An Examination of the Tripartite Game Model in E-commerce Channels with Consideration of Rent-Seeking Behavior

Xin Liu, Zhen Xu*, Qingxia Zhang, Liang Zhou

Abstract—**In the process of e-commerce channel cooperation, a principal–agent relationship exists between manufacturers and retailers. The behavior of retailers cannot be fully observed, leading to the possibility of rent-seeking behavior. This rent-seeking behavior in e-commerce has resulted in serious resource waste and loss of benefits. This study, based on game theory and the principal–agent problem, establishes a three-party game model involving manufacturers, retailers, and rent-seekers under risk neutrality. By solving the Nash equilibrium, the three-party game model explores the influencing factors of rent-seeking behavior in e-commerce channels. According to the results of the game model, governance and prevention measures for rent-seeking behavior are provided.**

Index Terms—**E-commerce channel, Rent-seeking behavior, Principal–agent, Game theory**

I. Introduction

Owing to the emergence and growth of technology[1], the digital economy has promoted the continuous expansion of e-commerce. Various e-commerce platforms have emerged and grown. In this context, E-commerce platforms represent another type of supply chain channel nurtured in this context: manufacturers produce goods and retailers sell on e-commerce platforms. Compared with traditional marketing models, e-commerce platforms can significantly reduce lost sales and the costs of conventional plans [2] while providing more transaction channels for consumers and manufacturers. This promotes the transformation of business models and consumer habits [3] and fosters the development of the logistics and supply chain industry.

As the goods produced by the manufacturer are sold to consumers through retailers, therefore,retailers can communicate directly with consumers through sales and quickly and accurately grasp market information. However, manufacturers can only improve the goods based on the information fed back by retailers. Therefore, the behavior of retailers cannot be fully observed, giving them an information advantage [2]. This establishes a principal–agent relationship in the channel. In this relationship,the retailer with the information advantage is the agent, and the manufacturer with the information disadvantage is the principal. To maximize their own interests, retailers may use their information advantage to generate rent-seeking motives, causing damage to the interests of manufacturers [4].

"Rent-seeking" refers to "seeking direct, nonproductive profit" [5]. The concept of rent-seeking was first proposed by American economist Krueger [6] in his study "Political Economy of Rent-Seeking Society." Subsequently, rent-seeking theory has been widely used to describe and explain transaction behaviors in nonproductive fields, particularly social phenomena related to privileges and corruption [7]. Baland, J.M. et al. [8] introduced the rent-seeking model into the opportunity cost research of giving up entrepreneurial spirit, finding that resource prosperity often increases in rent-seeking activities and promotes the emergence of the entrepreneurial spirit. Boldrin, M. et al. [9] reported that public and private rent-seeking behavior plays a vital role in determining the social utility of innovation. Hodler, R. [10] found that rent-seeking behavior may indeed be a major determinant of aid effectiveness. Luis, C. [11] reported that under autocratic rule, rent-seeking reflects the dictator's preference for such activities, and under parliamentary rule, rent-seeking depends on parliamentary voting. Choi, S.G. et al. [12] discussed from a cultural perspective how culture affects the nature and level of rent-seeking pursued by society and whether institutional changes will strengthen or undermine rent-seeking behavior. Chen Yijin [13] conducted further research on rent-setting and rent-seeking behaviors, finding that they are two aspects of a process, and if the right-holder participates in the entire process, then these two aspects always play a role. He Wei [14] conducted an analysis of rent-seeking behavior from the perspective of political economy. By making innovations based on Western economic theory, he managed to successfully construct an analytical framework that is applicable to the rent-seeking issues in China's transitional period. He also established a corresponding theoretical system, interpreted novel domestic phenomena, and furnished solid theoretical support and

Manuscript received September 10, 2024; revised June 22, 2025.

This work was supported in part by the Youth Science Foundation of the Sichuan Provincial Department of Science and Technology under Grant No. 2022NSFSC.

Xin Liu is a postgraduate student at the College of Science, Southwest Petroleum University, Chengdu, China (e-mail: 18108047386@163.com).

Zhen Xu is a doctoral student at the Graduate School of Information, Production and Systems, Waseda University, Kitakyushu, Japan (e-mail: davidxu@asagi.waseda.jp).

Qingxia Zhang is a professor at the College of Science, Southwest Petroleum University, Chengdu, China (e-mail: zqx121981@126.com).

Liang Zhou is a postgraduate student at Southwest Petroleum University, Chengdu, China (e-mail: zhouliangu@126.com).

