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Research Article

Green Product Market Development Strategy of Mobile Network Group Buying Community: Based on Three-Party Evolutionary Game and Simulation Analysis

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With the advent of the 5G era, the mobile network group buying community dominated by focusing on social relations shows great development potential. However, in the mobile network group buying community, the mixed information makes the information environment of the community more complex. Information asymmetry will lead to "mistakes" in consumers' choice, making it impossible for some important markets to be fully developed. Considering the gains and losses of three interest subjects—governments, enterprises, and consumers in the green product market under information symmetry, in this paper, an evolutionary game model involving governments, enterprises, and consumers was built. Numerical experiments and simulation were performed using SciPy, a scientific computing library of Python, to study the main factors influencing the healthy development of the green product market. The research results showed under information symmetry, when the governments' benefit from increased government credibility was higher than the cost of governments for screening the information of enterprises' products and identifying the green products, the expected fine of enterprises for producing high carbon products was higher than the difference between the actual cost increment and the actual income increment of enterprises for producing green products, and the utility perception of consumers from purchasing green products was higher than the cost of consumers for purchasing green products, the three-party game would evolve to a socially ideal stable state. The above conclusions provide useful policy suggestions for governments to vigorously develop the green product market.

1. Introduction

Green economy arouses wide concern among countries around the world amid growing environmental pollution, ecological environmental degradation, and global warming. In 2016, the State Council issued the opinions on establishing unified green product standards, certification, and identification system, which means that China is substantially promoting the certification and identification system of "Chinese green products." Green product refers to the product with low toxicity and little harm, health and safety, and good ecological effects, which can reduce energy consumption and pollutant emissions [1]. The development of green

economy boosts people's demand for green products. However, information asymmetry prevents enterprises from clearly conveying the attributes of their products and consumers from accurately distinguishing the green products. The "profit-driven" producers of high carbon products tend to provide false information for the low production cost of high carbon products, seriously hindering the development of the green product market.

Information asymmetry refers to the different product information owned by both the buyer and the seller in the incomplete information market, which hinders the buyer from making right choices, thus affecting the transaction behavior and market efficiency [2]. Especially information asymmetry

in the green product market will lead to so many "mistakes" in consumers' choice that they will buy so-called "green products" damaging their health, such as the fake "green pork" incident of Wal-Mart exposed in 2011. It is difficult for the green product market to be formed and fully developed as consumers cannot accurately identify the key information of green products; so, governments need to control, identify, and disclose the information of green products and standardize the development of the green product market.

In the process of formation and development of the green product market, governments, enterprises, and consumers interact with one another. Enterprises, the supplier of green products, lack the enthusiasm to produce green products because of their high production cost and large number of false green products in the market. Consumers, the demander of green products, lose confidence in the green product market for paying high prices for fake green products resulting from information asymmetry. As a result, governments should identify and disclose the information of green products as an authority, which will play a crucial role in the formation and development of the green product market.

In recent years, scholars have conducted indepth research on the behavior of relevant stakeholders in the green product market. Liu [2] used the mathematical model to study the impact of information asymmetry on the green product market based on the relationship between manufacturers and consumers. Yan and Yu [3] used the imperfect information dynamic game theory to study the process of price game between producers and consumers in the green product market. Sun and Yu [4] analyzed the role of government subsidies in the development of green products using the two-stage game model. Liu et al. [5] analyzed the impact of environmental regulation and government subsidies on the production of green products of enterprises using the panel threshold model. However, there are deficiencies in the above studies. For example, some scholars studied the behavior of producers and consumers in the market using game models, but they ignored the key role of governments in the development of the green product market; some scholars took into account the role of governments by analyzing the impact of government subsidies on the production of green products of enterprises, but they ignored the impact on consumers. Therefore, in this paper, an evolutionary game model involving governments, enterprises, and consumers was built to discuss the factors of formation and development of the green product market that influences the socially ideal stable state where governments chose the strategy of information symmetry, enterprises chose the strategy of producing green products, and consumers chose the strategy of purchasing green products, with a view to providing feasible suggestions for cultivating green products and developing green economy in China.

2. Hypothesis and Construction of the Three-Party Evolutionary Game Model

Evolutionary game theory is to study the evolutionary stable state (ESS) of game groups in a competitive environment of survival of the fittest based on the hypothesis of bounded rational man [6, 7]. Referring to the game assumptions of Cheng et al. [8], Xu and Lv [9], and Yu and Hu [10], this paper built an evolutionary game model involving governments, enterprises, and consumers.

To cultivate green industries, develop green economy, and protect ecological environment, governments need to search, identify, and publicly verify the information of green products in the trading market. Their behavior strategy space was (information symmetry, information asymmetry), with the probability of $(x, 1 - x)$, respectively. "Information symmetry" means governments identify and publicly verify the information of green products, which can help enterprises clearly convey the attributes of green products, and consumers accurately distinguish the green products and punish the high carbon products. Enterprises gain reputation by producing green products that requires huge costs and faces many uncertainty risks, and their production strategy is greatly influenced by the depth and breadth of governments' information disclosure and consumers' strategy of purchasing green products. Their behavior strategy space was producing (green products, high carbon products), with the probability of $(y, 1 - y)$, respectively. Consumers choose the strategy according to the purchase cost of green products and their utility perception from purchasing green products. Their behavior strategy space was (purchasing, not purchasing) green products, with the probability of $(z, 1 - z)$, respectively. Conforming to the hypothesis of bounded rational man, the three-party game players constantly changed their own strategy in the game so that the three-party game finally evolved to an evolutionary stable state (ESS). A game tree model of behavior strategy spaces of the three-party game players was built, as shown in Figure 1.

