Evolutionary Game Analysis of the Participants in the Realization of Ecological Product Value

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Abstract: Realizing the value of ecological products is the key point to realize the integration of the dual goals of ecological civilization construction and economic development in China, and is a powerful grip for promoting industrial transformation and upgrading and implementing high-quality development tactics. In the value realization mechanism of ecological products, it is most critical to coordinate the relationship among farmers, ecological product developers and the government. Based on the systematic analysis of the game relationship among three subjects, this study constructs a game model and uses evolutionary game and numerical simulation methods to analyze the model, obtains the conditions of pure strategy selection of three subjects and the evolutionary law of mixed strategy probability combinations. This study confirms the crowding-out effect and the effectiveness of combining incentive policies such as government subsidies, fines, and required loss compensation, providing a decision reference for building an eco-product value realization system from the perspective of organizational relationship governance and policy mechanism construction.

1. Introduction

The Third Plenary Session of the 18th CPC Central Committee explicitly called for deepening the reform of the system for ecological progress, accelerating the establishment of the system for ecological progress, and promoting the formation of a new pattern of modernization featuring harmonious development between man and nature. As the construction of ecological civilization deepens, the ecological concept of the Party and the country is also gradually changing, and the importance of ecological industry and ecological economy development is re-examined. Equal emphasis on ecological civilization construction and ecological economic development is a scientific development model that implements General Secretary Xi Jinping's important concept of "clear waters and lush mountains, but also invaluable assets".

Among the development modes of ecological economy, the value realization mechanism of ecological products has received the most extensive attention at present [1]. In the current exploration and practice in China, the mechanisms to realize the value of ecological products mainly include ecological title trading, ecological resources operation, development and utilization, eco-compensation, etc [2]. Through the transaction and reorganization of ecological resources, ecological products are created, ecological consumption services are provided, and ecological industries are developed [3]. Due to the separation of ownership, occupation, use right, usufruct, and other rights and interests of ecological resources and products, the value realization mechanism of ecological products usually requires the joint participation of the government, the market and farmers, and adopts a mixed operation and development mode [4]. In this model, the government ACTS as planners, coordinators, and supervisors, the market is the main subject of ecological product development and operation. On the one hand, farmers are the beneficiaries of the realization of the value of ecological products, but on the other hand, they will also be the supervisors of the excessive exploitation of ecological resources and ecological environment pollution in the process of realizing the value of ecological products.

There are many participants during the realization mechanism of ecological product value. But different participants play different roles. As they have different interest demands, there are game relations among them. In fact, many scholars have applied game theory method to explore the mechanism of ecological product value realization. For example, Mengfei Gao et al. (2019) constructed a gambling model between forest farmers and the local government when implementing ecological compensation in the process of commercial forest development [5], and Wanlin Cao (2016) systematically discussed the evolutionary game mechanism of consumers' consumption decisions of ecological products in the market [6].

However, at present, domestic and foreign studies on the value realization of ecological products mainly focus on approaches [7], models [8], problems [9], and tactics [10], and lack systematic discussion on the participants and their relationships in realizing the value of ecological

products. Therefore, this paper incorporates the government, ecological product developers (representing market forces), and farmers (representing social forces) into the research model, adopts the evolutionary game method to explore the operation mechanism and evolutionary path of ecological product value realization. At the same time, we use MATLAB simulation method to deduce the stable game tactic among the participants in the system, so as to provide theoretical guidance for the construction of a smooth and efficient realization mechanism of ecological products.

2. Game Relation Analysis

There are narrow sense and broad sense of ecological products. In the narrow sense, ecological products refer to the safe ecological system, good living environment, and natural products such as air and water directly obtained from the ecological system that have no direct relationship with human labor. Ecological products in a broad sense include processed products produced through green and clean technologies in addition to natural products [11]. The main actors involved in realizing the value of ecological products include the government, farmers and ecological product developers, and their contradictory relations and conflicts of interest have an important impact on the operation and development of the value realization system of ecological products [12]. The ecological product value realization system has two goals: the realization of value brought by product development, and the quality improvement of the ecosystem that integrates development, operation and protection. These two goals are difficult to achieve at the same time most of the time, but, only in the case of system design and multi-party collaborative governance is it possible to achieve a delicate balance and harmonious evolution of the two [13]. The relationship game between the government, farmers and ecological product developers is the mechanism and path to achieve this balance.

(1) Game relationship between local government and farmers. Local governments mainly play the role of communication and control in the value realization mechanism of ecological products. When farmers and developers of ecological products conflict, local government should balance and solve their interest demands. The government should not only do a good job in planning the development of ecological industry, fully integrate and utilize local ecological resources to promote the development of local ecological economy, but also do a good job in recycling ecological resources and protecting the development of ecological environment to maintain the health and stability of the ecosystem. That requires the government to regulate the development activities of eco-product developers so that both development and conservation are within a reasonable limit. However, the government is not a direct participant in the realization of the value of ecological products, and there is an information gap between the government and ecological product developers. Farmers' participation in the supervision of environmental protection is the key to solving the problem of information asymmetry [14]. Moreover, farmers themselves also have their own interest demands for ecological environmental protection, and they are willing to actively participate in environmental protection. When developers of ecological products infringe upon the rights and interests of farmers in ecological resources and environment or the distribution of benefits in realizing the value of ecological products, farmers will actively seek protection from the government. If the government can deal with the problem in a timely and effective manner, farmers will vote for the local government and take actions to support the government. If the government does not work in a timely manner, handles problems inappropriately or does not supervise effectively, it may cause dissatisfaction among farmers, encounter resistance and lead to a decline in government's credibility.

