ value of consumer’s environmental preference payment coefficient is greater than 0.5, the local government adopts the passive rural revitalization strategy and the township enterprises do not carry out product innovation, which hinders the transmission mechanism of the central government’s project subsidy policy. When the $k$ value of consumer’s environmental preference payment coefficient is greater than 1.7, the local government adopts the active rural revitalization strategy and the township enterprises carry out product innovation. The above shows that the online retail model can promote the rural revitalization strategy to develop faster and better.

In fact, in the early stage when the rural revitalization strategy was put forward, the local government’s “inaction” behavior was more prominent, which was in line with the “rational person” hypothesis. However, with the country’s vigorous promotion of rural revitalization, especially after...
the symbolic event of "General Secretary Xi’s live broadcasting with goods", the public has strongly supported the implementation of the rural revitalization strategy. The "in-action" of local governments has been significantly reduced, and many governments in poor areas have benefited from the rural revitalization strategy, thus actively promoting the rural revitalization strategy. For the central government, although the implementation of the rural revitalization strategy will lose its own profit due to project subsidies in the short term, in the long term, with the strong support from the public for the rural revitalization strategy, it will eventually increase the overall social welfare and realize the transformation of social and economic development.

B. TOWNSHIP ENTERPRISE LOAN MODEL SELECTION

This article IV.A has proved that the township enterprises will choose the online retail model for product sales is the best decision for the whole supply chain. So naturally the next question is introduced, which loan model will the township enterprises choose? Through Matlab calculation, it can be found that the difference in expected profit of township enterprises, e-commerce platforms, local governments and central governments among different loan models and the same products has nothing to do with the payment coefficient $k$ value of consumers’ environmental preferences but is related to the loan interest rate of e-commerce platforms, which indicates that the loan interest rate $r_e$ set by e-commerce platforms is the core variable in the decision-making of township enterprises for the selection of loan models for township enterprises. And through calculation, we found that the increase in loan interest rate $r_b$ set by banks will lower the expected profit of township enterprises, e-commerce platform 2, local government 2 and central government 2. In the actual situation, because the banks are lending to rural revitalization products, the central government will generally require the banks to set loan interest rates $r_b$ as low and stable as possible, so this paper only considers the constant loan interest rates $r_b$ set by the banks. Furthermore, as the lending contracts between e-commerce platforms and township enterprises are standardized, the interest rates between them cannot be freely changed in the short term. Therefore, this paper assumes that interest rates are exogenous to explore the impact of changes in e-commerce platform interest rates on each participant’s behavioral decisions.

1) Impact analysis of changes in loan interest rates $r_e$ formulated by e-commerce platforms

Same as IV.A, the values of each parameter are:

$$r_b = 0.06, c_1 = 2, c_2 = 3, h_1 = 0, h_2 = 1, U_0 = 4, k = 2.$$ 

We bring the parameter setting into the constraint conditions, so that the range of $r_e$ value with optimal solution is $r_e > 0$. This paper makes $r_e = [0.04, 0.3]$.

As shown in fig. 13 to fig. 16, relative to the bank lending model, under the e-commerce lending model, with the increase of the loan interest rate $r_e$ set by the e-commerce platform, the retail price and wholesale price of the two types of products and the demand for product 1 are on the rise, and the upward trend is significant with the increase of the central government subsidy rate $t$ value; Among them, the upward trend of wholesale price of products is the most obvious. This shows that although the e-commerce platform increases the set loan interest rate $r_e$ value, the township enterprises can ensure their own profit by increasing the wholesale price of products. While the e-commerce platform cannot significantly increase the retail price of its products due to competition constraints in the product market. However, as the wholesale price of township enterprises continues to rise, the e-commerce platform will eventually increase the retail price of its products because such price increase is not driven by product innovation, and eventually the e-commerce platform 2 will lose part of the market share of the products.

As shown in fig. 17, relative to the bank lending model, under the e-commerce lending model, the greenness of product 2 shows a downward trend with the increase of the loan interest rate $r_e$ set by the e-commerce platform, and the downward marginal trend is significant with the increase of the central government subsidy rate $t$ value.

As shown in fig. 18 to fig. 19, compared with the bank
Figures 15 to 19 illustrate the impact of changes in the loan interest rate $r_e$ on various financial supply chain metrics. These diagrams show how market demand, optimal product green degree, and government external impact coefficients change with different values of $r_e$.

The figures indicate that as the loan interest rate $r_e$ increases, the market demand for products 1 and 2, as well as the optimal product green degree, show a rising trend. This trend is more pronounced for government 1, which has a higher external impact on township enterprises 2.

As shown in figures 20 to 23, compared with the bank lending model, under the e-commerce lending model, with the increase of the loan interest rate $r_e$ set by the e-commerce platform, the externality impact coefficient of the two local governments on the township enterprises shows a rising trend. The rising trend speed of the local government 1 is higher than the rising trend speed of the local government 2. Secondly, the rising marginal tendency is significant with the increase of the subsidy rate $t$ value of the central government.

As shown in fig. 20 to fig. 23, compared with the bank lending model, under the e-commerce lending model, with the increase of the loan interest rate $r_e$ set by the e-commerce platform, the profit of the township enterprise 2 and the e-commerce platform 2 is on the rise, and the profit of the township enterprise 1 and the e-commerce platform 1 will also rise slightly. The reason is that the profit gained by township enterprise 1 due to the price spillover effect is obtained by the local government 1 because there is no central government policy support. Since township enterprises 2 has the policy support of the central government, local governments 2 has a low external impact on township enterprises 2, and the...
income share of local governments is also small. And the profit of the township enterprise 2 and e-commerce platform 2 increases with the increase of policy support from the central government.