When choosing the strategy of information symmetry, governments will pay a cost C_g for screening the information of enterprises' products such as R & D and production, transportation and distribution, material procurement, and identifying the green products, get a fine F_e from illegal enterprises, and gain a benefit U_g from increased government credibility. When choosing the strategy of information asymmetry, governments will pay a cost F_g for being punished by higher authorities or losing credibility because of enterprises producing high carbon products.

When choosing the strategy of producing green products, enterprises will pay an additional cost C_e such as R & D cost and uncertainty cost for producing green products, gain a market return U_{e1} from producing green products, and get an additional benefit U_e from producing green products, such as improved enterprise reputation for gaining consumer recognition. When choosing the strategy of producing high carbon products, enterprises will gain a market return U_{e2} from producing high carbon products, also the cost of consumers for purchasing high carbon products, and pay a fine F_e for producing high carbon products under information symmetry.

When choosing the strategy of purchasing green products, consumers will pay a cost U_{e1}, get the utility perception U_c such as physical health and psychological satisfaction from purchasing green products, and gain an additional benefit U_{gc} from improved consumer confidence
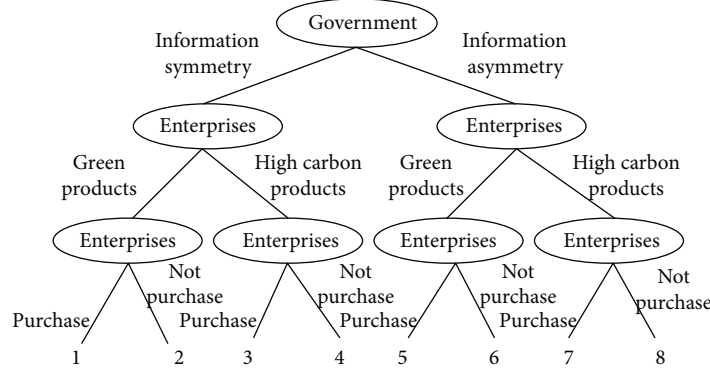
FIGURE 1: Game tree model of behavior strategy spaces of the three-party game players.

in the market products under information symmetry. Drawing on the views of Xu et al. [11], under the condition of information asymmetry, consumers are at a disadvantage and lack of understanding whether the purchased products are green products, which has hit consumers' purchase enthusiasm. If choosing green products, consumers can obtain the utility perception At the same time, pay a cost U_{e1}. When choosing the strategy of purchasing high carbon products, consumers will pay a cost U_{e2}, an additional cost C_c such as physical damage and psychological damage from purchasing high carbon products, and a negative impact C_{gc} such as environmental pollution from enterprises producing high-carbon products on consumers. The parameters of the three-party game players are shown in Table 1. According to the above assumptions and parameter settings, a payoff matrix of the three-party game players was obtained, as shown in Table 2.

3. Equilibrium Analysis of the Evolutionary Behaviors of the Three-Party Game Players

3.1. *Expected Benefits of the Three-Party Game Players.* According to Table 2, the expected benefits of the three-party game players were obtained:

Governments' expected benefit when choosing the strategy of "information symmetry," expected benefit when choosing the strategy of "information asymmetry," and average expected benefit were expressed as E_{g1}, E_{g2}, and $\overline{E_g}$, respectively:

$$
\begin{aligned}
E_{g1} &= yz(U_g - C_g) + y(1-z)(U_g - C_g) \\
&\quad + (1-y)z(U_g - C_g + F_e) \\
&\quad + (1-y)(1-z)(U_g - C_g + F_e),
\end{aligned}
$$

$$
E_{g2} = (1-y)z(-F_g) + (1-y)(1-z)(-F_g),
$$

$$
\overline{E_g} = xE_{g1} + (1-x)E_{g2}. \tag{1}
$$

Enterprises' expected benefit when choosing the strategy of producing "green products," expected benefit when

choosing the strategy of producing "high carbon products," and average expected benefit were expressed as E_{e1}, E_{e2}, and $\overline{E_e}$, respectively:

$$
\begin{aligned}
E_{e1} &= xz(U_{e1} + U_e - C_e) + x(1-z)(U_e - C_e) \\
&\quad + (1-x)z(U_{e1} + U_e - C_e) \\
&\quad + (1-z)(1-x)(U_e - C_e),
\end{aligned}
$$

$$
E_{e2} = xz(U_{e2} - F_e) + x(1-z)(-F_e) + (1-x)zU_{e2},
$$

$$
\overline{E_e} = yE_{e1} + (1-y)E_{e2}. \tag{2}
$$

Consumers' expected benefit when choosing the strategy of "purchasing" green products, expected benefit when choosing the strategy of "not purchasing" green products, and average expected benefit were expressed as E_{c1}, E_{c2}, and $\overline{E_c}$, respectively:

$$
\begin{aligned}
E_{c1} &= xy(U_c + U_{gc} - U_{e1}) \\
&\quad + x(1-y)(U_{gc} - U_{e2} - C_c - C_{gc}) \\
&\quad + (1-x)y(U_c - U_{e1}) \\
&\quad + (1-x)(1-y)(-U_{e2} - C_c - C_{gc}),
\end{aligned}
$$

$$
\begin{aligned}
E_{c2} &= xyU_{gc} + x(1-y)(U_{gc} - C_{gc}) \\
&\quad + (1-x)(1-y)(-C_{gc}),
\end{aligned}
$$

$$
\overline{E_c} = zE_{c1} + (1-z)E_{c2}. \tag{3}
$$

3.2. *Replicated Dynamic Analysis of the Three-Party Game Players*

(1) The replicated dynamic equation for governments to choose the strategy of information symmetry was

$$
\begin{aligned}
F(x) &= dx/dt = x(E_{g1} - \overline{E_g}) \\
&= x(x-1)[y(F_g - F_e) - (F_g - F_e - C_g + U_g)].
\end{aligned} \tag{4}
$$

TABLE 1: Parameters and their meanings of the three-party game players.