(2) Game relationship between farmers and developers of ecological products. The development activities of ecological product developers are conducive to promote local social and economic development, improving the living standards of farmers and stimulating urban and rural employment. However, developers of ecological products may take some destructive development activities or excessively exploit and utilize resources in the pursuit of maximizing economic benefits, thus causing pollution and damage to the ecological environment. When ecological product developers choose unreasonable development methods, developers will choose to hide information from the government, but the farmers who suffered losses will gradually find out. When farmers find possible problems in the process of realizing the value of ecological products, generally speaking, they will choose to negotiate with the developers of ecological products. For example, if there are some price declining, farmers will struggle for their benefit together with developers of ecological products. However, most of the time, farmers have weak negotiation ability and are in a weak position, so their rights and interests cannot be protected. Farmers will seek for help from government and try to solve problems actively. These measures will interfere with the actions of ecological product developers and intensify the contradiction between ecological product developers and farmers. Certainly, if ecological product developers and farmers can foresee each other's actions, they may consider each other's goals and bottom line before making decisions, and make compromises in advance and prepare for later actions, which is the reflection of game relationship.

(3) The game relationship between the government and ecological product developers. On the one hand, the government hopes to attract ecological product developers to develop ecological products in the local area by attracting investment, so as to drive local employment and local economic development. Therefore, in the process of realizing the value of eco-products, there is a certain degree of consistency and even interdependence between the government and developers. The strength of this dependence determines the government's supervision effect on the development behavior of ecological product developers. On the other hand, On the other hand, the government, as the protector of public rights and interests, must take the protection of public rights and interests and

the protection of the ecological environment as its goal and code of action, otherwise it may cause tension among the masses and affect the image and credibility of the government. This constraint mechanism compels the government to make appropriate supervision on the developers of ecological products and to guide legitimacy and sustainability in the process of realizing the value of ecological products.

3. Hypotheses

3.1 Model assumption

Game theory is based on scientific and standardized mathematical models to explore the method by which players choose dynamic optimal solution tactics under existing conditions [15]. Evolutionary game combines game analysis and dynamic evolution mechanism, which can simulate the tactic evolution paths and dynamic equilibrium tactics of multiple parties in the game, which is in line with the reality of this study [16]. Therefore, the evolutionary game analysis method is adopted to construct and analyze the model in this study. Here, based on the game relationship between participants and the method requirements, we make the following assumptions for participants:

Hypothesis 1: In the value realization system of ecological products, there are three players: local government, local farmers, and ecological product developers. The tactic selection space of local governments is (strict supervision, light supervision), the tactic selection space of ecological product developers is (reasonable development, unreasonable development), and the tactic selection space of local farmers is (inform, do not inform).

Hypothesis 2: All three players are bounded rational and have incomplete information.

Hypothesis 3: According to the requirements of China's environmental protection policy, the government's supervision of ecological environment has become a normal task. However, the government can adjust the regulatory tactic according to its dependence with ecological product developers, and take the regulatory tactic as the starting point to guide and encourage ecological product developers. When the government strictly supervises, developers of ecological products will be punished if they have unreasonable development behavior. When the government relaxed regulation, the unreasonable development behavior of ecological product developers will be hidden protection. When the government adopts a light-touch regulatory tactic, the cost is negligible compared with strict regulation.

Hypothesis 4: When farmers choose informing tactic, the government needs to take regulatory measures on ecological product developers, solve the problems after verifying the problems, and reward the informants. However, if the government adopts a relaxed supervision tactic when the farmers choose to inform, the government will have to pay extra costs to verify the relevant problems. If problems informed to the government by farmers about eco-product developers are verified, the government will punish eco-product developers and require them to compensate the farmers for their losses. However, if farmers choose not to inform the problem, eco-product developers are not required to compensate farmers for their losses, even if government supervision finds problems.

3.2 Parameter setting

(1) The cost incurred by farmers when they choose to inform (C1), including environmental testing costs and litigation costs, etc.

(2) The cost invested in environmental protection when developers of ecological products develop rationally (C2).

(3) Regulatory cost when the government chooses strict regulatory strategies (C3).

(4) Developers of ecological products should be subsidized by government preferential policies when they develop them reasonably (G).

(5) When developers of ecological products adopt unreasonable development tactics, the government shall impose a fine on them (E).

(6) Negative spillover effect obtained by the government when ecological product developers choose unreasonable development tactics (W).