guidance for the construction of China's socialist market economic system.and developed a rent-seeking theory suitable for our country. Zheng Changde et al. [15] analyzed the reasons for the agent's participation in rent-seeking behavior in the principal–agent relationship in enterprises from the perspective of game theory and proposed methods to prevent rent-seeking behavior. Li Yueheng [16] established a game relationship between rent-seeking behavior between universities and teachers and proposed policy recommendations for governance. Li Baiyan [17] established an evolutionary game model of the project quality responsible team and the external regulatory body from the perspective of project quality to study the rent-seeking behavior in project quality supervision. Zeng Xiping et al. [18] analyzed the possible rent-seeking behaviors in the process of government procurement in universities based on its characteristics and proposed countermeasures according to the analysis results. Wang Binghong [19] analyzed various rent-seeking behaviors, causes, and costs involved in the supply of affordable housing in Nanjing. Zhang Jiahong [20] studied rent-seeking behavior from the perspective of price monopoly behavior and proposed regulatory suggestions in areas such as the legal system, competitive environment, information disclosure, and punishment measures. Wang Xiaoyu [21] conducted research on rent-seeking behavior at different stages based on the characteristics of project bidding. Yang Jing [22] started from the perspective of the entire cycle of affordable housing, identified whether there is rent-seeking behavior during this stage, and analyzed the performance of rent-seeking at each stage, thereby defining the subject of rent-seeking behavior at this stage. Song Hongru [23] built a model to analyze the impact of government subsidies, corporate innovation, and political rent-seeking on investors' investment decisions based on theoretical research. Xu Dongsheng et al. [24] combined the agency problem in venture capital with rent-seeking theory, established a game model that includes monitoring and rent-seeking items, and solved the equilibrium result of the game model as (supervision, no rent-seeking). Scholars have conducted in-depth research on rent-seeking problems in engineering projects, universities, housing, etc.[[25]-[30]]. However, in real-world circumstances[31], few scholars have conducted research on rent-seeking behavior in e-commerce channels.

In e-commerce channels, rent-seeking behavior may manifest in the following forms: (1) using the rules or loopholes of the platform to conduct false transactions, order - manipulation, review - manipulation, etc., and obtaining improper benefits to improve their own sales or reputation, damaging the interests of other retailers or consumers; (2) using the data or resources of the platform to engage in unfair competition or cooperation, obtaining unfair advantages or profits, damaging the fairness of the platform; and (3) using the influence or status of the platform to perform unreasonable charges, revenue sharing, promotions, etc., obtaining excessive income or returns and damaging the sustainable development of the platform. Herein, we discuss these areas[32]. This study conducts in-depth research on the second type of rent-seeking behavior in e-commerce channels; establishes a three-party game model involving manufacturers, retailers, and rent-seekers; and solves it. Finally, based on the conclusions, this study proposes suggestions for governance and prevention of rent-seeking behavior in the principal–agent model relationship within e-commerce channels.

II. Model Assumptions and Description

In real-world decision-making[32], the members of the e-commerce channel consist of a manufacturer, a retailer, and a rent-seeker. The manufacturer only produces one type of product, while retailer only sells one type of product, and the rent-seeker only conducts rent-seeking activities with this retailer. The rent-seeking activities between the retailer and the rent-seeker, as well as the manufacturer's supervision of these activities, constitute a three-party game. In this game, the manufacturer wholesales the goods to the retailer, and the retailer sells the goods. In this process, the retailer can grasp the basic information of the goods and obtain the preferences and feedback of consumers on the goods. The retailer can then sell the private information to the rent-seeker to conduct rent-seeking activities. For the sake of simplicity, but without loss of generality[34], this study first makes the following parameter settings and basic assumptions to better analyze and study the game model.

We assume that the market sales volume of the product is as follows:

$$Q = A - bP + Ke + \varepsilon,$$

Where P is the market sales price of the product, A is the market saturation point, K is the e-commerce efficiency coefficient, and ε is the random market factor. Additionally, $\varepsilon \sim N(0, \sigma^2)$. $b(b > 0)$ is the proportionality coefficient, e is the effort made by the retailer to sell the product, and the cost function of the retailer's effort is $c(e) = e^2$. The unit cost paid by the manufacturer to produce the goods is W, and the wholesale price set is C_1, satisfying $C_1 < W < P$. Therefore, the retailer's marginal profit is $P - W$. The retailer sells the private information they have acquired to the rent-seeker at a price of I. After obtaining the retailer's private information, the rent-seeker improves and manufactures the goods. The manufacturing unit cost isC_2, and the wholesale price is Y, satisfying $C_2 < Y < P$. Therefore, the retailer's marginal profit is $P - Y$. Assume that the retailer's preference for purchasing goods from the manufacturer is λ, and the preference for purchasing goods from the rent-seeker is $1 - \lambda$. After the retailer purchases goods from both sources, they will sell the goods at the same price, with the same level of effort, and incur the same cost of effort.

The basic assumptions of the three-party game model in the e-commerce channel are as follows:

(1) The manufacturer has two strategies to choose from, namely, supervision and nonsupervision, with the cost of supervision being S. The probability of the manufacturer's supervision is P_m; the probability of the manufacturer's successful supervision is P_v. If the supervision is successful,

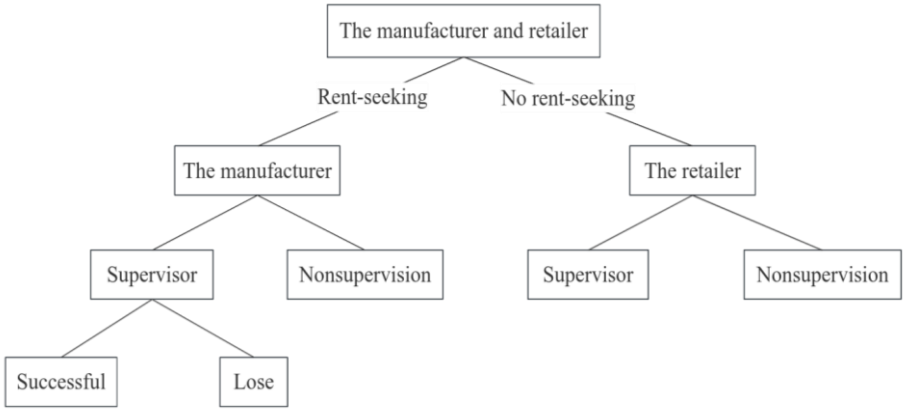

Fig. 1: Rent-seeking game process diagram

the manufacturer will collect N times the retailer's profit as a fine and M times the rent-seeker's profit as a fine.