Parameters	Meanings
C_g	Cost of governments for screening the information of enterprises' products and identifying the green products under information symmetry
U_g	Benefit of governments from increased government credibility under information symmetry
F_g	Cost of governments for being punished by higher authorities or losing credibility because of enterprises producing high carbon products under information asymmetry
C_e	Additional cost of enterprises such as R & D cost and uncertainty cost for producing green products
U_{e1}	Market return of enterprises from producing green products, also the cost of consumers for purchasing green products
U_e	Additional benefit of enterprises from producing green products (such as improved enterprise reputation for gaining consumer recognition)
U_{e2}	Market return of enterprises from producing high carbon products, also the cost of consumers for purchasing high carbon products
F_e	Fine of enterprises for producing high carbon products under information symmetry
U_c	Utility perception (physical health, psychological satisfaction) of consumers from purchasing green products
U_{gc}	Additional benefit of consumers from improved consumer confidence in the market products under information symmetry
C_c	Additional cost (physical damage, psychological damage) of consumers from purchasing high carbon products
C_{gc}	Negative impact (environmental pollution) of enterprises producing high-carbon products on consumers

According to the stability theorem of replicated dynamic equation and a stable strategy, x should meet $F(x) = 0$, 且 $F'(x) < 0$.

If $y = (F_g - F_e - C_g + U_g)/(F_g - F_e)$, then $F(x) \equiv 0$; that is, any strategy of governments was a stable strategy.

If $y \neq (F_g - F_e - C_g + U_g)/(F_g - F_e)$, set $F(x) = 0$, and then $x = 0$ and $x = 1$, two quasievolutionary stability points, were obtained. The following equation was obtained by taking derivative of $F(x)$:

$$F'(x) = (2x - 1)\left[y(F_g - F_e) - (F_g - F_e - C_g + U_g)\right]. \quad (5)$$

If $y > (F_g - F_e - C_g + U_g)/(F_g - F_e)$, then $(F'(x)|_{x=0}) < 0$ and $(F'(x)|_{x=1}) > 0$; so, $x = 0$ was a stable strategy; if $y < (F_g - F_e - C_g + U_g)/(F_g - F_e)$, then $(F'(x)|_{x=0}) > 0$ and $(F'(x)|_{x=1}) < 0$; so, $x = 1$ was a stable strategy. This showed that the strategy selection of governments was closely related to that of enterprises. When the proportion of enterprises choosing the strategy of producing green products was higher than $(F_g - F_e - C_g + U_g)/(F_g - F_e)$, governments will choose the strategy of information asymmetry for effective use of social resources; when the proportion was lower than $(F_g - F_e - C_g + U_g)/(F_g - F_e)$, and governments will choose the strategy of information symmetry.

Figure 2 shows the strategy proportion x of governments was only related to that y of enterprises, but not to that z of consumers; that is, governments will not decide whether to choose the strategy of information symmetry based on consumers' willingness to purchase enterprises' products.

(2) The replicated dynamic equation for enterprises to choose the strategy of producing green products was

$$F(y) = dy/dt = y(E_{e1} - \overline{E_e}) = y(1 - y)[z(U_{e1} - U_{e2}) - (C_e - xF_e - U_e)]. \quad (6)$$

If $z = (C_e - xF_e - U_e)/(U_{e1} - U_{e2})$, then $F(y) \equiv 0$; that is, any strategy of enterprises was a stable strategy.

If $z \neq (C_e - xF_e - U_e)/(U_{e1} - U_{e2})$, set $F(y) = 0$, and then $y = 0$ and $y = 1$, two quasievolutionary stability points, were obtained. The following equation was obtained by taking derivative of $F(y)$:

$$F'(y) = (1 - 2y)[z(U_{e1} - U_{e2}) - (C_e - xF_e - U_e)]. \quad (7)$$

With $U_{e1} > U_{e2}$, that is, enterprises can obtain higher benefit from producing green products, and $C_e - U_e$ considered as the actual production cost of enterprises for green products, there were two different situations:

If $xF_e > C_e - U_e$ or $z(U_{e1} - U_{e2}) > (C_e - U_e)$, then $(F'(y)|_{y=0}) > 0$, $(F'(y)|_{y=1}) < 0$, $y = 1$, was a stable strategy. This showed that if the fine of enterprises for producing high carbon products was higher than the actual production cost of enterprises for green products, enterprises will choose the strategy of producing green products.

If the above conditions were not met, there were two situations: if $z > (C_e - xF_e - U_e)/(U_{e1} - U_{e2})$, then $(F'(y)|_{y=0}) > 0$, $(F'(y)|_{y=1}) < 0$; so, $y = 1$ was a stable strategy; that is, enterprises will choose the strategy of producing green products; if $z < (C_e - xF_e - U_e)/(U_{e1} - U_{e2})$, then $(F'(y)|_{y=0}) > 0$, $(F'(y)|_{y=1}) < 0$, $y = 0$, was a stable strategy; that is, enterprises will choose the strategy of producing high carbon products. This showed the strategy selection of enterprises was related to that of both governments and consumers.