(7) When the developers of ecological products develop irrationally and the government regulates loosely, reputation loss is caused by the decline of the government's credibility (F).

(8) When developers of ecological products choose unreasonable development, environmental pollution and ecological damage will bring social reputation loss to developers (R).

(9) After the problem is verified, the government gives the reward to the informing farmer (S).

(10) Losses of farmers caused by environmental pollution and ecological destruction (M).

(11) When the developers of ecological products have unreasonable development behaviors and are informed, they must pay compensation to the farmers who suffer losses (N).

(12) The probability that farmers choose the informing tactic is X, the probability that ecological product developers choose the rational development tactic is Y, and the probability that the government chooses the strict supervision tactic is Z. The total probability of the whole set of policies in the three-way policy space is 1.

3.3 Pay off matrix

Based on the above model assumptions, the mixed-tactic income matrix of farmers, ecological product developers and the government in the realization of ecological product value is constructed, as shown in Table 1.

Table 1. Income matrix of the three parties in the realization of ecological product value

		Ecological product developer	Government	
			Severely supervision z	Lax regulation 1-z
Farmer	Inform x	Rational exploitation y	（-C1, G-C2, -C3-G）	（-C1, G-C2, -C3-G）
		Unreasonable development 1-y	（-C1-M+S+N, -E-N-R, -C3+E-W-S）	（-C1-M+S+N, -E-N-R, E-W-S-C3-F）
	Do not inform 1-x	Rational exploitation y	（0, G-C2, -C3-G）	（0, -C2, 0）
		Unreasonable development 1-y	（-M, -D-R, -C3+E-W）	（-M, -R, -W-R）

4. Model Analysis And Simulation Test

4.1 Pure tactic analysis

By analyzing the payoff matrix of the three-way game, we can find the possible pure tactic Nash equilibrium and its conditions. After analysis, we find that (inform, reasonable development, strict regulation), (inform, reasonable development, light regulation), (do not inform, reasonable development, strict regulation) and (inform, unreasonable development, light regulation) are not pure tactic combinations of Nash equilibrium. However, pure tactic combinations (do not inform, rational development, light regulation), (inform, unreasonable development, strict regulation), (do not inform, unreasonable development, strict regulation), and (do not inform, unreasonable development, light regulation) may appear Nash equilibria as long as they satisfy conditions (1) and (4), respectively.

$$C_2 < R \quad (1) \qquad \begin{cases} C_1 < S + N \\ C_2 > R + E + N + G \end{cases} \quad (2)$$

$$\begin{cases} C_1 > S + N \\ C_2 > R \\ C_3 < F + E \end{cases} \quad (3) \qquad \begin{cases} C_1 > S + N \\ C_3 > F + E \end{cases} \quad (4)$$

By analyzing the above conditions, we can draw the following conclusions:

(1) Whether ecological product developers choose a reasonable development tactic mainly depends on the consideration of C_2, the input cost of environmental protection. If C_2 is small and can be lower than the social reputation loss R caused by environmental pollution and ecological destruction, then ecological product developers will establish a self-restraint mechanism and consciously choose reasonable development tactics without the need for government and social supervision. However, this situation is difficult to arise in reality, because the cost of ecological protection and governance is usually not low. In order to achieve the conditions through guidance, the developer's social reputation loss R must be increased, which requires the establishment of the whole society's supervision mechanism and reputation mechanism.

(2) If the ecological environmental protection input cost of product developers C_2 is very high, even higher than the developers' social reputation losses R, government fines E, compensate farmers N and government subsidies G, the sum of the developer will not have the intrinsic motivation to choose reasonable development tactic, but will choose not to reasonable development tactic, giving farmers the inform and government regulation. From another perspective, we can find effective tactics to prevent unreasonable development behavior of developers. From the social perspective, we should establish a social reputation system to improve the potential cost of social reputation loss of developers. From the point of view of the government, at the same time, we should increase the subsidy and reward of reasonable development and the penalty and punishment of unreasonable development to form effective guidance and incentive. From the perspective of the market, we will establish a sound contract system to allow developers to compensate farmers for their losses and protect the basic rights and interests of farmers in terms of ecology and living environment.

(3) If the environmental protection input cost C_2 of the ecological product developer is high, which is higher than the sum of social reputation loss R, government fine E, compensation for farmer loss N and government subsidy G (this is the most realistic situation), this When ecological product developers choose a reasonable development tactic, it comes not from internal motivation but from external regulatory pressure. Moreover, this regulatory pressure does not actually come from the informs of farmers, but more from the attitude and actions of the government to strictly regulate. However, if the government wants to adopt strict supervision tactic, it also needs the condition that the cost of strict supervision, C_3, should be low, at least lower than the sum of the loss of credibility, reputation and fine income, F and E. However, the cost of strict supervision cannot be too low, so the key for the government to establish a strict supervision mechanism is to establish a public trust system of the government, or for the government to increase the punishment of unreasonable development behavior, to compensate for the cost of supervision with the fine income.