(2) The retailer and the rent-seeker have two strategies to choose from, namely, rent-seeking and nonrent-seeking, and the rent-seeker has a fixed source of income α. The probability of both parties seeking rent is P_r. In the rent-seeking activity, the rent obtained by the retailer is I, and the cost paid by the rent-seeker is I.

(3) If the retailer and the rent-seeker do not engage in rent-seeking activities, and the manufacturer does not supervise, the payments of the three parties are calculated as follows:

$(P-W)Q-e^2$、α、$(W-C_1)Q$.

(4) If the retailer and the rent-seeker do not engage in rent-seeking activities and the manufacturer conducts supervision, the payments of the retailer, the rent-seeker, and the manufacturer are calculated as follows:

$(P-W)Q-e^2$、α、$(W-C_1)Q-S$.

(5) If the retailer and the rent-seeker engage in rent-seeking activities and the manufacturer does not supervise, the payments of the retailer, the rent-seeker, and the manufacturer are calculated as follows:

$\lambda(P-W)Q+(1-\lambda)(P-Y)Q+I-e^2$ 、 $(1-2\lambda)(Y-C_2)Q+\alpha-I$、$(2\lambda-1)(W-C_1)Q$.

(6) If the retailer and the rent-seeker engage in rent-seeking activities, and the manufacturer conducts supervision but fails, the payments of the retailer, the rent-seeker, and the manufacturer are calculated as follows:

$$\lambda(P-W)Q+(1-\lambda)(P-Y)Q+I-e^2$$
$$(1-2\lambda)(Y-C_2)Q+\alpha-I$$
$$(2\lambda-1)(W-C_1)Q-S$$

(7) If the retailer and the rent-seeker engage in rent-seeking activities, and the manufacturer conducts supervision and succeeds, the payments of the retailer, the rent-seeker, and the manufacturer are calculated as follows:

$$(1-N)[\lambda(P-W)Q+(1-\lambda)(P-Y)Q+I-e^2]$$
$$(1-M)[(1-2\lambda)(Y-C_2)Q-I]+\alpha$$
$$N[\lambda(P-W)Q+(1-\lambda)(P-Y)Q+I-e^2]+M[(1-2\lambda)(Y-C_2)Q-I]+(2\lambda-1)(W-C_1)Q-S$$

Based on the above assumptions, draw a diagram of the rent-seeking game process between the retailer, the rent-seeker, and the manufacturer as shown above[35].

Hence, the three-party game model of the retailer, the rent-seeker, and the manufacturer is shown in Fig. 1.

III. Model Solution

Case 1: When the retailer and the rent-seeker engage in rent-seeking activities with a probability of P_r, the expected profits of the manufacturer when supervising and not supervising are calculated as follows:

$$\pi_1=P_r\left\{\begin{array}{l}P_v\left\{\begin{array}{l}N\left[\lambda(P-W)Q+(1-\lambda)(P-Y)Q+I-e^2\right]+\\M[(1-2\lambda)(Y-C_2)Q-I]+(2\lambda-1)(W-C_1)Q-S\end{array}\right\}\\+(1-P_v)[(2\lambda-1)(W-C_1)Q-S]\end{array}\right\}$$
$$+(1-P_r)[(W-C_1)Q-S]$$

Assume $P_vN[\lambda(P-W)Q+(1-\lambda)(P-Y)Q+I-e^2]+P_vM[(1-2\lambda)(Y-C_2)Q-I]=X$.

$$\pi_1=P_rX+P_rP_v[(2\lambda-1)(W-C_1)Q-S]+(1-P_r)[(W-C_1)Q-S]-P_rP_v[(2\lambda-1)(W-C_1)Q-S]+(1-P_r)[(W-C_1)Q-S]$$
$$\pi_1=P_rX+[P_r(2\lambda-2)+1][(W-C_1)Q]-S \quad (1)$$
$$\pi_2=P_r[(2\lambda-2)+1][(W-C_1)Q] \quad (2)$$

When the expected economic profits of the manufacturer are equal whether it supervise or not, we can obtain the optimal rent-seeking probabilities of the retailer and the rent-seeker at the game equilibrium.

$$\pi_1=\pi_2\rightarrow P_rX+[P_r(2\lambda-2)+1][(W-C_1)Q]-S=P_r[(2\lambda-2)+1][(W-C_1)Q]$$
$$P_rX=S\rightarrow P_r=\frac{S}{X}$$
$$=\frac{S}{P_vN[\lambda(P-W)Q+(1-\lambda)(P-Y)Q+I-e^2]+P_vM[(1-2\lambda)(Y-C_2)Q-I]} \quad (3)$$

The optimal rent-seeking probability of the retailer and the rent-seeker is related to $S,P_v,N,M,\lambda,Q,Y,W,P,C_2,I,e^2$. P_r is positively proportional to S,e^2 and inversely proportional to P_v,N,M,Q,I. When $Y-W>\frac{2M(Y-C_2)}{N}$, P_r is inversely proportional to λ, and when $Y-W<\frac{2M(Y-C_2)}{N}$, P_r is positively proportional to λ.