TABLE 2: Payoff matrix of the three-party game players.

Game players				Consumers					
				Purchasing			Not purchasing		
Governments	Information symmetry	Enterprises	Green product	$U_g - C_g$	$U_{e1} + U_e - C_e$	$U_c + U_{gc} - U_{e1}$	$U_g - C_g$	$U_e - C_e$	U_{gc}
			High carbon products	$U_g - C_g + F_e$	$U_{e2} - F_e$	$U_{gc} - U_{e2} - C_c - C_{gc}$	$U_g - C_g + F_e$	$-F_e$	$U_{gc} - C_{gc}$
	Information asymmetry	Enterprises	Green product	0	$U_{e1} + U_e - C_e$	$U_c - U_{e1}$	0	$U_e - C_e$	0
			High carbon products	$-F_g$	U_{e2}	$-U_{e2} - C_c - C_{gc}$	$-F_g$	0	$-C_{gc}$

$$y^* > (F_g - F_e - C_g + U_g) / (F_g - F_e), x \longrightarrow 0$$
$$y^* < (F_g - F_e - C_g + U_g) / (F_g - F_e), x \longrightarrow 1$$
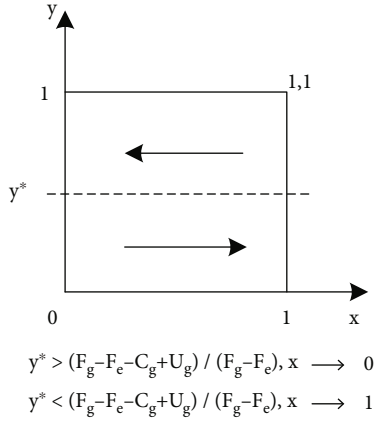
FIGURE 2: Schematic diagram of the dynamic evolution of governments' strategy.

Figure 2 shows the strategy proportion x of governments was only related to that y of enterprises, but not to that z of consumers, t.

Figure 3 shows the strategy proportion y of enterprises was related to both x of governments and z of consumers. In other words, the factors affecting enterprises' strategy were complex and multifaceted, which further showed the interaction among governments, enterprises, and consumers should be comprehensively taken into account in the formation and development of the green product market.

(3) The replicated dynamic equation for consumers to choose the strategy of purchasing green products was

$$F(z) = dz/dt = z(E_{c1} - \overline{E_c})$$
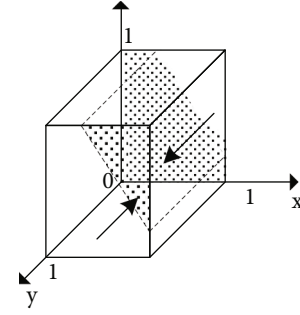$$= z(1 - z)[y(U_c - U_{e1} + U_{e2} + C_c) - (U_{e2} + C_c)]. \tag{8}$$

If $y = (U_{e2} + C_c)/(U_c - U_{e1} + U_{e2} + C_c)$, then $F(z) \equiv 0$; that is, any strategy of consumers was a stable strategy.

If $y \neq (U_{e2} + C_c)/(U_c - U_{e1} + U_{e2} + C_c)$, set $F(z) = 0$, and then $z = 0$ and $z = 1$, two quasievolutionary stability points, were obtained. The following equation was obtained by taking derivative of $F(z)$:

$$F'(z) = (1 - 2z)[y(U_c - U_{e1} + U_{e2} + C_c) - (U_{e2} + C_c)]. \tag{9}$$

With $U_{e2} + C_c > 0$, $(U_c - U_{e1} + U_{e2} + C_c) = [U_c - (U_{e1} - U_{e2} - C_c)]$, considered as the difference between the utility perception of consumers from purchasing green products and the additional cost, there were two different situations:

If $[U_c - (U_{e1} - U_{e2} - C_c)] < 0$ and $y(U_c - U_{e1} + U_{e2} + C_c) - (U_{e2} + C_c) < 0$, then $(F'(z)|_{z=0}) < 0$, $(F'(z)|_{z=1}) > 0$; so, $z = 0$ was a stable strategy. This showed if the utility perception of consumers from purchasing green products was lower than the additional cost, consumers will choose the strategy of not purchasing green products.

$$z > (C_e - xF_e - U_e) / (U_{e1} - U_{e2}), y \longrightarrow 1$$
$$z < (C_e - xF_e - U_e) / (U_{e1} - U_{e2}), y \longrightarrow 0$$

FIGURE 3: Schematic diagram of the dynamic evolution of enterprises' strategy.
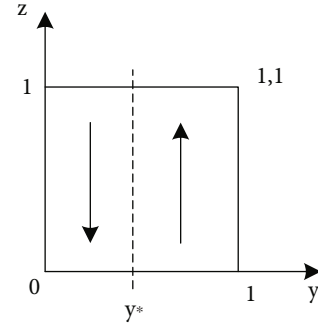
$$[U_c - (U_{e1} - U_{e2} - C_c)] > 0 \text{ and } y^* > \frac{U_{e2} + C_c}{(U_c - U_{e1} + U_{e2} + C_c)} \quad z \longrightarrow 1$$
$$[U_c - (U_{e1} - U_{e2} - C_c)] > 0 \text{ and } y^* > \frac{U_{e2} + C_c}{(U_c - U_{e1} + U_{e2} + C_c)} \quad z \longrightarrow 0$$

FIGURE 4: Schematic diagram of the dynamic evolution of consumers' strategy.

