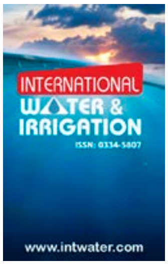

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Research on the value creation mechanism of green-driven products in the Internet+ era

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Abstract In order to improve the value of green-driven products, this paper studies the value creation mechanism of green-driven products in the Internet+ era. Under the framework of the classic Cournot output game, based on the bounded rationality assumption of the participants, this paper constructs a novel Cournot duopoly investment game model, and analyzes the dynamic adjustment mechanism of the participants' investment. The decision variable of participating enterprises is to select the optimal investment amount, and each production enterprise makes investment decisions in the next period according to the observed marginal profit of the current period to maximize the profit. Through calculation and analysis, it can be known that three boundary equilibriums and one interior point equilibrium of the discrete dynamic model system are obtained in this paper. The experimental analysis shows that the value creation mechanism of green-driven products proposed in this paper can effectively promote the value of green-driven products.

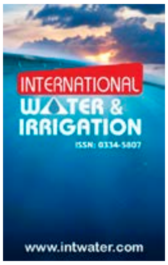
Keywords: Internet+; green drive; product value; creation mechanism.

1 INTRODUCTION

The development of green products also needs to be driven by customer needs. How to reasonably plan the customer needs of green products into new products is the primary consideration for every enterprise before designing green products. Moreover, green product planning is the premise of green product design and a bridge connecting the market and the development and production process of green products of enterprises. Its core task is to systematically find and select promising products as development objects on the basis of grasping the changes in customer needs and the development of green design technology and market conditions, so as to clarify the goals and requirements of green product design, and formulate short-term and long-term plans for enterprise green product development [1].

The overall planning of green products should meet the customers' needs for the basic functions of the products. Such needs are the minimum requirements of the products, and generally there is no room for change. Next, it is necessary to subdivide the market according to different customers' preferences for the environmental performance of products, and plan the environmental needs of specific customer groups into new products. The differentiated product environmental performance requirements of customer groups require enterprises to produce differentiated green products to meet the needs of different markets. In the overall planning process, through the combination or innovation of different environmental performance of products, green product series meeting different markets will be formed, so that products will occupy a dominant position in the fierce market competition [2]. The overall environmental performance of green products should not only meet the needs of customers, but also adapt to the technical strength and production conditions of enterprises, such as the supply of raw materials, plants, equipment, talents, etc. Successful green product development is always carried out under the promotion of the market and the restriction of material conditions. Any product development that exceeds the enterprise's capabilities will inevitably lead to failure. When planning green products, it is necessary to deeply analyze the existing technical foundation of the enterprise, especially the enterprise's green design technical capability, and then formulate a practical technical scheme, which is crucial for the enterprise to ultimately achieve green product development [3]. Products are developed to meet the needs of customers, and profit is the biggest goal of enterprises to develop products. Therefore, green product development is not unlimited to meet customer needs, but also to consider the cost and economy of product development. Otherwise, the high development cost will cause the product to die in the middle and late stages of the development process due to lack of financial support. Even if it can be successfully completed, the high product development cost will eventually be passed on to consumers, which will be unacceptable to consumers. Green product planning needs to consider how to maximize the product to meet customer environmental needs and achieve maximum customer satisfaction under the limited development budget [4]

Document [5] proposed a modular design for recycling with functional analysis, quality function configuration and recycling mapping as the core, and pointed out that only when the knowledge about recycling is well integrated into the development environment and supported by corresponding development tools can this design be truly implemented. Literature [6] believes that modules in a product can be regarded as "products in the product", Then, each module is manufactured in the mode of "factories in the factory". First, the concept of module drive is proposed, that is, various evaluation criteria behind modularity in the product life cycle, and the modular function deployment (MFD) method is proposed, which uses QFD matrix to take modularity as the design requirement. Reference [7] The assembly system of modular products is analyzed, and some algorithms to solve the system decomposition problem in assembly are proposed. Literature [8] combined the functional analysis of traditional modular design with some objectives concerned by green design, and defined the life cycle module: as a relative property, modules and their interactions are measured by the properties of parts in the whole life cycle process, such as R&D, testing, manufacturing, assembly, packaging, transportation, service, scrapping, and the similarity and independence of the processes they experience, The modular



product design based on life cycle is proposed. Literature [9] gives a series of life cycle objectives of modular design. Its modular design process includes: 1) problem definition. Determine the type and nature of design problems; Determine design knowledge such as functional structure and physical structure; Determine design objectives (single or weighted comprehensive objectives): including maintenance service, reuse, recycling, waste disposal, etc; 2) Interaction analysis. Determine the relevant factors of each design goal, and determine the interaction value of each part; Calculate the weighted average interaction value of the part; 3) Simulated annealing algorithm is used to construct modules. In order to reduce the adverse impact on the environment and shorten the research and development cycle, the literature [10] introduced tools such as genetic algorithm, proposed the concept and method of modular process design, and developed support tools.

