How to Build a Collaborative Model for Express Packaging Recycling –An Evolutionary Game Perspective

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Abstract: *As the e-commerce and express delivery industries grow rapidly, the environmental pollution caused by express delivery packaging waste is becoming more serious. The current recycling model is difficult to promote effectively due to its high cost, limited coverage, and low public participation, and there is an urgent need to build a multi-party collaborative governance mechanism based on evolutionary game theory. The study finds that: (1) the government policy intensity has a significant driving effect on the recycling behavior of online shopping platforms, and a reasonable reward and punishment mechanism can accelerate the evolution of its positive strategy; (2) the leading role of the government is especially critical when the initial willingness of consumers to participate is low, and it is necessary to enhance the public's awareness of environmental protection by means of policy guidance and publicity and education; (3) there is a significant synergistic effect among the three parties, and the government needs to balance the distribution of subsidies between the platforms and the consumers and ensure that the policy benefits are higher than the non-compulsory strategy.*

Keywords: Express packaging recycling, Evolutionary game, Collaborative governance, Numerical simulation.

1. Introduction

E-commerce is rapidly developing as a consequence of globalization and the Internet economy, and the express delivery industry is expanding at an unprecedented rate. With the growing wealth of the social economy and the rapid development of e-commerce, an increasing number of consumers are changing their shopping habits, preferring online buying, which accelerates the development of the express delivery business [1-2]. According to the information of China Postal Bureau, in 2024, the annual volume of postal industry sending and delivering business completed 193.7 billion pieces, an increase of 19.2% year-on-year; the industry's business income completed 1.7 trillion Yuan, an increase of 10.7% year-on-year. Among them, the express business volume and business income concluded 175.08 billion pieces and 1.4 trillion Yuan respectively, up 21.5% and 13.8% year-on-year [3]. According to the above synthesis, the volume of express delivery business will continue to increase at a medium to high rate, and the express delivery industry has significant possibilities for expansion. However, the packaging problem caused during the logistics process is becoming one of the environmental contamination problems that must be addressed immediately, and it is critical to encourage the long-term development of the express delivery business. To address this dilemma, governments and businesses are actively investigating effective express package recycling rules and procedures. The practical experience of express packaging recycling in industrialized nations has demonstrated that it is challenging to accomplish the necessary objectives only through market means, and express packaging recycling cannot be separated from government involvement [4]. The government's policies not only establish a legal framework and standard system, but also encourage the reduction, harmlessness, and recycling of express packaging through incentives and limits. For example, through government subsidies and tax incentives, firms can minimize the cost of implementing green packaging while also improving their economics [5]. Simultaneously, the government has enhanced consumer environmental knowledge and participation through publicity, education, and public involvement. However, because the current stage has not yet constructed a unified express packaging recycling model and has failed to develop a standardized recycling program, most of the recycling activities now implemented have limited types of recycled packages, high recycling costs, and significant coverage limitations, resulting in low motivation for public participation in recycling [6]. As a result, the first objective is to establish an appropriate express package recycling model, and from there, it is critical to gain cost savings and efficiency in reverse logistics. Although previous research has offered much theoretical and empirical support for express packaging recycling, there are still certain limitations. For starters, most existing research concentrate on the behavioral study of a single subject, resulting in a limited knowledge of the dynamic interplay between e-commerce platforms, consumers, and the government. Second, the research methodology primarily focuses on qualitative research and quantitative questionnaire surveys, which lacks a systematic game-theoretic perspective and makes it difficult to completely explain the complex relationship among multiple subjects. Furthermore, there are relatively few empirical studies on the effects of policies, which lack in-depth analysis of the combined effects of various policy measures.

Addressing the aforementioned issues, this study adopts a tripartite evolutionary game theory framework to systematically examine the strategic interactions among e-commerce platforms, consumers, and governmental entities in the context of express packaging recycling. Specifically, it investigates: (1) The underlying mechanisms governing the interplay between these stakeholders in the recycling process; (2) The critical conditions shaping their respective optimal strategy choices; and (3) The differential impacts of policy interventions on recycling behaviors. The paper is structured as follows: Section 2 reviews the relevant literature, Section 3 develops the theoretical model, Section 4 analyzes the

evolutionary game dynamics, Section 5 presents simulation results, and the final section discusses key findings and implications.