If $[U_c - (U_{e1} - U_{e2} - C_c)] > 0$ and $y > (U_{e2} + C_c)/(U_c - U_{e1} + U_{e2} + C_c)$, then $(F'(z)|_{z=0}) > 0$, $(F'(z)|_{z=1}) < 0$; so, $z = 1$; that is, purchasing green products was a stable strategy; if $[U_c - (U_{e1} - U_{e2} - C_c)] > 0$ and $y < (U_{e2} + C_c)/(U_c - U_{e1} + U_{e2} + C_c)$, then $(F'(z)|_{z=0}) < 0$, $(F'(z)|_{z=1}) > 0$; so, $z = 0$; that is, not purchasing green products was a stable strategy. It indicated when the utility perception of consumers from purchasing green products was large enough, the behavior strategy of consumers will depend on the probability of enterprises choosing to produce green products, that is, whether it was higher than $(U_{e2} + C_c)/(U_c - U_{e1} + U_{e2} + C_c)$.

Figure 4 shows the strategy proportion z of consumers was only related to that y of enterprises, but not to that x of governments.

3.3. Evolutionary Stability Analysis of the Three-Party Game.

According to the evolutionary stability analysis of Friedman [6], the evolutionary stable strategy of the three-party game players can be judged by $\text{Det} J > 0$ and $\text{Tr} J < 0$. The Jacobian matrix was obtained by taking partial derivatives of (4), (6), and (8) about x, y, and z, respectively:

$$J = \begin{bmatrix} \dfrac{\partial F(x)}{\partial x} & \dfrac{\partial F(x)}{\partial y} & \dfrac{\partial F(x)}{\partial z} \\[2mm] \dfrac{\partial F(y)}{\partial x} & \dfrac{\partial F(y)}{\partial y} & \dfrac{\partial F(y)}{\partial z} \\[2mm] \dfrac{\partial F(z)}{\partial x} & \dfrac{\partial F(z)}{\partial y} & \dfrac{\partial F(z)}{\partial z} \end{bmatrix} = \begin{bmatrix} J_{11} & J_{12} & J_{13} \\ J_{21} & J_{22} & J_{23} \\ J_{31} & J_{32} & J_{33} \end{bmatrix},$$

(10)

where

$$J_{11} = (2x-1)[y(F_g - F_e) - (F_g - F_e - C_g + U_g),$$

$$J_{12} = x(x-1)(F_g - F_e),$$

$$J_{13} = 0,$$

$$J_{21} = 0,$$

$$J_{22} = (1-2y)[z(U_{e1} - U_{e2}) - (C_e - xF_e - U_e)],$$

$$J_{23} = y(1-y)(U_{e1} - U_{e2}),$$

$$J_{31} = 0,$$

$$J_{32} = z(1-z)(U_c - U_{e1} + U_{e2} + C_c),$$

$$J_{33} = (1-2z)[y(U_c - U_{e1} + U_{e2} + C_c) - (U_{e2} + C_c)],$$

(11)

so that

$$\begin{aligned} DetJ =\ & (2x-1)\left[y(F_g - F_e)(F_g - F_e - C_g + U_g)\right] \\ & \cdot \left\{(1-2y)[z(U_{e1} - U_{e2}) - (C_e - xF_e - U_e)]\right. \\ & \cdot (1-2z)[y(U_c - U_{e1} + U_{e2} + C_c) - (U_{e2} + C_c)] \\ & \left. - z(1-z)(U_c - U_{e1} + U_{e2} + C_c)y(1-y)(U_{e1} - U_{e2})\right\}, \end{aligned}$$

$$\begin{aligned} TrJ =\ & (2x-1)\left[y(F_g - F_e) - (F_g - F_e - C_g + U_g)\right] \\ & \cdot (1-2y)[z(U_{e1} - U_{e2}) - (C_e - xF_e - U_e)] \\ & \cdot (1-2z)[y(U_c - U_{e1} + U_{e2} + C_c) - (U_{e2} + C_c)]. \end{aligned}$$

(12)

The evolutionary stability of the three-party game system is shown in Table 3.

4. Model Simulation and Sensitivity Analysis

4.1. Case Simulation. This paper is aimed at promoting the evolution of the three-party game to an ideal stable state. According to Equations (4), (6), (8), and Table 3, $U_g > C_g$ can make x show a trend of monotonic increasing and evolving to $x \longrightarrow 1$. Thus, the evolutionary conditions can be maintained by limiting the initial threshold of x, making the three-party game evolve to (1,1,1). If $x = 0.4$, that is, the superior government required 40% of governments in the region to choose the strategy of information symmetry as the lower limit, the three-party game will eventually evolve to a socially ideal stable state, as shown in Table 4.