(4) The condition for farmers to choose the informing tactic is that the informing cost C_1 should be low, which should be at least lower than the sum of the government reward S and the developer's loss compensation N after informing. Otherwise, farmers will choose not to inform the tactic. The condition for the government to choose a strict regulatory tactic is that the regulatory cost C_3 should be low. When C_1 and C_3 are very high, the ecological products value realization mechanism of social supervision and government supervision system paralysis, unreasonable ecological product developers have enough power to choose development tactic, to contribute to the ecosystem and environment damage, ecological resources may be excessive development and unsustainable utilization, tragedy of public products.

4.2 Mixed tactic analysis based on evolutionary game

When there is no pure tactic Nash equilibrium in a three-way game, they will play a mixed tactic, that is, they will combine their strategy sets in a probabilistic form.

According to the construction principle and steps of the evolutionary game model [17], it is not difficult to obtain the replication dynamic equation of pure tactics combined by probability based on the three-party payoff matrix.

The replication dynamic equation of the probability x of farmers choosing the informing tactic is:

$$F(x) = dx/dt = x(1-x)[S - C_1 - y + N(1-y)] \quad (5)$$

The replication dynamic equation of the probability y of ecological product developers choosing reasonable development tactics is:

$$F(y) = dy/dt = y(1-y)[(G+E)(x+z-xz) + Nx - C_2 + R] \quad (6)$$

Choosing a strict regulatory tactic is:

$$\begin{aligned} F(z) &= dz/dt \\ &= x(1-x)[z(1-z)(E - C_3 - Ey - Gy - Ex + Exy + Gxy + C_3x - Fy + F)] \end{aligned} \quad (7)$$

The replication dynamic equation reflects the adjustment direction and speed of the mixed tactic by farmers, ecological product developers and government. When all three equations are equal to zero, the tactic adjustment stops and the three-way game reaches the equilibrium stable state. Theoretically, the equilibrium mixed tactic can be obtained by solving the system of equations when the three equations are all equal to zero. However, considering that the system of equations has many parameters, the equilibrium solution is complicated and the information interpretation is weak, so the system of equations is not solved in this paper.

In order to be more realistic and refer to the latest research results in the field of evolutionary game, we introduce a dynamic reward and punishment system [18, 19]. Let $G^*=P_1Gy$, $E^*=P_2G(1-y)$, $N^*=P_3N(1-y)$. Among them, P_1, P_2 and P_3 are subsidy, penalty and compensation coefficients respectively. Thus, G^* represents the dynamic subsidy given by the government to ecological product developers, which is positively correlated with the probability Y that ecological product developers choose reasonable development tactics. E^* represents the government's dynamic punishment for ecological product developers who choose unreasonable development tactics, which is positively correlated with the probability (1-y) of ecological product developers choosing unreasonable development tactics. N^* represents the compensation that ecological product developers need to make to farmers after being informed, which is also positively correlated with the probability (1-y) that developers choose unreasonable development tactics.

When the probability y is 1, there have $G^*=P_1G$ and $E^*=N^*=0$; With probability y equal to 0, there have $G^*=0$, $E^*=P_2E$, and $N^*=P_3N$. For simplicity without loss of generality, let P_1, P_2, and P_3 be equal to 1. By introducing the dynamic reward and punishment system, the optimized replication dynamic equations can be obtained, as shown in Equation (8).

$$\begin{cases} F(x) = x(1-x)(S + N^* - C_1 - y) = 0 \\ F(y) = [G^*(1-y) + E^*y](x + z - xz) + N^*xy + y(1-y)(R - C_2) = 0 \\ F(z) = x(1-x)\{z(1-z)[(E^* - G^* - C_3)(1-x) + F(1-y)]\} = 0 \end{cases} \quad (8)$$

By solving Equation (8), the following conclusions can be obtained:

(1) Either (x^*, y^*, z^*) or (0,1,0) is the solution of the system of equations, but (0,0,0) is more stable than (0,1,0). That is, when the farmers and the government are not responsible for the supervision, the decision-making of ecological product developers will tend to evolve towards unreasonable development tactics.

(2) In the case of $x^*=0$ and $y^*\neq 0$ or 1: when $C_2<R$, z^* will have no solution; When $C_2 \geqslant R$, $z^* = \frac{y(1-y)(C_2-R)}{G^*(1-y)+E^*y}$. In this case, if $y^*<0.5$, then $z^{*'}>0$; Otherwise, $z^{*'}<0$. That is the probability that the government chooses the strict supervision tactic depends on the probability that the ecological product developers choose the reasonable development tactics. When the ecological product developers are more inclined to choose the unreasonable development tactic, the government will increase the probability of strict supervision. On the contrary, when the probability of ecological product developers choosing reasonable development tactics is high, the government will consider lowering the probability of strict supervision tactics, which deeply reflects the game relationship between the government and ecological product developers.