2. Literature Review

2.1 The Role of E-commerce Platforms in Express Packaging Recycling

In recent years, with the widespread popularization and application of new-generation information technology, e-commerce platforms have become an important engine to promote the global new retail [7], and leveraging on e-commerce platforms is considered to be an ideal path to realize express packaging recycling[8]. However, the e-commerce platform dominated by big data has also exposed problems such as unjust distribution of benefits, reprocessing "kill familiarization", and regulatory difficulties. For example, because consumers join the e-commerce platform needs to pay a certain cost, there is also a greater risk and uncertainty in the recovery of express packaging, so consumers back to weigh the benefits and costs of choosing whether to join the platform, e-commerce platforms will also be due to the amount of government subsidies, the uncertainty of revenue and other issues to weigh the process of empowering the recovery of express packaging to optimize the service or not [9]. As the primary user of express packaging, e-commerce platforms also have significant responsibilities in the recycling process. Some studies have pointed out that e-commerce platforms can substantially improve the packaging recycling rate by optimizing packaging design and providing recycling services [10]. Studies have shown that implementing reusable packaging materials and providing convenient recycling channels can effectively increase residents' recycling participation [11]. Platforms should enhance their sustainability responsibilities and actively communicate with residents and the government. However, research on the specific role of e-commerce platforms in the recycling chain and their gaming relationship with residents and the government is still insufficient, and how to build an effective recycling mechanism at the platform level to balance economic interests and environmental responsibilities is an important issue to promote sustainable development. Therefore, how to further understand the generation and evolution mechanism of e-commerce platform empowering express packaging recycling deserves attention, and the solution of this problem not only helps to clarify the key mechanism of empowerment from the theoretical level, but also provides policy insights for the healthy and orderly development of e-commerce platform.

2.2 The Importance of Consumers in the Recycling of Express Packaging

Consumers are the direct beneficiaries of express packaging recycling, they can comment on express packaging recycling through social media and express their attitudes and opinions, but also have the right to report to the government for personal privacy leakage to protect their rights, is the synergistic subject of express packaging recycling governance [12]. The introduction of consumer participation in regulation is an essential initiative to improve the current limited awareness of express packaging recycling and insufficient motivation for government regulation. Studies have paid attention to the role played by consumers in the regulation of express packaging recycling, and in-depth analysis of consumer evaluation and complaints and other behaviors on the impact of express packaging recycling, that consumers can through the complaint of express packaging recycling governance effect [13]. However, only rely on individual behavior is difficult to establish a normalized social supervision of express packaging recycling. On the one hand, adopting a rights defense strategy requires more time costs, and when social media find out that it is a false report, they will be penalized by credit downgrading, restricting recycling, or even blocking the number [14]. On the other hand, some consumers may choose to ignore this behavior because of the time cost, etc., coupled with their knowledge and perceived value of express packaging recycling behavior is not high, there is a psychological not to regulate the report, while concerned about the penalties faced by the failure of the report, etc., and will not take the right to defend the strategy [15]. Therefore, relying on consumers alone to regulate express packaging recycling lacks the necessary driving force.

Due to the complex external environment and limited access to information, express packaging recycling behavior is not completely rational, and evolutionary game theory based on limited rationality has become an essential method and tool for studying such problems and has been widely used. The theory believes that individuals can perpetually adjust their own behavior by imitating the behavior of others, and eventually make the whole system optimal. Therefore, it is feasible to use evolutionary game theory to investigate the dynamic recycling behavior and evolution law of express packaging. In the process of express packaging recycling, the government will intervene through a variety of strategies to achieve the optimal operation of the network as a whole, during which all the participating subjects may choose the strategy from the perspective of their own profits, through the prospect theory can better reveal the strategy of the subject of the inter-subject game and the optimal strategy. Based on this, this project chooses to combine evolutionary game theory and prospect theory to explore the strategy choice of the main body of express packaging recycling, and better reveal the evolution of the behavior of express packaging recycling under the perspective of synergistic multiple subjects.

3. Methods and Model

The study considers the interaction mechanism of the government, online shopping platform and consumers in the process of express packaging recycling, constructs evolutionary game models in different contexts, and realizes the resource complementarily of multiple subjects by exploring the stable state of the behavior of the three parties' game subjects according to the analysis of the collaborative regulation of multiple subjects.

3.1Assumptions

Assumption 1. In the courier packaging recycling game process, there are three main parties involved: the government, enterprises, consumers, the three parties in the limited rationality of the premise of strategic choice, according to their own interests in decision-making. Each subject will

choose the strategy that can maximize their own benefits. In addition, it is assumed that all participants have access to information about the strategic choices of other agents and their potential benefits. This means that each subject is able to take into account the behavior of the other subjects when making decisions.

Assumption 2. The government strategies are mandatory recycling (p) and non-mandatory recycling ($1-p$). The online shopping platform decides whether or not to actively recycle express delivery packaging, with strategies of active recycling (q) and no recycling ($1-q$). Consumers decide whether or not to participate in recycling, with the strategies participate in recycling (r) and not participate in recycling ($1-r$).