This paper studies the value creation mechanism of green-driven products in the Internet+ era, and analyzes through intelligent models to improve the scientificity of the value-creation mechanism of green-driven products.

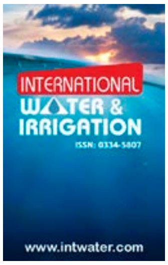
2 GAME DYNAMICS ANALYSIS OF COURNOT GREEN DRIVE PRODUCT INVESTMENT BASED ON LINEAR FUNCTION ASSUMPTION

This paper establishes a decision-making dynamic system for green-driven product investment in which participants make adaptive adjustments to green-driven product investment based on the local estimation of the previous period's marginal profit. In this paper, the two production enterprises are labeled as Enterprise 1 and Enterprise 2, and they develop and produce homogeneous products. The action strategy of each enterprise is to select the investment amount of green-driven products in each period (the period mentioned in this article is understood as a unit of several years). It is assumed here that the two participating companies formulate corresponding green-driven product investment strategies on discrete time axes.

In this paper, it is assumed that $K_i(t-1)$ represents the investment stock of green driving products of enterprise i in period t-1, and $x_i(t)$ is the investment amount of green driving products in a single period in period t. Considering the depreciation of capital, the capital stock $K_i(t-1)$ of green-driven product investment flows into the next economic period, and the residual value rate θ is suitable for both participating enterprises and the value range is $0<\theta<1$. Therefore, the relationship between the green-driven product investment capital stock of enterprises in two adjacent periods can be obtained as follows:

$$K_i(t)=\theta K_i(t-1)+x_i(t), i=1,2 \quad (1)$$

Regarding the quantity of products produced by each enterprise in a certain period, according to the research background, this paper believes that the enterprise's green-driven product investment capital accumulation $K_i(t)$ in period t determines its product production potential in this period,



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that is, output $q_i(t)$ is a function of capital stock $K_i(t)$. This paper considers a simple linear form, $q_i(t) = B_i K_i(t)$, where the normal number B_i represents the technological level of each enterprise to develop and produce emerging products. In this paper, the formula (1) is substituted into the output function to obtain the specific expression:

$$q_i(t) = B_i\left(\theta K_i(t-1) + x_i(t)\right), i = 1,2 \quad (2)$$

This paper assumes that the sales price of such products in the market is a linear inverse demand function, as follows:

$$p(t) = a - bQ(t), \quad (3)$$

At the same time, this paper ignores the fixed cost and considers the linear production cost function of each enterprise, as follows:

$$C_i\left(q_i(t)\right) = c_i q_i(t), i = 1,2 \quad (4)$$

Marginal costs c_1 and c_2 are both positive numbers.

According to the above assumptions about the functional relationship of relevant variables, the profit of enterprise i in period t (the profit mentioned here actually refers to the marginal contribution, that is, the sales revenue minus the variable cost) is calculated as:

$$\pi_i\left(x_1(t), x_2(t)\right) = q_i(t)p(t) - C_i\left(q_i(t)\right) - x_i(t), i = 1,2 \quad (5)$$

In this paper, the specific expression of each variable is substituted into formula (5) to get:

$$\begin{aligned} &\pi_i\left(x_1(t), x_2(t)\right) = \left(aB_i - B_i c_i\right)\left(\theta K_i(t-1) + x_i(t)\right) - bB_i^2\left(\theta K_i(t-1) + x_i(t)\right)^2 \\ &-bB_i B_j\left(\theta K_i(t-1) + x_i(t)\right)\left(\theta K_j(t-1) + x_j(t)\right) - x_i(t), \\ &i \neq j, i, j = 1,2 \end{aligned} \quad (6)$$

Then, the marginal profits of enterprise i's profit $\pi_i\left(x_1(t), x_2(t)\right)$ in period t to the investment in green-driven products are:

$$\begin{aligned} \varphi_1(t) &= \frac{\partial \pi_1\left(x_1(t), x_2(t)\right)}{\partial x_1(t)} \\ &= \left(aB_1 - B_1 c_1 - 1\right) - 2bB_1^2\left(\theta K_1(t-1) + x_1(t)\right) \quad (7a) \\ &-bB_1 B_2\left(\theta K_2(t-1) + x_2(t)\right) \end{aligned}$$

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$$\varphi_2(t) = \frac{\partial \pi_2\left(x_1(t), x_2(t)\right)}{\partial x_2(t)}$$
$$= \left(aB_2 - B_2 c_2 - 1\right) - 2bB_2^2\left(\theta K_2(t-1) + x_2(t)\right) \quad (7b)$$
$$-bB_1B_2\left(\theta K_1(t-1) + x_1(t)\right)$$