Case 2: When the manufacturer conducts supervision actions with a probability of P_m, the expected profits of the

retailer when engaging in rent-seeking activities and normal work are calculated as follows:

$$\pi_3 = P_m \begin{Bmatrix} P_v(1-N)\left[\lambda(P-W)Q+(1-\lambda)(P-Y)Q+I-e^2\right] \\ +(1-P_v)[\lambda(P-W)Q+[(1-\lambda)(P-Y)Q+I-e^2] \end{Bmatrix} +(1-P_m)[(1-\lambda)(P-Y)Q+I-e^2]$$

Assume $\lambda(P-W)Q+(1-\lambda)(P-Y)Q+I-e^2=Z$

$$\pi_3 = Z - P_m P_v ZN = [\lambda(P-W)Q+(1-\lambda)(P-Y)Q+I-e^2] - P_m P_v N[\lambda(P-W)Q+(1-\lambda)(P-Y)Q+I-e^2] \quad (4)$$

$$\pi_4 = P_m\left\{P_v\left[(P-W)Q-e^2\right]+(1-P_v)\left[(P-W)Q-e^2\right]\right\} +(1-P_m)\left[(P-W)Q-e^2\right] = (P-W)Q-e^2 \quad (5)$$

When the expected profits of the retailer are equal whether they engage in rent-seeking activities or normal work, we can obtain the optimal supervision probability of the manufacturer at the game equilibrium.

$$\pi_3 = \pi_4 \rightarrow [\lambda(P-W)Q+(1-\lambda)(P-Y)Q+I-e^2] - P_m P_v N[\lambda(P-W)Q+(1-\lambda)(P-Y)Q+I-e^2] = (P-Y)Q-e^2$$

$$P_m = \frac{(\lambda-1)(Y-W)Q+I}{P_v N[\lambda(P-W)Q+(1-\lambda)(P-Y)Q+I-e^2]} \quad (6)$$

The optimal rent-seeking probability of the manufacturer is related to $P_v, N, \lambda, Q, Y, W, P, I, e^2$. P_m is positively proportional to e^2 and inversely proportional to P_v, N, I, λ, Q.

Case 3: When the manufacturer takes supervisory actions with a probability of P_m, the expected returns of the rent-seeker from rent-seeking activities and normal work are calculated as follows:

$$\pi_5 = P_m \begin{Bmatrix} \{P_v(1-M)\left[(1-2\lambda)(Y-C_2)Q-I\right]+P_v\alpha\} \\ +(1-P_v)[(1-2\lambda)(Y-C_2)Q+\alpha-I] \end{Bmatrix} +(1-P_m)[(1-2\lambda)(Y-C_2)Q+\alpha-I] = -P_m P_v M[(1-2\lambda)(Y-C_2)Q]+P_m P_v MI+(1-2\lambda)(Y-C_2)Q+\alpha-I$$

$$\pi_5 = P_m P_v M[I-(1-2\lambda)(Y-C_2)Q]+(1-2\lambda)(Y-C_2)Q+\alpha-I \quad (7)$$

$$\pi_6 = P_m[P_v\alpha+(1-P_v)\alpha]+(1-P_m)=\alpha \quad (8)$$

In the situation where the expected returns from rent-seeking activities and those from normal work are equal for the rent-seeker, we can obtain the optimal supervision probability of the manufacturer at the game equilibrium.

$$\pi_5 = \pi_6 \rightarrow P_m P_v M[I-(1-2\lambda)(Y-C_2)Q]+(1-2\lambda)(Y-C_2)Q+\alpha-I=\alpha$$

$$P_m = \frac{1}{P_v M} \quad (9)$$

Through the process of solving the model, we can obtain the mixed strategy Nash equilibrium of the three-party game model involving the retailer, the rent-seeker, and the manufacturer as follows:

$$[P_r^* = \frac{S}{P_v N\left[\lambda(P-W)Q+(1-\lambda)(P-Y)Q+I-e^2\right]+P_v M[(1-2\lambda)(Y-C_2)Q-I]},$$

$$P_{m1}^* = \frac{(\lambda-1)(Y-W)Q+I}{P_v N[\lambda(P-W)Q+(1-\lambda)(P-Y)Q+I-e^2]}]$$

or

$$[P_r^* = \frac{S}{P_v N\left[\lambda(P-W)Q+(1-\lambda)(P-Y)Q+I-e^2\right]+P_v M[(1-2\lambda)(Y-C_2)Q-I]},$$

$$P_{m2}^* = \frac{1}{P_v M}]$$

Conclusion 1: The rent-seeking behavior of the retailer and the rent-seeker is influenced by the rent-seeking rent[36], supervision cost, supervision efficiency, penalty coefficient, the retailer's purchasing preference for goods, the retailer's effort cost, and the volume of goods sold.