Assumption 3. It is assumed that the cost and benefit structure of each subject is known, and the benefits obtained by all three parties are positive and can be quantified by specific parameters in the model. Online shopping platform and the initial benefits of consumers as Re. Consumers participate in each unit of express packaging recycling will produce a unit of Rc_1 revenue, produce a unit of Cc_1 cost ($Rc_1 > Cc_1$), where Rc_1 for the participation in the recycling of express packaging activities generated by the revenue, Cc_1 for the recycling of express packaging produced by the human, material resources and time and other costs. Each unit of online shopping platform to participate in the recovery of express packaging will get a unit of revenue Re_1 ($Re_1 > F_1$).

Assumption4. Online shopping platform express packaging recycling operations, need to pay a certain fee. If the online shopping platform directly express packaging recycling, the cost incurred is F_1, if the online shopping platform chooses not to recover the express packaging or recycling from the agency, the cost incurred is F_2, which does not recover the express packaging gained Re_2 ($Re_2 > F_2$), the gain from the agency recycling Re_3, here, the agency refers to the consumer does not want to participate in the recovery of express packaging, they will be entrusted to professional organizations to do, the cost of the consumer's own burden, and the agency at this time the cost of recycling express packaging for Cc_2 ($Re_2 > Cc_2$).

Assumption 5. The responsibility of the government department is to supervise the online shopping platform's express packaging recycling as well as to promote the recycling of express packaging by consumers, and to reward or penalize them according to their behaviors, and the government's revenue in express packaging recycling operations is Rg_1, Rg_2.

Rg_1 is the tax revenue generated by the online shopping platform's express packaging recycling. Rg_2 is the additional revenue generated by the online shopping platform and consumers' active express packaging recycling operations. The cost of government regulation is Cg ($Cg < Rg_1$), and δ denotes the ratio of the revenue generated by the government not enacting a mandatory recycling policy to the revenue generated by the government choosing to enact a mandatory recycling policy ($0 < \delta < 1$). When the online shopping platform chooses not to carry out express packaging recycling, the government department has a certain penalty for the online shopping platform P_1. When consumers choose not to

participate in express packaging recycling, the government department can impose a certain penalty P_2 for them. And in order to encourage the online shopping platform and consumers to carry out express packaging recycling, the government gives them a certain amount of subsidy K, ($K < Rg_2 < Rg_1$), where the distribution of the online shopping platform coefficient is a, and the distribution coefficient of consumers is b.

Assumption 6. It is assumed that the external environment remains relatively stable without significant changes during the model analysis period, and that consumers' willingness to participate in packaging recycling is influenced by government policies and corporate behavior, and that the participation rate of consumers is correlated with the recycling measures of corporations and the strength of government policies.

3.2 Evolutionary Game Model of Three-Party Subjects

In the game model, the three parties involved in the game according to their own will to game strategy selection, and according to the above assumptions, the construction of the government, online shopping platforms, consumers, the three-party game benefit matrix is as follows.

Table 1: Game matrix of express packaging recycling under government mandatory recycling policy (p)

Consumer	Online shopping platform	
	Participation in recycling(q)	Not involved in recycling($1-q$)
Participate (r)	$R_{g1}+R_{g2}-C_g-K$	$R_{g1}+aP_1-C_g-bK$
	$R_e+R_{e1}+(1-b)K-F_1$	$R_e+R_{e2}-P_1-F_2$
	$R_c+R_{c1}-C_{c1}+F_1+bK$	$R_c+R_{c1}-C_{c1}+(1-a)P_2+bK$
Non-partici pation ($1-r$)	$R_{g1}-C_g-(1-b)K+aP_1$	$R_{g1}-C_g$
	$R_e+(1-a)P_2+(1-b)K-F_1+R_{e3}$	R_e
	$R_c-P_1-C_{c2}+F_1$	R_c-C_{c2}

Table 2: Game matrix of ($1-p$) express packaging recycling under the government's non-compulsory recycling policy

Consumer	Online shopping platform	
	Participation in recycling(q)	Not involved in recycling($1-q$)
Participate (r)	δR_{g1}	δR_{g1}
	$R_e+R_{e1}-F_1$	$R_e+R_{e2}-F_2$
	$R_c+R_{c1}-C_{c1}+F_1$	$R_c+R_{c1}-C_{c1}$
Non-participatio n ($1-r$)	δR_{g1}	δR_{g1}
	$R_e+R_{e3}-F_2$	R_e
	$R_c-C_{c2}+F_1$	R_c-C_{c2}