Therefore, the dynamic adjustment mechanism of enterprise i's green-driven product investment can be expressed as:

$$x_i(t+1) = x_i(t) + \alpha_i\left(x_i(t)\right)\varphi_i(t), i = 1,2 \quad (8)$$

This paper still considers the linear adjustment function $\alpha_i\left(x_i(t)\right) = \alpha_i x_i(t)$, and the coefficient $\alpha_i > 0$ represents the speed at which the enterprise adjusts the green-driven product investment strategy according to the marginal profit signal. Then, the dynamic Formula (8) is:

$$x_i(t+1) = x_i(t) + \alpha_i x_i(t)\varphi_i(t), i = 1,2 \quad (9)$$

Combining Formulas (1), (7a-7b) and (9), we obtain a four-dimensional discrete dynamic model as follows:

$$\begin{cases} x_1(t+1) = x_1(t) + \alpha_1 x_1(t)\left[aB_1 - B_1c_1 - 1 - 2bB_1^2\left(\theta K_1(t-1) + x_1(t)\right)\right. \\ x_2(t+1) = x_2(t) + \alpha_2 x_2(t)\left[aB_2 - B_2B_2\left(\theta K_2(t-1) + x_2(t)\right)\right] \\ K_1(t) = \theta B_2^2\left(\theta K_2(t-1) + x_1(t)\right. \quad \left. -bB_1B_2\left(\theta K_1(t-1) + x_1(t)\right)\right] \\ K_2(t) = \theta K_2(t-1) + x_2(t) \end{cases}$$

(10)In order to be consistent in expression, this paper uses $I_i(t)$ to replace $K_i(t-1)$, and obviously $K_i(t)$ is replace by $I_i(t+1)$, then the dynamic system (10) can be rewritten into the following standard form:

$$\begin{cases} x_1(t+1) = x_1(t) + \alpha_1 x_1(t)\left[aB_1 - B_1c_1 - 1 - 2bB_1^2\left(\theta K_1(t-1) + x_1(t)\right)\right. \\ \left. -bB_1B_2\left(\theta K_2(t-1) + x_2(t)\right)\right] \\ x_2(t+1) = x_2(t) + \alpha_2 x_2(t)\left[aB_2 - B_2c_2 - 1 - 2bB_2^2\left(\theta K_2(t-1) + x_2(t)\right)\right. \\ \left. -bB_1B_2\left(\theta K_1(t-1) + x_1(t)\right)\right] \\ K_1(\mathrm{t}) = \theta K_1(t-1) + x_1(t) \\ K_2(\mathrm{t}) = \theta K_2(t-1) + x_2(t) \end{cases} \quad (11)$$

The discrete dynamical system (11) is based on the assumption that both the market inverse demand function and the production cost function are in linear form.

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2.1 Stability analysis of equilibrium point

In the dynamic system (11), we set $x_i(t+1)=x_i(t)$ and $I_i(t+1)=I_i(t), i=1,2$, we get:

$$\begin{cases} x_1(t)\left[aB_1-B_1c_1-1-2bB_1^2\left(\theta I_1(t)+x_1(t)\right)-bB_1B_2\left(\theta I_2(t)+x_2(t)\right)\right]=0 \\ x_2(t)\left[aB_2-B_2c_2-1-2bB_2^2\left(\theta I_2(t)+x_2(t)\right)-bB_1B_2\left(\theta I_1(t)+x_1(t)\right)\right]=0, \\ (1-\theta)I_1(t)=x_1(t) \\ (1-\theta)I_2(t)=x_2(t) \end{cases} \quad (12)$$

The four equilibrium points of the dynamic system (11) are obtained by solving the Formulas (12) as follows:

$$E_1=\left(\frac{(1-\theta)\left(aB_1-B_1c_1-1\right)}{2bB_1^2},0,\frac{aB_1-B_1c_1-1}{2bB_1^2},0\right),$$

$$E_0=(0,0,0,0),\ E_2=\left(0,\frac{(1-\theta)\left(aB_2-B_2c_2-1\right)}{2bB_2^2},0,\frac{aB_2-B_2c_2-1}{2bB_2^2}\right),$$

$$E^*=\left(x_1^*,x_2^*,I_1^*,I_2^*\right),$$

Among them,

$$x_1^*=\frac{(1-\theta)\left(B_1B_2\left(a-2c_1+c_2\right)+B_1-2B_2\right)}{3bB_1^2B_2},I_1^*=\frac{B_1B_2\left(a-2c_1+c_2\right)+B_1-2B_2}{3bB_1^2B_2},$$

$$x_2^*=\frac{(1-\theta)\left(B_1B_2\left(a+c_1-2c_2\right)-2B_1+B_2\right)}{3bB_1B_2^2},I_2^*=\frac{B_1B_2\left(a+c_1-2c_2\right)-2B_1+B_2}{3bB_1B_2^2}.$$