Because the python scientific computing library SciPy has a more convenient 3D drawing toolkit and computing ecology, numerical experiments and simulation were performed using SciPy, a scientific computing library of Python, to verify the above inferences. If the initial parameter setting met $U_g > C_g$, $xF_e > [(C_e - U_e) - (U_{e1} - U_{e2})]$, and $U_c > U_{e1}$, then the game may eventually evolve to a socially ideal stable state where all the three parties chose an active strategy. So, the following initial values were set: $F_g = 70$, $F_e = 60$, $C_g = 40$, $U_g = 80$, $C_e = 70$, $U_e = 65$, $U_{e1} = 100$, $U_{e2} = 40$, $C_c = 40$, and $U_c = 200$. This paper verified the strategy selection of the three-party game players under the premise that the lower limit of proportion of governments choosing the strategy of information symmetry was $x = 0.4$. In Figure 5, the initial values $x = 0.4$, $y = 0.6$, and $z = 0.7$, and $x = 0.5$, $y = 0.5$, and $z = 0.3$ were taken for an example, respectively. The simulation results showed the three-party game eventually evolved to a socially ideal stable state of (1, 1, 1), verifying the inference.

Evolutionary results are as follows: $x \longrightarrow 1$, $y \longrightarrow 1$, and $z \longrightarrow 1$.

Restrictive conditions are as follows: $U_g > C_g$, $xF_e > [(C_e - U_e) - (U_{e1} - U_{e2})]$, and $U_c > U_{e1}$.

Figure 5 shows under information symmetry, when the benefit of governments from increased government credibility was higher than the cost of governments for screening the information of enterprises' products and identifying the green products $U_g > C_g$, the expected fine of enterprises for producing high carbon products was higher than the difference between the actual cost increment and the actual income increment of enterprises for producing green products $xF_e > [(C_e - U_e) - (U_{e1} - U_{e2})]$, and the utility perception of consumers from table purchasing green products was higher than the cost of consumers for purchasing green products $U_c > U_{e1}$, the three-party game would evolve to a socially ideal stable state where governments chose the strategy of information symmetry, enterprises chose the strategy of producing green products, and consumers chose the strategy of purchasing green products.

4.2. Sensitivity Analysis. In order to explore the influence of different parameters on the formation and healthy development of the green product market, this paper analyzed the sensitivity of some parameters to study the influence of change in restrictive conditions on the evolution trajectory of the three-party game players.

Situation 1: set $C_g = 65$ and $U_g = 60$, and parameter setting met the evolution conditions of $U_g < C_g$, $xF_e > [(C_e - U_e) - (U_{e1} - U_{e2})]$, and $U_c > U_{e1}$. In Figure 6, the three-party game eventually evolved to a stable state of (0, 1, 1), verifying the inference.

Evolutionary results are as follows: $x \longrightarrow 0$, $y \longrightarrow 1$, and $z \longrightarrow 1$.

Restrictive conditions are as follows: $U_g < C_g$, $xF_e > [(C_e - U_e) - (U_{e1} - U_{e2})]$, and $U_c > U_{e1}$. Figure 6 shows when parameter conditions changed, that is, when the benefit of governments from increased government credibility was lower than the cost of governments for screening the information of enterprises' products and identifying the green

TABLE 3: Local stability analysis of the equilibrium points.

Equilibrium points	Det$J$	TrJ
$(0, 0, 0)$	$-(U_{e2} + C_c)(U_e - C_e)(F_g - F_e - C_g + U_g)$	$-(U_{e2} + C_c) + (U_e - C_e) + (F_g - F_e - C_g + U_g)$
$(0, 0, 1)$	$(U_{e2} + C_c)(U_e - C_e + U_{e1} - U_{e2})(F_g - F_e - C_g + U_g)$	$C_c + (U_e - C_e + U_{e1}) + (F_g - F_e - C_g + U_g)$
$(0, 1, 0)$	$-(C_e - U_e)(C_g - U_g)(U_c - U_{e1})$	$(C_e - U_e) - (C_g - U_g) + (U_c - U_{e1})$
$(0, 1, 1)$	$-(C_g - U_g)(U_c - U_{e1})(U_e - C_e + U_{e1} - U_{e2})$	$-(C_g - U_g) - U_c - (U_e - C_e - U_{e2})$
$(1, 0, 0)$	$-(U_{e2} + C_c)(C_e - F_e - U_e)(F_g - F_e - C_g + U_g)$	$-(U_{e2} + C_c) - (C_e - F_e - U_e) - (F_g - F_e - C_g + U_g)$
$(1, 0, 1)$	$(U_{e2} + C_c)(C_e - F_e - U_e - U_{e1} + U_{e2})(F_g - F_e - C_g + U_g)$	$C_c - (C_e - F_e - U_e - U_{e1}) - (F_g - F_e - C_g + U_g)$
$(1, 1, 0)$	$-(C_g - U_g)(U_c - U_{e1})(F_e + U_e - C_e)$	$(C_g - U_g) + (U_c - U_{e1}) - (F_e + U_e - C_e)$
$(1, 1, 1)$	$(C_g - U_g)(U_c - U_{e1})(C_e - F_e - U_e - U_{e1} + U_{e2})$	$(C_g - U_g) - U_c + (C_e - F_e - U_e + U_{e2})$

TABLE 4: Socially ideal stable state of the three-party game model for enterprises' green product innovation.