By solving Case 1, we can obtain the optimal rent-seeking probabilities of the retailer and the rent-seeker at the game equilibrium as follows:

$$P_r^* = \frac{S}{P_v N\left[\lambda(P-W)Q+(1-\lambda)(P-Y)Q+I-e^2\right]+P_v M[(1-2\lambda)(Y-C_2)Q-I]}$$

The game equilibrium indicates that the retailer and the rent-seeker will choose to engage in rent-seeking activities to obtain additional income with a probability of P_r^* as the optimal standard. When the probability of the retailer and the rent-seeker engaging in rent-seeking activities is $P_r > P_r^*$, the manufacturer's optimal strategy is to supervise; when the probability is $P_r < P_r^*$, the manufacturer's optimal strategy is not to supervise; when the probability is $P_r = P_r^*$, the manufacturer's optimal strategy is to randomly choose whether to supervise or not.

The probability P_r^* is directly proportional to the supervision cost S; in other words, a higher supervision cost yields a greater likelihood of rent-seeking activities. This is consistent with most research results, suggesting that supervision cost generally affects rent-seeking activities. Therefore, in real life settings, it is necessary to minimize supervision costs, improve the efficiency of supervision over rent-seeking activities, and reduce the occurrence of rent-seeking behavior [16][24][37][38].

The probability P_r^* is inversely proportional to the supervision efficiency P_v and the penalty coefficients N, M. In other words, a higher supervision efficiency and a greater penalty for rent-seeking activities yield a less likely occurrence of rent-seeking behavior. Therefore, the manufacturer needs to improve its own supervision efficiency over rent-seeking behavior, adopt diversified methods to supervise rent-seeking behavior, make the supervision mechanism more standardized and efficient, and increase the penalty intensity on the basis of effective supervision. Once rent-seeking behavior is discovered, it should not be tolerated, and the retailer and the rent-seeker should be immediately subjected to the penalty system. Only by resolutely and thoroughly implementing the supervision mechanism and penalty mechanism can the possibility of rent-seeking behavior be reduced.

The relationship between the probability P_r^* and the retailer's preference for purchasing goods λ is influenced by the wholesale prices of the manufacturer and the rent-seeker. When $Y-W > \frac{2M(Y-C_2)}{N}$, P_r^* is inversely proportional to the retailer's preference for purchasing goods λ ; when $Y-W < \frac{2M(Y-C_2)}{N}$, P_r^* is directly proportional to the retailer's preference for purchasing goods λ . As0020P_r^* is a parameter that only arises during the rent-seeking process, once rent-seeking behavior occurs, the retailer can choose to wholesale goods from two sources. If the wholesale price of

the rent-seeker is higher than the wholesale price of the manufacturer, the retailer will be more willing to purchase goods from the manufacturer. As the retailer only obtains a temporary benefit, which is not helpful for long-term development, the retailer's willingness to seek rent again will greatly reduce, and the possibility of rent-seeking activities will decrease.

The relationship between the probability P_r^* and the rent-seeking rent I is influenced by the manufacturer's penalty coefficients for the retailer and the rent-seeker. When $N > W$, P_r^* is inversely proportional to the rent-seeking rent I; when $N < W$, P_r^* is directly proportional to the rent-seeking rent I. Therefore, when the retailer's penalty coefficient is greater than the rent-seeker's penalty coefficient, the retailer will be at a disadvantage in this set of rent-seeking activities, receiving greater penalties and bearing greater risks, and the retailer naturally will not choose to seek rent.

The probability P_r^* is inversely proportional to the retailer's effort cost e^2 and the volume of goods sold Q. The more effort cost the retailer pays, the smaller the probability of rent-seeking activities, suggesting that the retailer is more focused on selling products at this time and has no intention to participate in rent-seeking activities.

Conclusion 2: Considering that the retailer's interests are maximized, the manufacturer's supervision behavior is related to the manufacturer's supervision efficiency, penalty coefficient, rent-seeking costs, and the retailer's effort costs.

By solving Case 2, we can obtain the optimal supervision probability of the manufacturer at the game equilibrium as follows:

$$P_{m1}{}^* = \frac{(\lambda-1)(Y-W)Q+I}{P_v N[\lambda(P-W)Q+(1-\lambda)(P-Y)Q+I-e^2]}$$

The game equilibrium indicates that the manufacturer will choose whether to supervise the retailer's rent-seeking activities based on the optimal supervision probability $P_{m1}{}^*$. When the probability of the manufacturer supervising the retailer's rent-seeking activities is $P_m > P_{m1}{}^*$, the retailer's optimal strategy is not to seek rent and to work normally; when the probability is $P_m < P_{m1}{}^*$, the retailer's optimal strategy is to seek rent; when the probability is $P_m = P_{m1}{}^*$, the retailer's optimal strategy is to randomly choose whether to seek rent or not.

The probability $P_{m1}{}^*$ is inversely proportional to the manufacturer's supervision efficiency P_v and the penalty coefficient N. A higher manufacturer's supervision efficiency and a greater penalty coefficient for rent-seeking behavior yield a lower probability of the retailer engaging in rent-seeking. This indicates that when the manufacturer has an efficient supervision system and a significant penalty for rent-seeking behavior, it can effectively suppress the retailer's rent-seeking activities, which helps reduce the manufacturer's optimal supervision probability.

The probability $P_{m1}{}^*$ is inversely proportional to the volume of goods sold Q. The more goods sold, the harder the retailer works to sell them. Consequently, the manufacturer is willing to wholesale more goods to the retailer and will trust the retailer more. Naturally, this will reduce the probability of supervising the retailer's rent-seeking behavior.