It is easy to know that E_0,E_1 and E_2 are boundary equilibrium points, and E^* is the only interior point equilibrium. Considering the practical economic significance of the system equilibrium point, only the non-negative equilibrium point is discussed in this paper. Since b,B_1,B_2 and θ are all positive parameters, when E_1,E_2 and E^* are all greater than zero, the parameters must meet the following conditions:

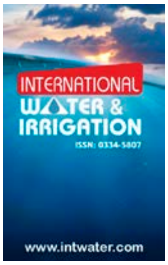
$aB_1-B_1c_1-1>0,$ (13a)

$aB_2-B_2c_2-1>0,$ (13b)

$B_1B_2\left(a-2c_1+c_2\right)+B_1-2B_2>0,$ (13c)

$B_1B_2\left(a+c_1-2c_2\right)-2B_1+B_2>0$ (13d)

In the analysis later in this paper, the non-negativity conditions (13a-13d) are assumed to hold.



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To discuss the stability of each equilibrium point (x_1, x_2, I_1, I_2) of the dynamic system (11), the corresponding Jacobian matrix is first calculated:

$$J(x_1, x_2, I_1, I_2) = \begin{pmatrix} 1+\alpha_1 M_1 & -bB_1B_2\alpha_1 x_1 & -2\theta bB_1^2\alpha_1 x_1 & -\theta bB_1B_2\alpha_1 x_1 \\ -bB_1B_2\alpha_2 x_2 & 1+\alpha_2 M_2 & -\theta bB_1B_2\alpha_2 x_2 & -2\theta bB_2^2\alpha_2 x_2 \\ 1 & 0 & \theta & 0 \\ 0 & 1 & 0 & \theta \end{pmatrix}, \quad (14)$$

Among them, the notation is $\begin{matrix} M_1 = aB_1 - B_1c_1 - 1 - 2bB_1^2(\theta I_1 + 2x_1) - bB_1B_2(\theta I_2 + x_2) \\ M_2 = aB_2 - B_2c_2 - 1 - 2bB_2^2(\theta I_2 + 2x_2) - bB_1B_2(\theta I_1 + x_1). \end{matrix}$.

Proposition 1 is that the boundary equilibrium point E_0 is unstable.

The proof is as follows: We substitute $E_0 = (0,0,0,0)$ into the general formula (14) of the Jacobian matrix of the system, and the Jacobian matrix $J(E_0)$ of the system (11) at the equilibrium point E_0 is expressed as follows:

$$J(E_0) = \begin{pmatrix} 1+\alpha_1(aB_1 - B_1c_1 - 1) & 0 & 0 & 0 \\ 0 & 1+\alpha_2(aB_2 - B_2c_2 - 1) & 0 & 0 \\ 1 & 0 & \theta & 0 \\ 0 & 1 & 0 & \theta \end{pmatrix},$$

It is calculated that $J(E_0)$ has four characteristic roots, which are $\lambda_1 = \lambda_2 = \theta, \lambda_3 = 1 + \alpha_1(aB_1 - B_1c_1 - 1)$ and $\lambda_4 = 1 + \alpha_2(aB_2 - B_2c_2 - 1)$.

According to the adjustment coefficient $\alpha_i > 0$ and the non-negativity conditions of the equilibrium point (13a-13b), the latter two eigenvalues satisfy $|\lambda_{3,4}| > 1$. Therefore, the equilibrium point E_0 is unstable.

Proposition 2 is that both E_1 and E_2 are unstable equilibrium points.

The proof is as follows: The specific form of the Jacobian matrix (14) at the boundary equilibrium point E_1 is:

$$J(E_1) = \begin{pmatrix} 1+\alpha_1(\theta-1)H_1 & \frac{\alpha_1 B_2(\theta-1)H_1}{2B_1} & \theta(\theta-1)\alpha_1 H_1 & \frac{\theta(\theta-1)\alpha_1 B_2 H_1}{2B_1} \\ 0 & 1+\frac{\alpha_2 H_2}{2B_1} & 0 & 0 \\ 1 & 0 & \theta & 0 \\ 0 & 1 & 0 & \theta \end{pmatrix},$$