4. Evolutionary game Analysis

4.1 Establishment of Dynamic Equations for Replication of Each Subject

According to Tables 1 and 2, the government's expected returns Ug_1 for choosing to enact a mandatory recycling policy, Ug_2 for choosing not to enact a mandatory recycling policy, and the average expected returns Ug at the time of the game are respectively:

$$U_{g1} = rq(R_{g1} + R_{g2} - C_g - K)$$
$$+ r(1-q)(R_{g1} - C_g + aP_1 - bK)$$
$$+ q(1-r)(R_{g1} - C_g - (1-b)K + aP_1)$$
$$+ (1-r)(1-q)(R_{g1} - C_g)$$

$$U_{g2} = rq\delta R_{g1} + r(1-q)\delta R_{g1} + q(1-r)\delta R_{g1}$$
$$+(1-r)(1-q)\delta R_{g1}$$
$$U_g = pU_{g1} + (1-p)U_{g2}$$

The expected returns Ue_1 of online shopping platforms choosing to recycle express packaging at the time of the game, the expected returns Ue_2 of choosing not to carry out express packaging recycling, and the average expected returns Ue are respectively:

$$U_{e1} = pr[R_e + R_{e1} - F_1 + (1-b)K]$$
$$+p(1-r)[R_e + R_{e3} - F_1 + (1-a)P_2 + (1-b)K]$$
$$+r(1-p)(R_e + R_{e1} - F_1)$$
$$+(1-p)(1-r)(R_e + R_{e3} - F_2)$$

$$U_{e2} = pr(R_e + R_{e2} - F_2 - P_1) + p(1-r)R_e$$
$$+r(1-p)(R_e + R_{e2} - F_2) + (1-p)(1-r)R_e$$

$$U_{e2} = qU_{e1} + (1-q)U_{e2}$$

The expected returns Uc_1 of consumers choosing to participate in express packaging recycling, the expected

returns Uc_2 of consumers choosing not to participate in express packaging recycling, and the average expected returns Uc at the time of the game are respectively:

$$U_{c1} = pq(R_c + R_{c1} - C_{c1} + F_1 + bK)$$
$$+p(1-q)(R_c + R_{c1} - C_{c1} + (1-a)P_2 + bK)$$
$$+q(1-p)(R_c + R_{c1} - C_{c1} + F_1)$$
$$+(1-p)(1-q)(R_c + R_{c1} - C_{c1})$$

$$U_{c2} = pq(R_c - C_{c2} + F_1 - P_1) + p(1-q)(R_c - C_{c2})$$
$$+q(1-p)(R_c - C_{c2} + F_1)$$
$$+(1-p)(1-q)(R_c - C_{c2})$$

$$U_c = rU_{c1} + (1-r)U_{c2}$$

According to the evolutionary game theory, the replicated dynamic equations of the tripartite strategies of express packaging recycling government, online shopping platform and government are established, and the three-dimensional dynamical system is formed as follows:

$$\begin{cases} F(p) = p(p-1)\left(C_g - R_{g1} - rqR_{g2} + rbK - qKb + qK + 2rqaP_1 - raP_1 - qaP_1 + \delta R_{g1}\right) \\ F(q) = -q(q-1)\begin{pmatrix} (r-1)p(F_1 - F_2) - rF_1 + (2r-1)F_2 + prP_1 + r(R_{e1} - R_{e2} - R_{e3}) \\ +R_{e3} + pP_2(1-r)(1-a) + (1-b)pK \end{pmatrix} \\ F(r) = -r(r-1)(-C_{c1} + C_{c2} + pqP_1 + R_{c1} + pP_2(1-a)(1-q) + pbK) \end{cases}$$

4.2 System Equilibrium and Stability Analysis

By solving the three-dimensional dynamical system, the replicated dynamic Jacobi matrix of the three-party game can be obtained as:

$$J = \begin{pmatrix} \frac{\partial F(p)}{\partial p} & \frac{\partial F(p)}{\partial q} & \frac{\partial F(p)}{\partial r} \\ \frac{\partial F(q)}{\partial p} & \frac{\partial F(q)}{\partial q} & \frac{\partial F(q)}{\partial r} \\ \frac{\partial F(r)}{\partial p} & \frac{\partial F(r)}{\partial q} & \frac{\partial F(r)}{\partial r} \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix}$$