The probability $P_{m1}{}^*$ is directly proportional to the retailer's effort cost e^2. The more effort the retailer puts in, the higher the costs generated in the sales process. If rent-seeking behavior is discovered, it will lead to greater losses; hence, the retailer will be less likely to engage in rent-seeking. Instead, the retailer is more likely to choose to improve their own sales skills to reduce effort costs.

Conclusion 3: Considering that the rent-seeker's interests are maximized, the manufacturer's supervision behavior is associated with the manufacturer's supervision efficiency and penalty coefficient.

By solving Case 3, we can obtain the optimal supervision probability of the manufacturer at the game equilibrium as follows: $P_{m2}{}^* = \frac{1}{P_v M}$. This optimal probability indicates that the manufacturer will choose whether to supervise the rent-seeker's rent-seeking activities based on the optimal supervision probability $P_{m2}{}^*$. When the probability of the manufacturer supervising the rent-seeker's rent-seeking activities is $P_m > P_{m2}{}^*$, the rent-seeker's optimal strategy is not to seek rent and to work normally; when the probability is $P_m < P_{m2}{}^*$, the rent-seeker's optimal strategy is to seek rent; when the probability is $P_m = P_{m2}{}^*$, the rent-seeker's optimal strategy is to randomly choose whether to seek rent or not.

The probability $P_{m2}{}^*$ is inversely proportional to the manufacturer's supervision efficiency P_v and the penalty coefficient M. This indicates that the supervision mechanism and penalty mechanism established by the manufacturer play a vital role in the game model. The manufacturer can constrain the rent-seeking behavior of the rent-seeker by establishing effective supervision mechanisms and penalty mechanisms, thereby reducing the probability of rent-seeking, lowering the optimal supervision probability, and achieving the goal of maximizing profits.

Conclusion 4: As evident from Scenario 1 and Scenario 2, the rent-seeking behavior of the retailer and the supervision behavior of the manufacturer are inversely proportional to the e-commerce efficiency coefficient. The e-commerce efficiency coefficient is an indicator that measures the attractiveness and influence of the e-commerce platform on retailers. The e-commerce efficiency coefficient is related to factors such as the traffic, conversion rate, product categories, and service quality of the e-commerce platform. A higher e-commerce efficiency coefficient K yields more customers, higher sales, lower operating costs, and a better user experience of the e-commerce platform for the retailers. This motivates retailers to invest more resources and energy on the e-commerce platform, reducing the motivation and space for rent-seeking behavior. Thus, the probability of the manufacturer supervising the retailer's rent-seeking behavior will decrease. A smaller value of the e-commerce efficiency coefficient K results in a weaker attractiveness and influence of the e-commerce platform on retailers. Retailers' profits on the e-commerce platform are smaller and their

competitiveness is weaker, and they may tend to improve their own profits through rent-seeking behavior. The probability of rent-seeking behavior will increase [39]. As a result, the manufacturer's supervision probability, supervision cost, and risk will increase.

IV. Conclusion and Suggestions

A. Conclusion

This study delves intothe tripartite rent-seeking game model among manufacturers, retailers, and rent-seekers within e-commerce channels. Furthermore, this study calculates the optimal rent-seeking probability of retailers and rent-seekers and the optimal supervision probability of manufacturers. Finally, this study determines the relationship between the optimal rent-seeking probability, the optimal supervision probability, and other factors. The main conclusions of this study are as follows:

By solving the tripartite game model of e-commerce channels, we can obtain the mixed strategy Nash equilibrium of the game model of retailers and manufacturers as follows:

$$[P_r^* = \frac{S}{P_v N\left[\lambda(P-W)Q+(1-\lambda)(P-Y)Q+I-e^2\right]+P_v M[(1-2\lambda)(Y-C_2)Q-I]},$$

$$P_{m1}^* = \frac{(\lambda-1)(Y-W)Q+I}{P_v N[\lambda(P-W)Q+(1-\lambda)(P-Y)Q+I-e^2]}]$$

The mixed strategy Nash equilibrium of the rent-seeker and manufacturer game model is calculated as follows:

$$[P_r^* = \frac{S}{P_v N\left[\lambda(P-W)Q+(1-\lambda)(P-Y)Q+I-e^2\right]+P_v M[(1-2\lambda)(Y-C_2)Q-I]},$$

$$P_{m2}^* = \frac{1}{P_v M}]$$

In game equilibrium, the rent-seeking behaviors of retailers and rent-seekers are related to supervision costs, supervision efficiency, penalty coefficient, rent - seeking return, sales volume of goods, retailers' effort costs, and purchase preference. Specifically, the optimal rent-seeking probability is positively correlated with supervision costs and inversely correlated with supervision efficiency, penalty coefficient, retailer's effort costs, and commodity sales volume. The manufacturer can judge whether to supervise the retailer's behavior according to the optimal rent-seeking probability and optimize its supervision efficiency according to the relationship between the optimal rent-seeking probability and other factors.

In game equilibrium, the manufacturer's optimal supervision probability is related to its supervision efficiency, penalty coefficient, rent-seeking costs, and retailer's effort costs. Specifically, the optimal supervision probability is positively correlated with the effort costs of retailers and inversely correlated with the probability of successful supervision, penalty coefficient, and sales volume of goods. Manufacturers can judge their current supervision efficiency according to the optimal supervision probability and reduce the probability of retailers seeking rent by improving the probability and penalty coefficient of supervision success to better safeguard their own interests.