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Among them, the notation is $H_1 = aB_1 - B_1c_1 - 1, H_2 = B_1B_2\left(a + c_1 - 2c_2\right) - 2B_1 + B_2$. The characteristic root of the Jacobian matrix $J\left(E_1\right)$ is calculated as: $\lambda_1 = \theta$,

$$\lambda_2 = 1 + \frac{\alpha_2\left(B_1B_2\left(a + c_1 - 2c_2\right) - 2B_1 + B_2\right)}{2B_1},$$

$$\lambda_{3,4} = \frac{1}{2}\left(1 + \theta + \alpha_1(\theta - 1)\left(aB_1 - B_1c_1 - 1\right) \pm \sqrt{-4\theta + \left(1 + \theta + \alpha_1(\theta - 1)\left(aB_1 - B_1c_1 - 1\right)\right)^2}\right).$$

By presupposing the parameters $B_1, \alpha_2 > 0$ and then by the inequality (13d), it can be deduced that $\lambda_2 > 1$. E_1 is the unstable frontier equilibrium. Similarly, it can be proved that the boundary equilibrium point E_2 is also unstable.

This paper mainly discusses the stability of the interior-point equilibrium E^* . The Jacobian matrix (14) is expressed as follows at the interior point equilibrium E^* :

$$J\left(E^*\right) = \begin{pmatrix} 1 - 2\alpha_1 bB_1^2x_1^* & -\alpha_1 bB_1B_2x_1^* & -2\theta\alpha_1 bB_1^2x_1^* & -\theta\alpha_1 bB_1B_2x_1^* \\ -\alpha_2 bB_1B_2x_2^* & 1 - 2\alpha_2 bB_2^2x_2^* & -\theta\alpha_2 bB_1B_2x_2^* & -2\theta\alpha_2 bB_2^2x_2^* \\ 1 & 0 & \theta & 0 \\ 0 & 1 & 0 & \theta \end{pmatrix},$$

We record the characteristic polynomial of the matrix $J\left(E^*\right)$ as $P(\lambda)$, and set $P(\lambda) = \lambda^4 + p_1\lambda^3 + p_2\lambda^2 + p_3\lambda + p_4$, then the coefficients of the polynomial terms are calculated numerically as:

$$\begin{aligned}
p_1 &= 2\left(-1 - \theta + bB_1^2\alpha_1x_1^* + bB_2^2\alpha_2x_2^*\right) \\
&= \frac{2}{3B_1B_2}\left((1-\theta)\left(B_1^2\alpha_1X + B_2^2\alpha_2 + B_1B_2\left(\alpha_2Y - 2\alpha_1\right)\right) - 3B_1B_2(\theta + 1)\right) \\
p_2 &= 1 + 4\theta + \theta^2 - 2bB_2^2\alpha_2(1+\theta)x_2^* + bB_1^2\alpha_1x_1^*\left(-2 - 2\theta + 3bB_2^2\alpha_2x_2^*\right) \\
&= \frac{1}{3B_1B_2}\begin{bmatrix} 2B_2^2\alpha_2\left[\alpha_1(\theta-1) - 1 - \theta\right](1-\theta) + B_1^2\alpha_1(1-\theta)X\left[\alpha_2(1-\theta)Y - 2(\theta+1)\right] \\ +B_1B_2\begin{bmatrix} 2\alpha_2\left(\theta^2 - 1\right)Y + 3\left(1 + 4\theta + \theta^2\right) \\ +\alpha_1(1-\theta)\left(\alpha_2(\theta-1)\left(aB_2 + 4B_2c_1 - 5B_2c_2 - 5\right) + 4(1+\theta)\right) \end{bmatrix} \end{bmatrix}, \\
p_3 &= 2\theta\left(-1 - \theta + bB_1^2\alpha_1x_1^* + bB_2^2\alpha_2x_2^*\right) \\
&= \frac{2\theta}{3B_1B_2}\left[(1-\theta)\left(B_1^2\alpha_1X + B_2^2\alpha_2\right) + B_1B_2\left((1-\theta)\left(\alpha_2Y - 2\alpha_1\right) - 3(1+\theta)\right)\right], \\
p_4 &= \theta^2,
\end{aligned}$$

Among them, the notation is $X = aB_2 + B_2c_2 - 2B_2c_1 + 1, Y = aB_2 + B_2c_1 - 2B_2c_2 - 2$.