Among them,

$$a_{11} = (2p-1)\begin{pmatrix} C_g + Kbr - Kbq + Kq + 2P_1 arq - P_1 ar - P_1 aq + \delta Rg_1 - Rg_1 \\ -rqRg_2 \end{pmatrix}$$
$$a_{12} = p(p-1)(Kb + 2P_1 aq - P_1 a - qRg_2)$$
$$a_{13} = -p(p-1)(Kb - K - 2P_1 ar + P_1 a + rRg_2)$$
$$a_{21} = -q(q-1)(F_1 r - F_1 - F_2 r + F_2 - Kb + K + P_1 r + P_2 ar - P_2 a - P_2 r + P_2)$$
$$a_{22} = (1-2q)\begin{pmatrix} p(F_1 - F_2)(r-1) - F_1 r + 2F_2 r - F_2 - Kbp + Kp + (P_1 - P_2)pr \\ -P_2 ap(1-r) + P_2 p + r(R_{e1} - R_{e2} - R_{e3}) + R_{e3} \end{pmatrix}$$
$$a_{23} = -q(q-1)(F_1 p - F_1 - F_2 p + 2F_2 + P_1 p + P_2 ap - P_2 p + R_{e1} - R_{e2} - R_{e3})$$
$$a_{31} = -r(r-1)(Kb + P_1 q + P_2 aq - P_2 a - P_2 q + P_2)$$
$$a_{32} = -r(r-1)(pP_1 + pP_2 a - pP_2)$$
$$a_{33} = (1-2r)(-C_{c1} + C_{c2} + Kbp + P_1 pq + P_2 apq - P_2 ap - P_2 pq + P_2 p + R_{c1})$$

Table 3: Eigenvalues of the Jacobi matrix

Equilibrium point	Eigen value	characteristic value
$E_1(0,0,0)$	$\lambda_1 = -C_g - \delta R_{g1} + R_{g1}$ $\lambda_2 = -F_2 + R_{e3}$ $\lambda_3 = -C_{c1} + C_{c2} + R_{c1}$	Inconclusive
$E_2(1,0,0)$	$\lambda_1 = C_g + \delta R_{g1} - R_{g1}$ $\lambda_2 = -F_1 - Kb + K - aP_2 + P_2 + R_{e3}$ $\lambda_3 = -C_{c1} + C_{c2} + R_{c1} + Kb - aP_2 + P_2$	Non-stationary point
$E_3(0,1,0)$	$\lambda_1 = -C_g - \delta R_{g1} + R_{g1} - Kb + aP_1$ $\lambda_2 = -F_1 + F_2 + R_{e1} - R_{e2}$ $\lambda_3 = C_{c1} - C_{c2} - R_{c1}$	Inconclusive
$E_4(0,0,1)$	$\lambda_1 = -C_g - \delta R_{g1} + R_{g1} + Kb - aP_1 - K$ $\lambda_2 = -F_2 - R_{e3}$ $\lambda_3 = -C_{c1} + C_{c2} + R_{c1}$	Non-stationary point
$E_5(1,1,0)$	$\lambda_1 = C_g + \delta R_{g1} - R_{g1} + Kb - aP_1$ $\lambda_2 = -F_1 + F_2 - Kb + K + P_1 + R_{e1} - R_{e2}$ $\lambda_3 = C_{c1} - C_{c2} - R_{c1} - Kb + aP_2 - P_2$	Inconclusive
$E_6(1,0,1)$	$\lambda_1 = C_g + \delta R_{g1} - R_{g1} - Kb - aP_1 + K$ $\lambda_2 = F_1 + Kb - K + aP_2 - P_2 - R_{e3}$ $\lambda_3 = -C_{c1} + C_{c2} + R_{c1} + Kb + P_1$	ry point
$E_7(0,1,1)$	$\lambda_1 = -C_g - \delta R_{g1} + R_{g1} - K$ $\lambda_2 = F_1 - F_2 - R_{e1} + R_{e2}$ $\lambda_3 = C_{c1} - C_{c2} - R_{c1}$	Inconclusive
$E_8(1,1,1)$	$\lambda_1 = C_g + \delta R_{g1} - R_{g1} + K - R_{g2}$ $\lambda_2 = F_1 - F_2 - R_{e1} + R_{e2}$ $\lambda_3 = C_{c1} - C_{c2} - R_{c1}$	Inconclusive

The equilibrium points E1-E8 can be brought into the above equation to obtain the corresponding equilibrium values, as shown in Table 3. In order to facilitate the analysis of the equilibrium point under different characteristic values, without loss of generality assumption: the government, business, consumer returns are positive that is $-C_g - \delta R_{g1} + R_{g1} > 0$; $-C_{c1} + C_{c2} + R_{c1} > 0$.