B. Suggestions

Based on the above research, this study proposes suggestions from the following aspects:

1) Whether it is the optimal supervision probability of the manufacturer or the optimal rent-seeking probability of the retailer and the rent-seeker, is influenced by elements withinthe manufacturer's supervision mechanism ,such as the penalty coefficient. Therefore, the manufacturer should establish a comprehensive supervision and punishment mechanism, including clear rules, systems, rewards and punishments, audits, and reports. The use of the Internet, big data, and other technologies can improve the efficiency and accuracy of supervision, reduce the manpower and time required for supervision, lower the costs of supervision, and make the supervision process and results public to enhance the credibility and fairness of supervision and strengthen the deterrent and influence of supervision.

2) A higher effort costs indicates that the retailer has spent more time and energy to increase the sales volume of goods. The manufacturer can encourage the retailer's efforts by providing rewards, training, support, and other incentives, which can enhance the cooperative relationship with the retailer and reduce the occurrence of rent-seeking behavior. Moreover, the manufacturer needs to strengthen communication and coordination with the retailer, understand the retailer's needs and difficulties, endeavor to reduce conflicts and disputes caused by information asymmetry, respect the legitimate rights and interests of the retailer, not use its own advantageous position to squeeze the profit space of the retailer, and not damage the development potential of the retailer, and establish a fair, just, and open e-commerce channel relationship.

3) Manufacturers should reasonably set wholesale prices to balance their own profits, the interests of retailers, and market competitiveness. Manufacturers can adjust wholesale prices flexibly based on the retailer's preference for purchasing goods and market conditions. On the one hand,if the retailer has a high preference for purchasing goods, it indicates that the retailer is not greatly affected by the wholesale price of the goods and will continue to wholesale goods from the manufacturer. On the other hand,if the retailer has a low preference for purchasing goods", it indicates that the retailer is sensitive to the wholesale price of the goods, and the volume of goods purchased will be affected by the price. In this case, the manufacturer should timely understand the situation with the retailer, set a reasonable wholesale price, and reduce the probability of rent-seeking behavior.

4) We increase the traffic and conversion rate of the e-commerce platform to expand the customer base and sales opportunities for retailers, thereby enhancing their loyalty and satisfaction[40]. We optimize the technology and management of the e-commerce platform to improve operational efficiency and service quality, reduce the operating costss and risks borne by retailerscosts, and streamline supplier selection decisions. This will improve the entire business process within organizations[41]. We establish a credit and supervision mechanism for the e-commerce platform to standardize the behavior and responsibilities of retailers, minimize the occurrence and impact of rent-seeking behavior, and protect the interests and rights of manufacturers.

REFERENCES

[1] Preeyanat Eapsirimetee;Nanthi Suthikarnnarunai;Somchai Hanhirun.Canned Pineapple's Demand Forecast Using Econometrics Mode.Lecture Notes in Engineering and Computer Science, Vol.2194, pp1064-1067, 2011.

[2] BUSABA PHRUKSAPHANRAT.FUZZY MULTIPLE OBJECTIVE PRODUCTION AND LOGISTICS PLANNING MODEL WITH INTERVAL DEMAND AND UNCERTAIN CAPACITY.International Multi-Conference of Engineers and Computer Scientists, 2012.

[3] Xue Fang. Research on the collaborative development of e-commerce and logistics enterprises under the background of the digital economy. Market Modernization, vol.24, pp36-38, 2023.

[4] Chan Y,Siegel D,Thakor A V.Learning,corporate control and performance requirements in venture capital contracts.International Economic Review, Vol.31, No.2,P365-381, 0020-6598, 1990.

[5] Xin Wang, Yuanhua Jia,Xiaofei Ma. Rent-seeking Analysis of National S&T Plan Projects Determination Based on Game Theory. Science & Technology Progress and Policy, vol. 28, pp27-30, 2011.

[6] Buchanan, James M..Rent Seeking and Profit Seeking.40 Years of Research on Rent Seeking, Vol.1, pp55-67, 2008.

[7] Anne O. Krueger.The Political Economy of the Rent-Seeking Society.The American Economic Review, Vol.64(3),pp291-303, 1974.

[8] Jingwei Zhou. Analysis of rent-seeking behavior in asset evaluation in China. Friends of Accounting, vol.(08), pp42-43, 2010.

[9] Jean-Marie Baland, Patrick Francois.Rent-seeking and resource booms.Journal of Development Economics, Vol.61(2), pp527-542, 2000.

[10] Boldrin, M.;Levine, D.K..Rent-seeking and innovation.Journal of Monetary Economics, Vol.51(1), pp127-160, 2004.

[11] Roland Hodler.Rent seeking and aid effectiveness.International Tax and Public Finance, Vol.14(5), pp525-541, 2007.

[12] Luis C. Corchón.Forms of governance and the size of rent-seeking.Social Choice and Welfare, Vol.30(2), pp197-210, 2008.

[13] Choi, Seung Ginny (AUTHOR)(ginny.choi@stvincent.edu) Storr, Virgil Henry (AUTHOR)(vstorr@gmu.edu).A culture of rent seeking. Public Choice, Vol.181(1), pp101-126, 2019.