In this paper, the system parameters are substituted into it and simplified to get:

$$
\begin{aligned}
&P(1) = 1 + p_1 + p_2 + p_3 + p_4 \\
&= \frac{\alpha_1 \alpha_2 (\theta - 1)^2 \left(B_1 B_2 \left(a + c_1 - 2c_2\right) - 2B_1 + B_2\right)\left(B_1 B_2 \left(a - 2c_1 + c_2\right) + B_1 - 2B_2\right)}{3B_1 B_2} > 0 \\
&P(-1) = 1 - p_1 + p_2 - p_3 + p_4 \\
&= \frac{1}{3B_1 B_2}\left[\begin{array}{l} -2B_2^2 \alpha_2 (\theta - 1)\left(\alpha_1 (\theta - 1) - 2(1 + \theta)\right) + B_1^2 \alpha_1 (\theta - 1) X \left(\alpha_2 (\theta - 1) Y + 4(\theta + 1)\right) \\ + B_1 B_2 \left[\begin{array}{l} 4(\theta + 1)\left(\alpha_2 (\theta - 1) Y + 3(1 + \theta)\right) \\ -\alpha_1 (\theta - 1)\left(\alpha_2 (\theta - 1)\left(a B_2 + 4B_2 c_1 - 5B_2 c_2 - 5\right) + 8(1 + \theta)\right) \end{array}\right] \end{array}\right] > 0 \\
&1 \pm p_4 = 1 \pm \theta^2 > 0.
\end{aligned}
$$

From the positive and negative assumptions of the system parameters and the inequalities (13c-13d), it is obvious that $P(1) > 0$ and $1 \pm p_4 > 0$ in the stable condition. Therefore, the sufficient conditions for the asymptotic stability of the interior-point equilibrium E^* of the green-driven product investment game dynamic system (11) are classified as: $P(-1) = 1 - p_1 + p_2 - p_3 + p_4 > 0$ and $\left|M_3^{\pm}\right| > 0$, that is:

$$
\begin{cases} p_1 + p_3 < 1 + p_2 + p_4 \\ p_2 - p_2 p_4 + p_4 - p_4^3 - p_1 p_3 + p_1^2 p_4 < \left|1 - p_4^2 + p_2 p_4 - p_2 p_4^2 + p_1 p_3 p_4 - p_3^2\right| \end{cases} \tag{15}
$$

2.2 Numerical simulation

For convenience, in all the numerical simulation results in this paper, some parameters are set as follows: $a = 5, b = 1, B_1 = 0.6, B_2 = 0.8, c_1 = 0.3, c_2 = 0.5$.

The strategy adjustment speed of fixed enterprise 2 is $\alpha_2 = 2.2$. Figure 1 shows the bifurcation diagram of the system (11) with the adjustment speed θ of enterprise 1 under three different situations of $\theta = 0.35, \theta = 0.5$ and $\theta = 0.69$ respectively. It is easy to see that in Fig. 1(A) and Fig. 1(B), with the constant increase of the value of α_1, the system is stable from interior point equilibrium to repeated period-folding and finally enters a chaotic state. In Figure 1(C), more complex dynamical phenomena can be observed, with Neimark-Sacher bifurcation and periodic window appearing in the process of system evolution. Figure 2 gives a more detailed description of the system orbit change, which is a two-dimensional phase diagram corresponding to the α_1 value in different motion states of the orbit in Figure 1. Corresponding to the Neimark-Sacher bifurcation in Fig. 1(C), an invariant closed curve appears in Fig. 2(C).

Figure 1 not only presents the different paths of the chaotic phenomenon in the system, but also shows that when the residual value rate θ is larger (that is, the capital depreciation rate is smaller), the later the trajectory of the state variable enters the chaotic state, the stronger the stability of the system. This conclusion is well verified in Figure 3, which calculates the equilibrium point

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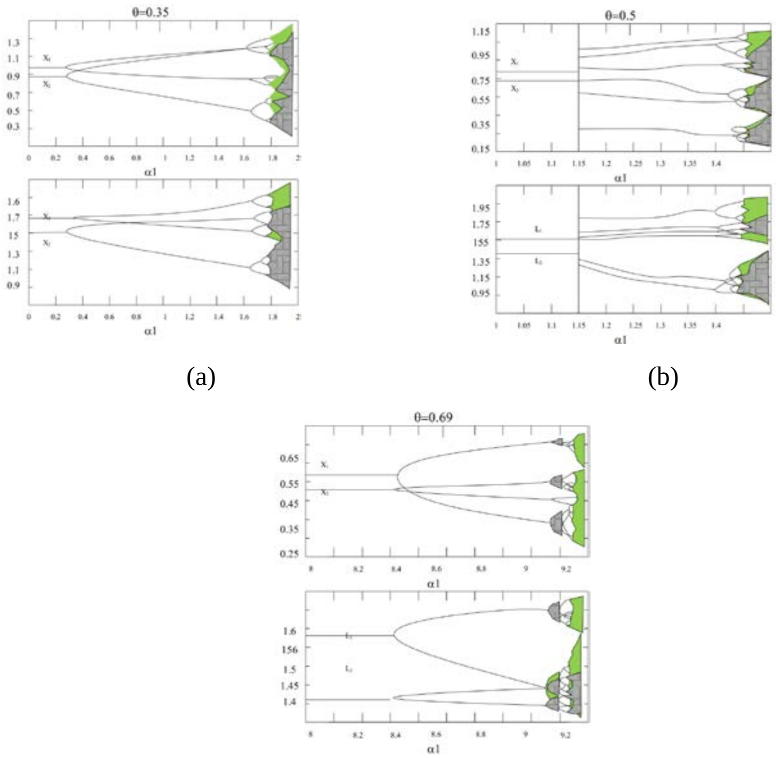
stability condition (15) by the program and draws the stable region of the system on the (α_1, α_2) plane. Comparing the three subgraphs in Fig. 3, it can be seen that the increase of θ increases the stability region of the system (11), so that the dynamic evolution of the system is more stable.