5. Simulation and Analysis

In order to further verify the validity of the evolutionary equilibrium solution and analyze the influence of the initial participation willingness of the three parties of express packaging recycling on the process and results of the system evolutionary game, this paper uses Matlab R2024b to carry out numerical simulation, and gives assumptions on the initial values of the parameters of the revenue matrix, and the government revenue as Rg_1=3.4, cost as Cg=5, the government's financial support as K=0.4，the penalty asP_1=1, P_2=1, the initial willingness of consumers, online shopping platform and government is $r = q = p = 0.5, \delta = 0.5, b = 0.5, Cc_1 = 0.3, Cc_2 = 0.5, F_1 = 0.6, F_2 = 0.1, Rc_1 = 0.5, Re_1 = 0.4, Re_2 = 0.6, Re_3 = 0.7, Rg_2 = 1$.

5.1 Impact of Tripartite Initial Willingness on System Evolution

Figure 1 is a simulation of the impact of changes in the overall willingness of consumers, online shopping platforms, and the government on the evolution results under the premise of other parameters remaining unchanged. From Figure 1, it can be concluded that regardless of the initial willingness of the three parties, the result of the three-party evolution always tends to 1. However, with the increase of the initial willingness of the three parties, the convergence rate of the three-party willingness to participate in express packaging recycling gradually accelerates, and finally reaches the equilibrium point (1,1,1). With the increase of the initial willingness of the three parties to participate, the convergence curve of consumers and online shopping platforms and the trend of the government's convergence curve is gradually close to the government's participation in the consumer and online shopping platforms to participate in the recovery of express packaging play a leading role. That is, a higher willingness of the government to participate in encouraging and guiding consumers and online shopping platforms to participate in the recovery of express packaging, and promote the formation of a good express packaging recycling environment, and a high initial willingness to further accelerate the three parties to participate in the recovery of express packaging and the formation of a stable system of speed, then, in the initial period, the government should be in advance of the preheat, on the one hand, the introduction of relevant policies to make online shopping platforms with a higher willingness to participate.
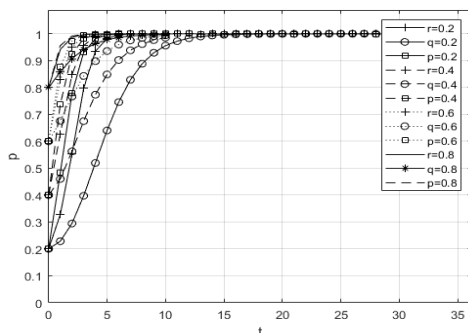

Figure 1: Impact of changes in the initial willingness of the three parties on the evolution of the system

On the other hand, it should also increase publicity and promotion as well as related education, so that consumers have a full understanding of the benefits of express packaging recycling, and have a high willingness to participate.

5.2 The Impact of Online Shopping Platform Recovery Costs on System Evolution

Figure 2 illustrates the simulation of the impact of the change of the cost Cc_1 of express packaging recycling by online shopping platforms on the government and consumers' participation in express packaging recycling under the condition of other parameters being unchanged. As can be seen in Figure 2, the critical value of the initial recycling cost Cc_1 is between 2-4, when Cc_1 is larger than the critical value, r converges to 0, p, q converges to 1 and the final equilibrium point tends to (0,1,1), at this time, with the reduction of Cc_1, the convergence rate of p, q increases, and q converges faster than p. The simulation results show that the increase or decrease of the cost of recycling express packaging by the online platform affects the strategic choices of both the online platform and the government, and it has an impact on the government and consumers' participation in the recycling of express packaging. The strategy choices of online shopping platform and the government, and the influence on online shopping platform is larger than that of the government.
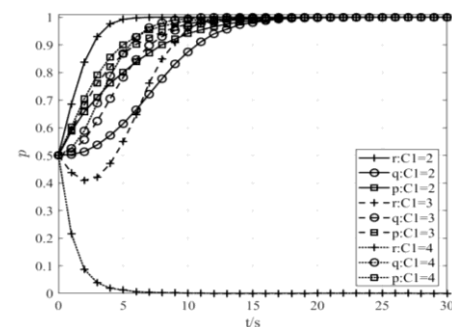

Figure 2: Impact of online shopping platform recovery costs on system evolution

Simulation results show that when the cost of recycling on the online shopping platform is less than the critical value, the cost does not affect the online shopping platform to choose to carry out express packaging recycling, although the speed of convergence will be slowed down with the increase of the cost, but will eventually converge to 1, that is, the online shopping platform chooses to carry out express packaging recycling; and when the cost is higher than the critical value, the online shopping platform will take negative measures, that is, ultimately choose not to participate in express packaging Recycling, this is because at this time, the online shopping platform to obtain the benefits and costs are equal or even less than the cost of high, express packaging recycling on the enterprise has no significance.