[14] Yijin Chen. An economic analysis of rental and rent-seeking behavior. Economic Research Journal,vol. (04), pp66-73, 1997.

[15] Wei He. The Political Economy Analysis on Rent-seeking. Shanghai University of Finance and Economics, 2005.

[16] Changde Zheng,Weiwu Zhang. Analysis of agent's rent-seeking action in the principal-agent relations of firm. Journal of Southwest Minzu University(Natural Science Edition),vol. (03), pp338-344, 2002.

[17] Yueheng LI. Game analysis of academic rent-seeking behavior of university teachers based on principal-agent. Systems Engineering,vol.26(11), pp85-89, 2008.

[18] Baiyan Li. Research on the Evolution Mechanism of Rent-seekingBehavior of Engineering Project Quality Supervision. Dongbei University Of Finance And Economics,2023.

[19] Zeng Xiping,Wu Junmin. Analysis and Countermeasure of Rent-seeking Behavior of Government Procurement in Universities. Journal of Wuhan Engineering Institute,vol.35(01), pp54-56+68, 2023.

[20] Binghong Wang. Study on rent-seeking behavior in the supply of public goods - taking the supply of affordable housing in Nanjing as an example. Vitality,vol.(20), pp93-95, 2022.

[21] Jiahong Zhang. Rent-seeking game and supervision suggestions of price monopoly behavior. Prices Monthly,vol.(12), pp18-24, 2021.

[22] Xiaoyu Wang. A Thesis Submitted to Chongqing Universityin Partial Fulfil1ment of the Requirement for The Professional Degree. ChongqingUniversity,2015.

[23] Qian Yang. Research on rent seeking governance mechanism of affordable housing based on Evolutionary Game. Xi'an University of Architecture and Technology,2021.

[24] Hongru Song. Analysis on the Impact of Government Subsidies, EnterpriseInnovation and Rent-seeking Behavior on Investor Decisions. Shandong University of Science and Technology,2020.

[25] Dongsheng Xu,Han Qiao,Yanran Hong. Research on venture capital model considering rent-seeking and monitoring. Friends of Accounting,vol. (01), pp129-132, 2020.

[26] Jinghua Liang,Jun Liang. Research on the Mechanism of lntegrity,Risk Prevention and Control in Secondary Colleges of UniversitesBased on the Analysis of Rent-seeking Theory. Higher Education Forum,vol. (12), pp101-103, 2021.

[27] Fanqin Kong. Prevention and control mechanism of rent-seeking phenomenon under decentralized purchasing management mode in colleges and universities. China Tendering,vol. (03), pp26-28, 2019.

[28] Haicheng Ma,Jing Jia,Huimin Li,Jinxi Sheng. Game Analysis on Rent-seeking Behavior of Risk ManagementOrganization based on Engineering Quality Insurance. Construction Quality, vol.38(11), pp87-91, 2020.

[29] Hong Ren,Dandan Qi,Qing Zhong. Study on Power-seek-rent among Public Rental Housing Administrative Departments [J]. World Sci-Tech R & D,2013,35(04):522-525.

[30] Liu Wu,Wangbo Li. Analysis of rent-seeking behavior in the implementation of affordable housing projects [J]. Co-Operative Economy & Science,2012,(13):74-76.

[31] KawakatsuH.An Inventory Model for Special Display Goods with Seasonal Demand[J].AIP Conference Proceedings,2010,1285(1):86.

[32] AswalA,Prasanna SN G.A Robust Approach to Inventory Optimization Under Uncertainty.AIP Conference Proceedings,vol. 1174(1), pp117, 2009.

[33] HasuikeT,IshiiH.Robust Programming Problems Based on the Mean-Variance Model Including Uncertainty Factors.AIP Conference Proceedings,vol. 1089(1), pp224, 2009.

[34] N.A. Nechval;G. Berzins and K.N. Nechval.Improved airline seat inventory control under incomplete information.IAENG Transactions on Engineering Sciences, pp279-288, 2014.

[35] Qun Feng,Xuejun Shi,Wei Xu.Power rent-seeking governance of construction engineering safety supervision system: based on the perspective of evolution game of rent-seeking subjects. Chinese Journal of Management Science, vol.23(S1), pp9-14, 2015.

[36] Houping Tian,Changxian Liu. Incentive contract design in distribution channel with asymmetric information. Journal of Management Sciences in China,vol.12(3), pp77-82, 2009.

[37] Fang Li,Wei Zhang,Jin Liu. The Incentive Mechanism for the Reverse Supply Chain Based on Hidden Information of Reverse Costss. Industrial Engineering and Management,vol.16(1), pp1-5, 2011.

[38] Xin Wang. Research on Risk Management of National S&TPlanned projects Based on the Asymmetric Information Theory. Beijing Jiaotong University,2012.

[39] Xingyu Wang,Laiyi Xue. Analysis of three-party game model of rent-seeking theory.Research on Financial and Economic Issues,vol. (11), pp14-17, 2001.

[40] Xiaojia Peng. Study on the Development Efficiency andInfluencing Factors of Rural E-commerce. Hunan Agricultural University,2020.

[41] Dominic P,Akashah E,Nee K G.The Role of Mathematical Model In Managerial Decisions- With Special Reference To Supplier Selection.Lecture Notes in Engineering and Computer Science,vol. 2183(1), pp277, 2010.