In this paper, the adjustment coefficient value $\alpha_1 = 1.426$ in a chaotic state of the system in Fig. 3.1(B) is selected, and the initial values of the system are $(x_1(0), x_2(0), I_1(0), I_2(0)) = (0.78, 0.72, 1.56, 1.44)$ and (0.78001, 0.72, 1.56, 1.44), respectively, and the evolution graph of the orbit of the system state variable over time is drawn, and some of its images are shown in Figure 4.

Figure 4(A) and Figure 4(B) are the evolution process of each enterprise's green drive product investment amount x_i track and green drive product investment stock I_i track, respectively.



(a) (b) (c)

Figure 1 Bifurcation diagram of dynamic system (11) with the change of adjustment coefficient a_1

In order to highlight the influence of the residual value rate θ of investment capital of green drive products on the stability of the orbital motion of the power system (11), Figure 5 and Figure 6 depict the bifurcation results of the system with the change of θ under different values of the adjustment coefficient α_1, respectively. Observing Figure 5 and Figure 6, we can see the inverse doubling period and inverse Neimark-Sacher splitting phenomenon respectively, and the system tends to be stable with the increase of θ.

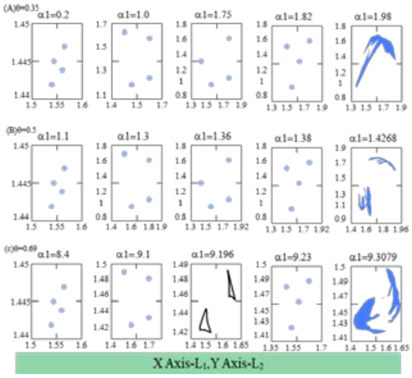


Figure 2 Phase diagram corresponding to bifurcation Figure under different values of parameters θ and a_1

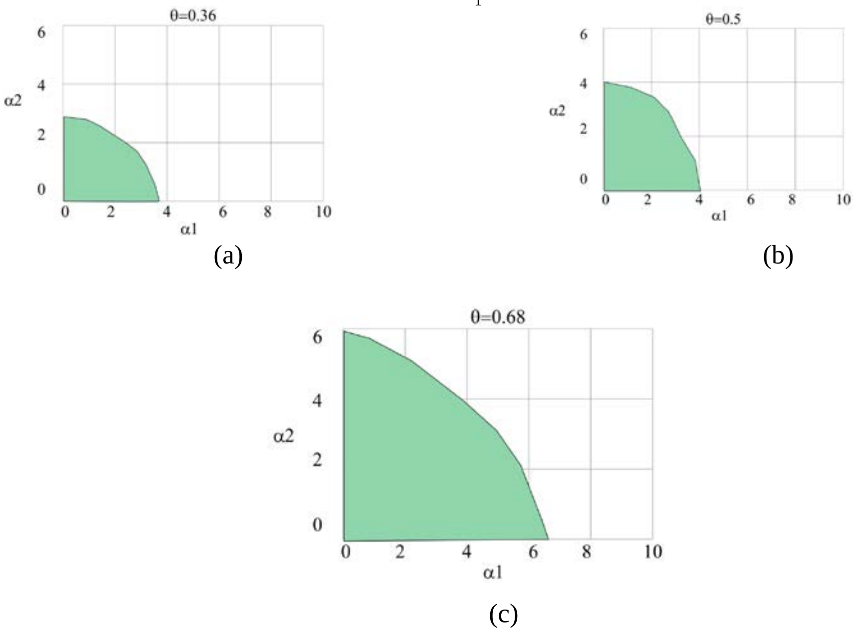


Figure 3 Stable region of dynamic system (11) on (a_1,a_2) plane

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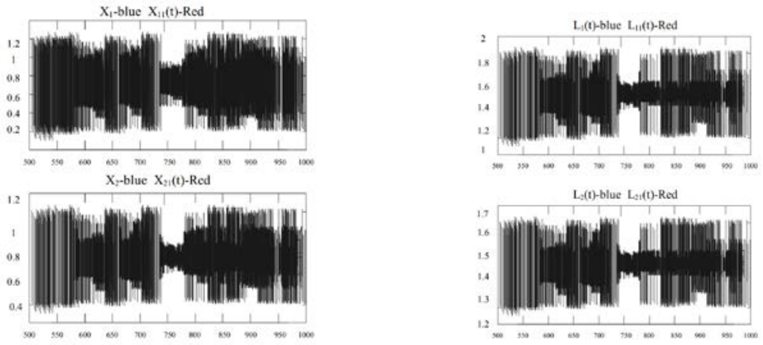