(3) When $x^*=1$, z^* is independent of y^* and $y^* = \frac{M \pm \sqrt{M^2 + 4G^*(R-C_2)}}{2(R-C_2)}$ is constant, Among them, $M=E^*+N^*-G^*+R-C_2$. This implies that when farmers choose the informing tactic, the government will tend to choose to give up the game with ecological product developers, and change from government administrative supervision to seeking social supervision. In this case, the regulatory environment faced by ecological product developers is actually completely determined. It only needs to decide whether to choose a reasonable development tactic according to its own revenue function, and can find the optimal probability of choosing a reasonable development tactic.

(4) Under the condition that the selection probability of rational development tactic of ecological product developers is fixed ($y^*=S+N^*-C_1$), the probability of farmers choosing informing tactic is related to the selection probability of government strict supervision tactic. When $z^*=0$, there's $x_1^* = \frac{y^*(1-y^*)(C_2-R)}{G^*(1-y^*)+(E^*+N^*)y}$; When $z^*=1$, there have $x_2^* = \frac{y^*(1-y^*)(C_2-R) - [G^*(1-y^*)+E^*y]}{N^*y}$. And, by simple proof, we get $x_1^*>x_2^*$. It can be seen that when the tactic of ecological product developers is fixed, farmers tend to lower the probability of choosing informing tactic if the government strictly regulates them, while farmers tend to increase the probability of choosing a informing tactic if the government chooses loose supervision. This reflects the function substitution between social supervision and government supervision, and also reflects the game relationship between the government and farmers.

4.3 Mathematical simulation

In order to observe the evolution process of tactic selection probability of farmers, ecological product developers and government more intuitively, we use MATLAB software to conduct numerical simulation. Considering the policies and measures of local governments in realizing the value of ecological products and ecological environmental protection and the actual situation of realizing the value of ecological products in China, combined with the model logic, the initial values of relevant parameters are set as follows: C_1=0.5, C_2 =4, C_3=2, G=2, E=3, W=3, F=2, R=1, S=2, M=1.5, N=2. The evolution time T is set as 30, and the parameters are substituted into the replication dynamic equation to obtain the simulation results of the evolution process of the mixed tactic selection probability (x, y, z) of farmers, ecological product developers and government, as shown in Figure 1.

As can be seen from the figure, under the current parameter Settings, the probability that the government chooses strict supervision and the probability that farmers choose informing tactic will both increase rapidly and eventually approach 1. The probability of ecological product developers choosing a reasonable development tactic also converges rapidly, but it is not close to 1, it is about 2/3. This is very accord with the current Chinese society actual: farmers and government for the development of ecological resources and ecological environment protection have to strengthen the will of the supervision and regulation, regardless of the regulation. However, no matter how strong the regulation is, eco-product developers with the goal of maximizing profit will always prefer to choose a mixed tactic rather than a pure tactic. In other words, the hybrid tactic can keep a special dynamic balance between rational and irrational development tactics for ecological product developers, making them walk in the middle ground. And this tactic can realize the combination of normal returns from government regulation and social supervision and excess profits under the irrational development tactic.

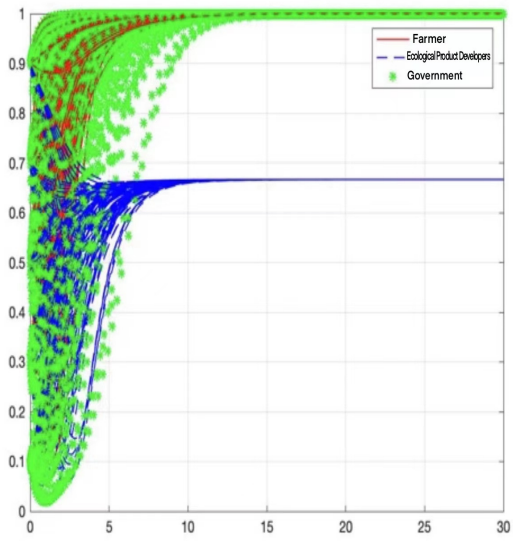

FIG 1. Evolution diagram of mixed tactic selection probability under three-way game

The government subsidy G was raised from 2 to 2.5, and a new evolution path diagram was obtained (see Figure 2). On this basis, the government's penalty E for the unreasonable development tactic of ecological product developers is raised from 3 to 3.5, and the evolution path diagram is obtained (see Figure 3).

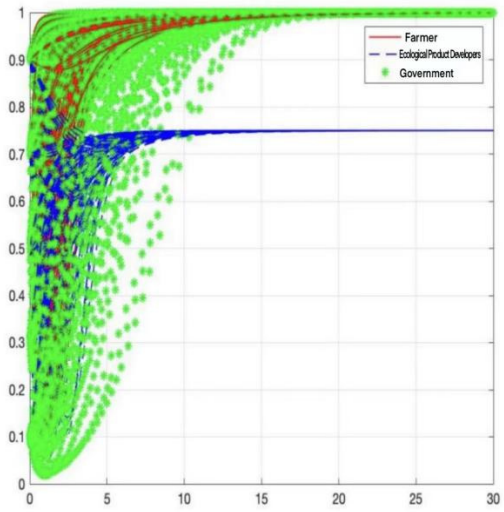

FIG 2. Probability evolution (G=2.5, other parameters unchanged)