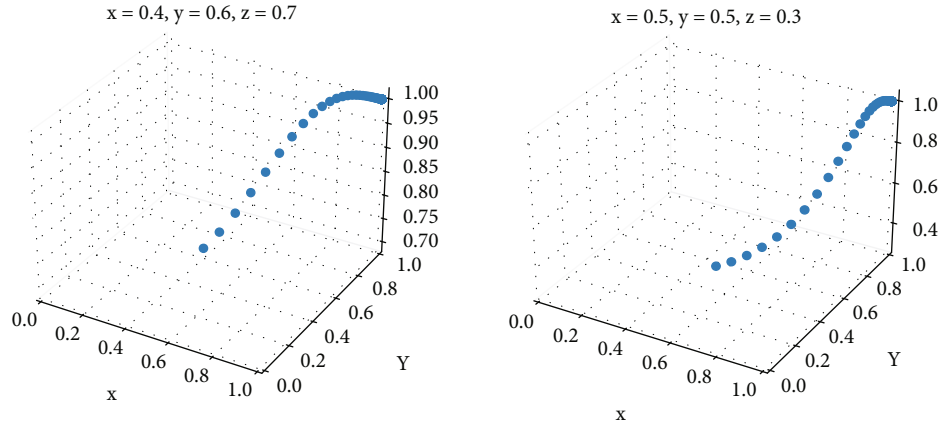| Strategy behaviors of game players	Parameter conditions	Trends of probability change
Governments choosing the strategy of information symmetry	$U_g > C_g$	$x \longrightarrow 1$
Enterprises choosing the strategy of producing green products	$xF_e > [(C_e - U_e) - (U_{e1} - U_{e2})]$	$y \longrightarrow 1$
Consumers choosing the strategy of purchasing green products	$U_c > U_{e1}$	$z \longrightarrow 1$

FIGURE 5: Evolutionary path diagram of the three-party game system.
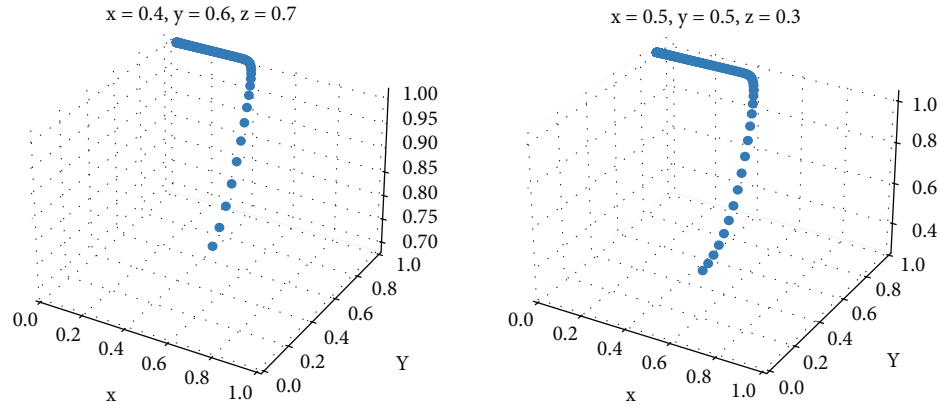
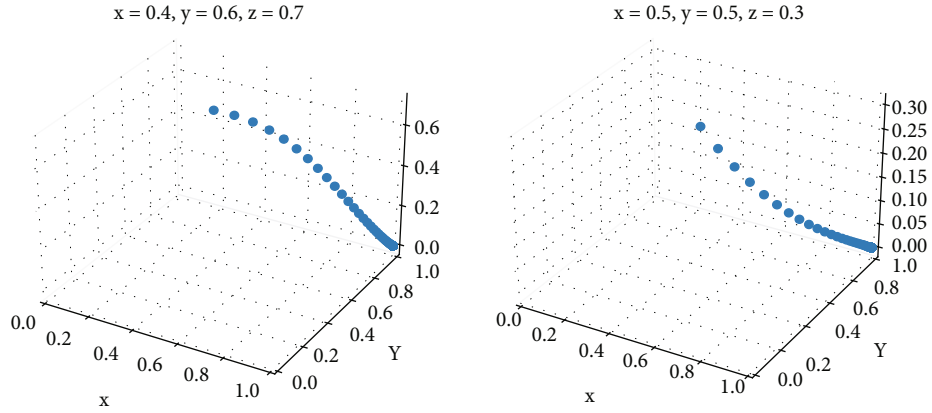FIGURE 6: Evolutionary path diagram of the three-party game system.

x = 0.4, y = 0.6, z = 0.7

x = 0.5, y = 0.5, z = 0.3

FIGURE 7: Evolutionary path diagram of the three-party game system.
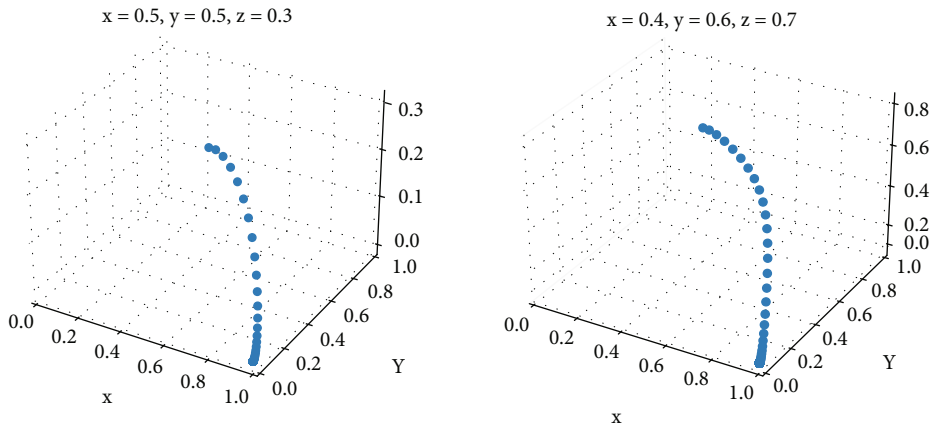
x = 0.5, y = 0.5, z = 0.3

x = 0.4, y = 0.6, z = 0.7

FIGURE 8: Evolutionary path diagram of the three-party game system.

products $U_g < C_g$, the expected fine of enterprises for producing high carbon products was higher than the difference between the actual cost increment and the actual income increment of enterprises for producing green products $xF_e > [(C_e - U_e) - (U_{e1} - U_{e2})]$, and the utility perception of consumers from purchasing green products was higher than the cost of consumers for purchasing green products $U_c > U_{e1}$, the three-party game would evolve to a stable state where governments chose the strategy of information asymmetry, enterprises chose the strategy of producing green products, and consumers chose the strategy of purchasing green products.