As shown in fig. 24 to fig. 25, compared with the bank lending model, under the e-commerce lending model, with the increase of the loan interest rate \( r_e \) set by the e-commerce platform, the total social welfare of local government 1 is on the rise, while the total social welfare of local government 2 is on the decline. Secondly, the significance of the trend increases with the increase of central government subsidy rate \( t \).

As shown in fig. 26, the central government’s total social welfare has nothing to do with the loan interest rate \( r_e \) set by the e-commerce platform, but the central government’s total social welfare decreases as the central government’s subsidy rate \( t \) value increases.

To sum up, the analysis shows that the total social welfare trend of the local government 2 and the enterprises under its jurisdiction is opposite, because in the e-commerce lending model, as the \( r_e \) value increases, the green degree of the products decreases while the price increases, encroaching on the consumer’s utility. This shows that in the process of the central government promoting the rural revitalization strategy, if the loan interest rate set by the e-commerce platform is too high, it will be beneficial to the township enterprises and e-commerce platform and harmful to consumers. In particular, the stronger the central government’s policy is, the more remarkable the effect will be. This is because in the process of rural revitalization strategy, the government’s guiding role to the public will be exploited by others. The practical significance of this is that the central government should not only control the loan interest rate set by banks, but also control the loan interest rate set by e-commerce platform, while promoting the rural revitalization strategy. If the central government only controls the loan interest rate set by the bank and does not control the loan interest rate set by e-commerce platform, the central government will fall into a bad situation. It clearly vigorously promotes the Rural Revitalization Strategy, and the people also trust the central government promoting the rural revitalization strategy more.
product greenness has decreased, which is contrary to the original intention of the policy implemented by the central government.

V. CONCLUSION

In this paper, a four-stage three-player game model is established among local governments, township enterprises and e-commerce platforms, taking into account the central government subsidies, the external influence of local governments on the enterprises under their jurisdiction, the green level of products, product competition, consumer preferences and other factors. Through further detailed analysis of examples, the following conclusions are drawn:

(1) For the Central Government: in the implementation of the Rural Revitalization Strategy, first of all, we should strive to cultivate and improve consumers’ support for the Rural Revitalization Strategy, which may be "thankless" in the short term, but it is a long-term plan to make all parties win-win. Secondly, the central government can organize to set up special e-commerce platforms to sell high-green products. Finally, while promoting the rural revitalization strategy, the central government should not only control the loan interest rate set by banks, but also control the loan interest rate set by e-commerce.

(2) For the local government, when the consumer’s preference coefficient $k$ value is low, the local government adopting the passive rural revitalization management strategy has higher profit than the local government adopting the active rural revitalization strategy. However, as the $k$ value and $t$ value increases, the situation will reverse. This is because the local government adopting the passive rural revitalization management strategy obtains more benefits from the township enterprises through external influence, while the local government adopting the active rural revitalization strategy obtains long-term stable benefits by cultivating enterprises through policies. Therefore, for the local government, the passive rural revitalization management strategy is beneficial in the short term but harmful in the long term, while the active rural revitalization strategy is ineffective in the short term but beneficial in the long term.

(3) For the e-commerce platform, it is necessary to control the loan interest rate set for township enterprises. Although in the short term, the act of raising the loan interest rate can bring benefits to itself, it is an act that damages the interests of consumers. In the short term, it can get benefits because of the policy support of the central government, but in the long run, it is digging its own grave and is not allowed by the market and the government.

(4) For township enterprises: first, choose the online retail model; this can not only improve the product’s greenness, but also improve its own profit, and expand its product sales volume by enabling e-commerce and providing credit. Secondly, do not infringe upon the interests of consumers; although the profit of the township enterprise increases with the increase in the value of loan interest rate $r_c$, set by the e-commerce platform, there is still the problem of negotiation...
right in the actual process. Township enterprises may not be able to profit from the increase in $r_e$ value. And because of the increase in $r_e$ value, township enterprises choose to reduce the green degree of their products in order to reduce the cost of loans. This is a "drain the pond to catch all the fish", which is not desirable in the long run because consumers are rational and cannot be fooled for a long time.

It should be noted that this model assumes that all parties in the game are under the condition of complete information and complete rationality. Therefore, this paper can only explain the local government and the market in the transition economy-taking the formation and development of yiwu market as an example. "Journal of committee of cpc zhejiang provincial committee Party School, no. 02, pp. 54–59, 2006.

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NAN XIE received the Ph.D. degree in management science and engineering from Central South University. She is currently a Associate Professor of Economics with the Business School, Hunan Normal University. She is broadly interested in financial engineering and risk management, behavioral finance, supply chain finance and Financial game model. Her current research lies at the sustainable development of rural revitalization. She is working on strategy of supply chain financial based on government project subsidy analysis.

HAITAO HE received the M.S. degree in management from Shaoyang University, Shaoyang, China, in 2018. He is recently working towards Master of Finance with Hunan Normal University, Changsha, China. His research interests include Supply chain finance, Internet finance and game theory.

YEZI TONG received the Bachelor of Economics from Hunan Agriculture University, Changsha City, China, in 2021. She is recently working towards Master of Finance with Hunan Normal University, Changsha City, China. Her research interests include Behavioral finance, Financial risk and Financial game model. She is good at English, especially in financial English. She has successfully passed CFA Level I.