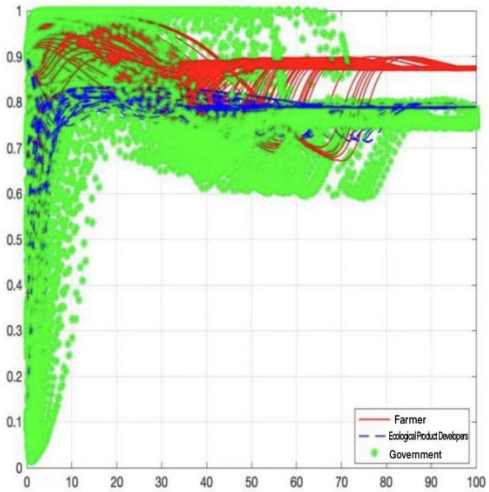

FIG 3. Probability evolution (G=2.5, E=3.5, other parameters unchanged)

As can be seen from FIG 2, when the government subsidy increases, the tactic selection probability of government supervision and farmer supervision will converge at a slower speed, but the convergence value will not change greatly and will still approach 1. The limit probability of ecological product developers choosing reasonable development tactics is significantly increased, from 2/3 to 0.8. This proves that government subsidies play a positive role in guiding and encouraging ecological product developers. As can be seen from Figure 3, when the government further increases the punishment for the

unreasonable development behavior of ecological product developers, the punishment itself can be used as an effective supervision tactic. At the same time, it also released a signal that the government will strictly supervise society and farmers and crack down on unreasonable development behaviors. In this case, the supervision intensity of both the farmers and the government can be moderately reduced. As shown in Figure 3, the probability of the farmers choosing the informing tactic will approach 0.9, while the probability of the government choosing the strict supervision tactic will decline more significantly and finally approach 0.8. It is worth pointing out that the comparison between Figure 2 and Figure 3 shows that the probability of ecological product developers choosing a reasonable development tactic will hardly change significantly even if the punishment is increased. This implies that from the standpoint of eco-product developers, whether it is administrative supervision, social supervision, or economic punishment, the intensity of supervision they feel will not change significantly, only the regulatory measures have changed. Further analysis shows that, in the case of sufficient supervision, increasing punishment will crowd out the functions of existing supervision measures, and the actual supervision effect will not be significantly improved.

The cost of compensating farmers for losses N is raised from 2 to 3, and the probability evolution path is shown in FIG. 4. By further combining the first two changes, the government subsidy G, government penalty E and compensation loss N to farmers are all raised at the same time, and G=2.5, E=3.5 and N=3 are set to obtain the probability evolution path as shown in FIG.5. To better observe the long-term evolution trend, the simulation period is increased to 100 in Figure 5.

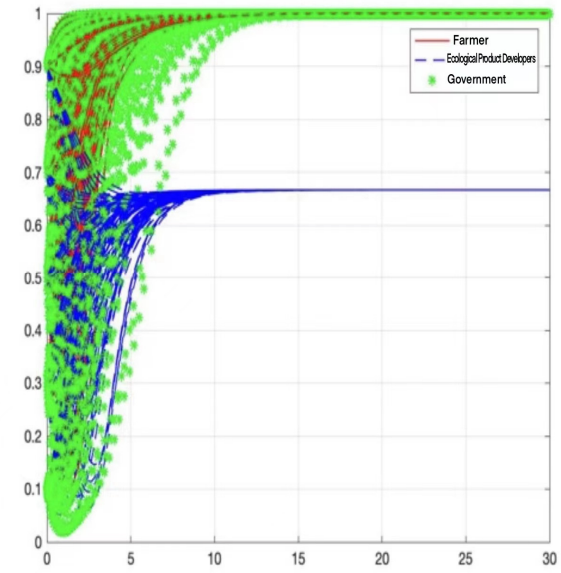

FIG 4. Probability evolution (N=3, other parameters unchanged)

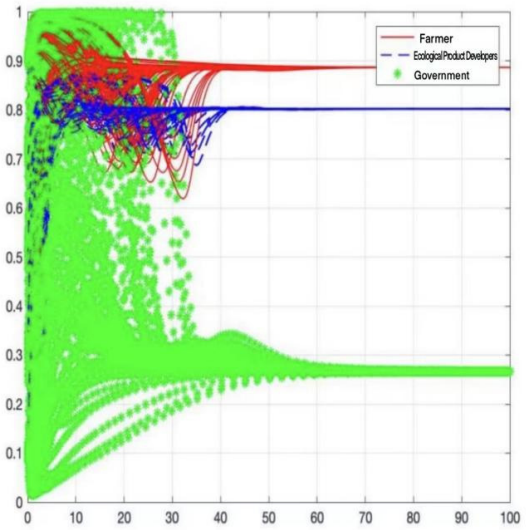

FIG 5. Probability evolution (G=2.5, E=3.5, N=3, other parameters unchanged)