Situation 2: set $U_{e1} = 150$, $U_c = 100$, and parameter setting met the evolution conditions of $U_g > C_g$, $xF_e > [(C_e - U_e) - (U_{e1} - U_{e2})]$, and $U_c < U_{e1}$. In Figure 7, the three-party game eventually evolved to a stable state of (1, 1, 0), verifying the inference.

Evolutionary results are as follows: $x \longrightarrow 1$, $y \longrightarrow 1$, and $z \longrightarrow 0$.

Restrictive conditions are as follows: $U_g > C_g$, $xF_e > [(C_e - U_e) - (U_{e1} - U_{e2})]$, and $U_c < U_{e1}$.

Figure 7 shows when parameter conditions changed, that is, when the benefit of governments from increased govern-

ment credibility was higher than the cost of governments for screening the information of enterprises' products and identifying the green products $U_g > C_g$, the expected fine of enterprises for producing high carbon products was higher than the difference between the actual cost increment and the actual income increment of enterprises for producing green products $xF_e > [(C_e - U_e) - (U_{e1} - U_{e2})]$, the utility perception of consumers from purchasing green products was lower than the cost of consumers for purchasing green products $U_c < U_{e1}$, the three-party game would evolve to a stable state where governments chose the strategy of information symmetry, enterprises chose the strategy of producing green products, and consumers chose the strategy of not purchasing green products. This also showed consumers pay more attention to the gains and losses of their own interests than green consumption in the spotlight when choosing to purchase green products, and consumers with higher green value perception are more willing to purchase green products.

Situation 3: set $F_e = 20$, $C_e = 100$, $U_e = 30$, $U_{e1} = 60$, and $U_{e2} = 50$, and parameter setting met the evolution conditions of $U_g > C_g$, $xF_e < [(C_e - U_e) - (U_{e1} - U_{e2})]$, and $U_c > U_{e1}$. In Figure 8, the three-party game eventually evolved to a stable state of (1, 0, 0), verifying the inference.

Evolutionary results are as follows: $x \longrightarrow 1$, $y \longrightarrow 0$, and $z \longrightarrow 0$.

Restrictive conditions are as follows: $U_g > C_g$, $xF_e < [(C_e - U_e) - (U_{e1} - U_{e2})]$, and $U_c > U_{e1}$.

Figure 8 shows when parameter conditions changed, that is, when the expected fine of enterprises for producing high carbon products was lower than the difference between the actual cost increment and the actual income increment of enterprises for producing green products $xF_e < [(C_e - U_e) - (U_{e1} - U_{e2})]$, no matter whether the utility perception of consumers from purchasing green products was higher than the cost of consumers for purchasing green products, consumers will chose the strategy of not purchasing green products, suggesting a long-term production of high carbon products by enterprises is unrealistic.

5. Conclusions and Suggestions

In view of the difficulties in the formation and healthy development of Chinese green product market, in this paper, an evolutionary game model involving governments, enterprises, and consumers was built. And numerical experiments and simulation were performed. The research results showed the relation between the governments' benefit from increased government credibility and the cost of governments for screening the information of enterprises' products and identifying the green products, between the expected fine of enterprises for producing high carbon products and the difference between the actual cost increment and the actual income increment of enterprises for producing green products, as well as the gains and losses of consumers from purchasing green products played a decisive role in the healthy development of the green product market. The above conclusions provide useful policy suggestions for governments to vigorously develop the green product market. In order to promote the healthy development of Chinese green product market, the following suggestions were drawn:

(1) Take measures to reduce the cost of governments for identifying the green products. Through extensive participation of all kinds of nongovernmental organizations such as the public and media in supervising the production process of green products of enterprises, establish and improve the mechanisms of industry collection, information disclosure, and social supervision and reduce the identification and certification fees of governments. Through the indepth cooperation among governments, industries, universities, and research institutes, establish a unified green product information platform for use and collection by the whole society

(2) Strengthen policy support for the R & D and production, transportation and distribution, consumption, and procurement of green products of enterprises, increase subsidies for green manufacturing, and green procurement to effectively reduce the burden of enterprises producing green products. Strictly implement the main responsibility of producers for product quality, establish a joint punishment mechanism for those who are serious trust breaking, and establish a blacklist system for enterprises violating laws and regulations

(3) Vigorously carry out the public welfare publicity of green products through the media, network and social publicity, spread the theory of green development, guide the green lifestyle, and improve the utility perception of consumers from purchasing green products. Affect consumers' negative attitude towards environmental crisis by truly reporting the harm of production of high carbon products. Reduce the purchase cost of green products through various means (such as guidance and support) and popularize the green consumption pattern

Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest

It is declared by the author that this article is free of conflict of interest.

Acknowledgments

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