5.3 The Effect of Different Government Policy Intensities on System Evolution

As can be seen from Figure 3, regardless of the government's willingness to supervise, it does not affect the initial willingness of consumers and online shopping platforms to participate in express packaging recycling, but with the increase of the government's willingness to supervise p, the convergence of the probability of consumers and online shopping platforms to participate in express packaging

recycling accelerates, and ultimately arrives at the equilibrium point $(1,1,1)$, at which time the rate of convergence of p is greater than that of q.
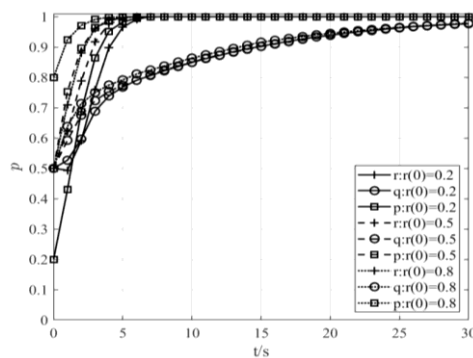

Figure 3: Impact of different government policy intensities on system evolution

The simulation results show that the increase of the government's initial willingness to participate in p increases, the willingness of consumers and online shopping platforms to participate in the gradual increase in the willingness of consumers to participate in express packaging recycling by the government is more influential, because the government's participation in the express packaging recycling market is more perfect, while the government's rewards and punishment system is also a better constraint on the unethical behavior of the main body of the express packaging recycling.

5.4 Impact of Government Subsidy Allocation Coefficients on System Evolution

Figure 4 shows the impact of changing the distribution coefficient of the government's subsidies to online shopping platforms and consumers on express packaging recycling under other unchanged conditions, which can be analyzed from Figure 4, when a=0.2, that is, when the government's subsidies are biased towards consumers, the probability of the government and online shopping platforms to participate in the recovery of express packaging converges slowly to 1, and with the government's subsidy coefficient a more and more inclined to online shopping platform, the probability of the online shopping platform and the government to participate in express packaging recycling tends to accelerate gradually to the rate of 1, and eventually tends to stabilize the strategy; in contrast, although consumers will eventually tend to stabilize the strategy, but the rate of consumers to participate in express packaging recycling tends to slow down to the rate of 1, and the impact of the coefficient of subsidy in favor of the consumer is decreasing and increasing.
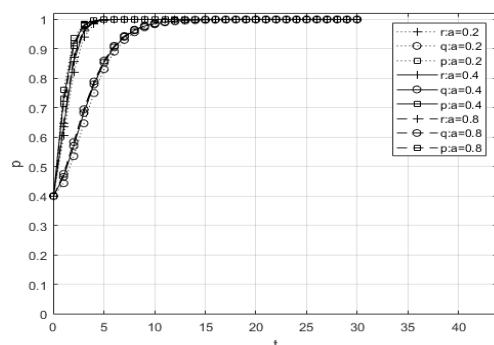

Figure 4: Impact of systematic evolution of government subsidy allocation coefficients

For the above results, the reason is that the reduction of subsidies has weakened the enthusiasm of consumers to participate in express packaging recycling, although increasing the subsidy coefficient of online shopping platforms can help the government and online shopping platforms to better participate in express packaging recycling, but it is still necessary to moderate, that is, to choose an appropriate coefficient that favors online shopping platforms while also allowing consumers to get a subsidy range they can accept, that is to say, when the government formulates the relevant policies, it is necessary to choose an appropriate coefficient that can make consumers get a subsidy range they can accept. That is to say, the government in the formulation of relevant policies, to do a good job of public opinion research, to understand the aspirations of the masses, to analyze the scope of subsidies in which consumers can participate in the recovery of express packaging to play a role in promoting the final decision-making.

5.5 The Impact of Government Penalties on Online Shopping Platforms on System Evolution

As can be seen from Figure 5, when $P_1 = 0.5$, i.e., when the government's penalty for online shopping platforms is low, the probability of online shopping platforms, consumers, and the government's participation in express packaging recycling varies slowly approaching 1, and with the increase of P_1, the online shopping platforms' participation in express packaging the probability of recycling tends to 1 at an accelerating rate, and eventually tends to stabilize the strategy. The reason for this phenomenon is that the lower penalty allows online shopping platforms to dare to slow down the implementation of the policy in order to obtain other benefits, and with the increase of the penalty, the gains obtained by the online shopping platforms participating in behaviors contrary to the policy are not enough to pay the penalty, which makes the online shopping platforms have to speed up implementation of the policy-guided courier packaging recycling behaviors, so that they can reach the stabilization strategy more quickly.
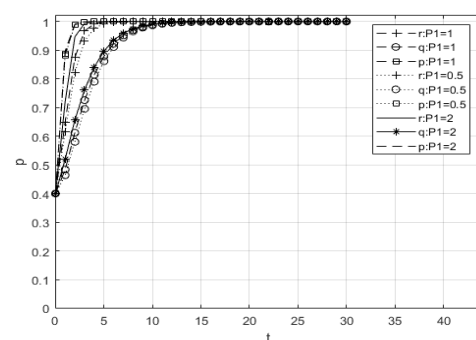