As can be seen in Figure 4, when the cost of ecological product developers to compensate farmers for their losses increases, it has a significant effect on the probability of ecological product developers to choose a rational development tactic, as shown by an increase in the probability convergence value and a faster probability convergence rate. But has almost no significant effect on the probability of farmers to choose a reporting tactic and the government to choose a strict regulation strategy. According to Figure 5, when government subsidies, fines and compensation for farmers' losses are increased, the probability of the government choosing a strict regulatory tactic will decrease significantly, and the government is even more inclined to choose a loose regulatory policy. The probability of choosing the informing tactic will also decrease significantly, but the decrease is not significant, and the final retention level is still high (close to 0.9). The convergence probability of ecological product developers choosing reasonable development tactics remains unchanged at 0.8 at the peak value. Simulation results show that when the government through subsidies and punishment policy to achieve greater strength and potential losses can get effective guarantee farmers, the government will choose to believe that the ecological product developers have enough motive and pressure to rationally develop ecological products and legal development of ecological industry, ecological reaction product developers to do so). At this time, the government will create a loose regulatory environment to support the value of ecological products to realize system operation and develop ecological economy.

5. Conclusion And Suggestions

Under the background of national efforts to build ecological civilization and develop ecological economy, the value realization mechanism of ecological products has become a policy buzzword in recent years [20]. In the opinions on improving the tactic and system of functional

zones issued by the CPC Central Committee and The State Council in 2017, it was clearly proposed to carry out pilot ecological product value realization mechanisms in Zhejiang, Jiangxi, Guizhou and Qinghai provinces. In April 2021, the "Opinions on Establishing and Improving the Mechanism for Realizing the Value of Eco-products" was officially issued, becoming China's first programmatic document that puts the concept of realizing the value of ecological products into the level of institutional arrangement and practical operation. Under this macro background, it is of great practical significance to study the organizational mechanism of realizing the value of ecological products.

This study believes that the most urgent problem to be solved in mechanism for Realizing the Value of Eco-products is the conflict between the goal of ecological environmental protection and the goal of economic value realization. And the key point to alleviate this conflict is to effectively organize and highly coordinate different participants in the realization of the ecological product value. Furthermore, the basic premise of organization and coordination is to establish a mechanism of benefit allocation and right protection among participants, so that different objectives among participants can achieve dynamic balance in the same scene of realizing the value of ecological products. In this paper, the complex relationship between participants is interpreted as a game, and the evolutionary game theory is used for scientific interpretation and modeling analysis. The results not only confirm the game relationship between participants in the theoretical analysis, but also reflect the influence of government policies such as subsidy incentives, economic penalties and loss compensation on the behavior tactic of participants in the realization of ecological product value.

According to the results of this study, we can get the following main conclusions: (1) In the mechanism for Realizing the Value of Eco-products, there will be game relationships among farmers, ecological products developers, and governments, and they have different goals and interests in ecological product development and ecological environmental protection. The key to the healthy and orderly operation and sustainable development of the ecological product value realization system is to promote the dynamic balance of their relationship through a complex benefit distribution and incentive guarantee mechanism; (2) Due to the profitability, ecological product developers will have the motivation to choose unreasonable development tactics under the comprehensive consideration of cost and income. And the unreasonable development of ecological resources and products will harm the interests of farmers. Therefore, farmers will choose the informing tactic. The government's function is to coordinate the interest conflicts between farmers and eco-product developers through social supervision and administrative measures. And government will take into account the comprehensive benefits of economic and environmental benefits under the perspective of government strategic perspectives; (3) The government can create a package of incentive policies such as subsidies, punishment, and ordering the Ecological product developers who violate regulations to compensate the farmer’s economic losses, and these policies can indeed achieve the expected effect on guiding and restraining ecological product developers' behaviors. However, when the policy intensity reaches a high level, there is no superposition but rather a crowding-out effect between higher intensity policies, making the policy pressure felt by eco-product developers reach the limit, which is manifested in the convergence of the probability of tactic choice of eco-product developers.; (4) Regardless of the positive subsidy policy or the negative punishment tactic, these incentive policies can produce effects. Compared with administrative supervision, the government is more inclined to adopt incentive policies to achieve the purpose of promoting the realization of the ecological product value.

Based on the conclusion of this study, we put forward the following policy suggestions : (1) The local government should attach great importance to, effectively build and actively make good use of the social supervision mechanism, and let farmers who participate in the process of realizing the value of ecological products to be the core subject of ecological environmental protection; (2) The local government need to establish a credibility and social reputation system for business organizations, raise the opportunity cost for eco-product developers to adopt unreasonable development strategies, and guide eco-product developers to establish a proactive mechanism for rational development of ecological resources and products; (3) On the basis of social supervision, the local governments still need to establish a supervision system for problems that may occur in the process of realizing the value of ecological products, so as to provide reasonable interests and rights protection for ecological product developers and farmers; (4) Considering the high-risk and low-return characteristics of eco-product value development, in order to encourage eco-product developers, the government needs to formulate a moderate financial subsidy policy to guide eco-product developers to operate in compliance through guaranteed returns.; (5) On the basis of the construction of the supervision system, the local governments need to allocate punishment policies for violations in the ecological product value realization system, which not only protects the interests of farmers, but also safeguards the healthy and sustainable development of the ecological product value realization system.