Figure 5: Impact of government penalties on online shopping platform

In summary, online shopping platforms and consumers want to achieve the optimal results, the supervision and promotion of government departments is necessary, the lack of government policies and incentives and penalties, both sides will be difficult to achieve the optimal results, so the process of courier packaging recycling needs to be supervised by the government's policy as well as to promote, so that the online shopping platform to get to the courier packaging recycling motivation, the consumer to get to courier packaging

recycling enthusiasm, so as to realize the stability of the strategy. The process of express packaging recycling needs government policy supervision and promotion, so that online shopping platforms get the motivation to carry out express packaging recycling, and consumers get the motivation to carry out express packaging recycling, so as to realize the optimal results of evolution.

6. Conclusion

This paper takes the difficulties and problems that express packaging recycling is facing as the background, and analyzes the stability of the strategy choices of the three main parties in express packaging recycling by constructing a tripartite evolutionary game model of the government, online shopping platforms and consumers, and reveals the impact of different strategy choices on the recycling effect. In the above simulation procedure, we can get:

1) The willingness of online shopping platforms to participate in express packaging recycling is influenced by government policy choices to a greater extent. The government reward and punishment mechanism can affect the willingness of e-commerce companies to adopt recycled packaging, although the initial willingness of the government to participate in the online shopping platform and consumers is not obvious, but with the government's willingness to formulate mandatory policies continue to improve the willingness of online shopping platforms and consumers to participate in the recovery of courier packaging, that is, the government's policy participation in the market of courier packaging recycling is more reasonable, and enhances the participation of online shopping platforms and consumers. The willingness of online shopping platforms and consumers to partake in the recycling market has been enhanced. Therefore, the online shopping platform as a key role in the recovery of express packaging, its implementation of express packaging recycling efforts and program selection have an important impact on the recovery of express packaging, the platform should be the backbone of express packaging recovery, should be developed for different situations of feasible and excellent recycling program to reduce the protection of waste, and establish a good corporate image.

2) The government performs a leading role in express packaging recycling. This paper finds that, compared with the high willingness to participate in the consumer, low willingness to participate in the government to develop mandatory recycling and incentives and penalties for the willingness to increase over time and the growth of the magnitude is greater, that is, when the consumer's willingness to participate in the recovery of courier packaging is not very strong, the government will play a dominant role in the external reasonable guidance planning, improve the courier packaging recycling operation mechanism, cultivate the consumer courier packaging recovery awareness, improve consumer willingness to participate in express packaging recycling. It can be seen that the consumer is the party that needs incentives and publicity, the initial enthusiasm of consumers is not affected by the willingness of the government and online shopping platforms, but with the increasing willingness of the government to participate in the recovery of express packaging, consumer participation in express packaging recycling convergence continues to accelerate, i.e., in the behavior of express packaging recycling, the government should be through the increase in publicity or incentives and other behavior, to cultivate consumer awareness of environmental protection and improve consumer participation in express packaging recycling. Environmental protection awareness and improve the willingness of consumers to partake in express packaging recycling.

3) The mutual influence of the government, online shopping platforms and consumers in express packaging recycling. Consumers are more affected by the government's willingness to participate than by the online shopping platform, and the influence of consumers on the government's willingness to participate will progressively increase over time. Therefore, the government should actively improve the rules of the express packaging recycling market, optimize the environment of the express packaging recycling market, improve the enthusiasm of consumers to participate in express packaging recycling, establish an express packaging recycling environment based on consumer participation, online shopping platforms to actively fulfill, and give full play to the government's role in the process of express packaging recycling, express packaging recycling and camping together to create a green and sustainable development to provide good Take the initiative.

The existing model in this paper only includes the government, online shopping platforms and consumers as the three main parties, and does not take into account the key stakeholders such as packaging manufacturers and recycling enterprises, which cannot fully reflect the synergistic effect of the industry chain. In the future, we can construct a five-party game model consisting of government, platform, consumer, producer and recycler to analyze the synergistic mechanism of the industry chain, and further explore related fields. Future research needs to break through the static framework and a single subject perspective, through dynamic, refined and empirical upgrading, in order to provide scientific support for the construction of an efficient and fair express packaging recycling governance system.

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