This study has some limitations. First, in addition to farmers, ecological product developers and governments, there are also more important participants in the value realization mechanism of ecological products, such as financial institutions. Limited by model and method, the action logic and tactic of these participants are not discussed in this study. Second, in addition to the function of social supervision, farmers have more functions in mechanism for Realizing the Value of Eco-products, such as product trading and participation in management. To highlight the main contradiction, these functions are ignored in this study. Third, in the absence of empirical research, the reliability of the results and conclusions of this study needs to be supplemented by evidence from practice. These limitations will be taken into consideration and gradually resolved in future research, hoping to produce research results with more theoretical and

scientific value and practical guiding significance.

References

1. Xiangang Zeng, “The value realization mechanism of ecological products,” J. Environment and Sustainable Development, vol 45(6), 2020, pp. 89-93.
2. Fan Jiang, Tao Qin, Yongfu Wang, et al, “Value Formation and Realization of Ecological Product,” J. Forest Inventory and Planning, vol 45(3), 2020, pp. 174-177.
3. Xiahui Wang, Yuanyuan Zhu, Yihui Wen, et al, “The Basic Patterns and Innovation Path of Realizing the Value of Ecological Products,” J. Environmental Protection, vol 48(14), 2020, pp. 14-17.
4. Bowen Sun, Xushu Peng, “Realization Mode, Key Issues and Institutional Guarantee System of Ecological Product Value ,” J. Ecological Economy, vol 37(6), 2021, pp.13-19.
5. Mengfei Gao, Yuxin Wang, Jing Zheng, “Research on the Stakeholder Evolution Game of Ecological Compensation for Commercial Forests in Key Ecological Locations,” J. Issues of Forestry Economics, vol, 39(5), 2019, pp. 490-498.
6. Wanlin Cao, “Evolutionary game analysis of consumers in ecological product market,” J. Journal of Zhoukou Normal University, vol, 33(4), 2016, pp.117-121.
7. Qing Chen, Wenming Zhang, “Research on the realization path and countermeasure of ecological product value,” J. Macroeconomics, vol, (12), 2020, pp.133-141.
8. Shuilin Qiu, Leshan Jin, “Value realization of ecological Products: Theoretical basis, Basic logic and Main mode,” J. Agricultural Economy, vol, (4), 2021, pp.106-108.
9. Yan Yang, Weiming Li, Shuzhong Gu., etc al., “At present, the ecological products value realization faces the outstanding problems and challenges,” J. Development Research, vol, (3), 2020, pp. 54-59.
10. Yin Fang, Jie Li, Xiaoxiao Liu, “The Legal Mechanism for the Realization of the Value of Ecological Products: Ideal Expectations, Realistic Dilemmas and Perfect Strategies,” J. Environmental Protection, vol, 49(9), 2021, pp. 30-34.
11. Boen Liu, “The Connotation, Classification and Institutional Framework of Value Realization Mechanism of Ecological Products,” J. Environmental Protection, vol, 48(13), 2020, pp. 49-52.
12. Yihong Zhou, Ruijie Gui, “Study on realization of ecological product value of olive in Longnan, Gansu Province,” J. Friends of Accounting, vol, (9), 2020, pp. 155-161.
13. Zhi Yang, Guimin Niu, Minyuan Guo, GUO Minyuan. “Driving mechanism and interactive logic of multiple subjects in environmental governance,” J. Yangtze River, vol, 52(7), 2021, pp. 38-44.
14. Fuzhou Luo, Jing Li, “Research on Evolutionary Game of Multi-Agent Cooperative Governance of Rural Ecological Environment ,” J. Ecological Economy, vol, 35(10), 2019, pp.171-176.
15. Weiying Zhang, “Game Theory and Information Economics,” M. Shanghai: Shanghai People's Publishing House, 2004.
16. Shen, Juqin, et al. "Prospect theory in an evolutionary game: Construction of watershed ecological compensation system in Taihu Lake Basin." Journal of Cleaner Production 291 (2021): 125929.
17. Ya Li, “Evolutionary game dynamics and their applications,” M. Beijing: Science Press, 2020.
18. Zhaopeng Chu, Chen Bian, Changxin Liu, et al, “Simulation of haze pollution，regulatory governance and public participation based on evolutionary game analysis,” J． China population， resources and environment，vol, 29(7), 2019,pp.101-111．
19. Wunder, S, “Revisting the concept of payments for environmental services,” J. Ecological Economics, vol, 117, 2015, pp. 234-243.
20. Jianpeng Chen, Shiyi Gao, “Promoting ecological product value realization policy progress in China,” J. Development Research, vol, (2), 2020, pp. 57-69.