(a) (b)

Figure 4 Sensitive dependence of the dynamic system (11) on the initial value after instability

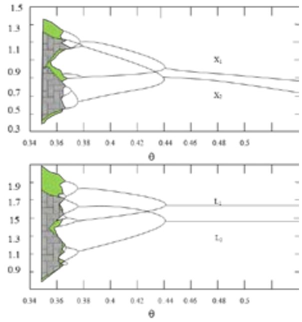


Figure 5 Bifurcation diagram of dynamic system (11) with residual value rate θ $(a_1=1.98)$

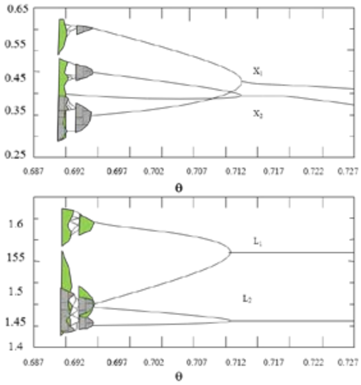
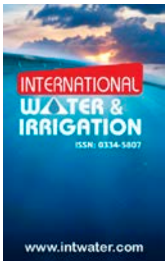


Figure 6 Bifurcation diagram of dynamical system (11) with residual value rate θ $(a_1=9.305)$ Chaos control



The investment adjustment speed and capital residual value rate of green-driven products have a great impact on the stability of the system.

We assume that the delay time is $\tau = 1$, and this paper considers adding feedback control term $k_i\left(x_i(t) - x_i(t+1)\right)$ to the state variable $x_i(t+1)(i=1,2)$ in the system, so the controlled dynamic system (11) is transformed into the following form:

$$\begin{cases} x_1(t+1) = x_1(t) + \alpha_1 x_1(t)\left[aB_1 - B_1c_1 - 1 - 2bB_1^2\left(\theta I_1(t) + x_1(t)\right)\right. \\ \qquad \left. - bB_1B_2\left(\theta I_2(t) + x_2(t)\right)\right] + k_1\left(x_1(t) - x_1(t+1)\right) \\ x_2(t+1) = x_2(t) + \alpha_2 x_2(t)\left[aB_2 - B_2c_2 - 1 - 2bB_2^2\left(\theta I_2(t) + x_2(t)\right)\right. \\ \qquad \left. - bB_1B_2\left(\theta I_1(t) + x_1(t)\right)\right] + k_2\left(x_2(t) - x_2(t+1)\right) \\ \qquad I_1(t+1) = \theta I_1(t) + x_1(t) \\ \qquad I_2(t+1) = \theta I_2(t) + x_2(t) \end{cases} \tag{16}$$

This shows that both participating companies balance their green-driven product investment strategies through reverse adjustment. This means that if the formula $x_i(t) - x_i(t+1) < 0, i = 1,2$ is established. Then, business participants will appropriately reduce investment in green-driven products to maintain their own profits, thereby stabilizing the market. Conversely, if W=1, the two participating companies will increase their investment in green-driven products in the next economic period. After finishing system (16), a new equivalent dynamical model is obtained:

$$\begin{cases} x_1(t+1) = x_1(t) + \dfrac{1}{1+k_1}\alpha_1 x_1(t)\left[aB_1 - B_1c_1 - 1 - 2bB_1^2\left(\theta I_1(t) + x_1(t)\right)\right. \\ \qquad \left. - bB_1B_2\left(\theta I_2(t) + x_2(t)\right)\right] \\ x_2(t+1) = x_2(t) + \dfrac{1}{1+k_2}\alpha_2 x_2(t)\left[aB_2 - B_2c_2 - 1 - 2bB_2^2\left(\theta I_2(t) + x_2(t)\right)\right. \\ \qquad \left. - bB_1B_2\left(\theta I_1(t) + x_1(t)\right)\right] \\ \qquad I_1(t+1) = \theta I_1(t) + x_1(t) \\ \qquad I_2(t+1) = \theta I_2(t) + x_2(t) \end{cases} \tag{17}$$

The stability analysis of the new system (17) is made below. The Jacobian matrix corresponding to the new system (17) is:

$$J = \begin{pmatrix} 1 + \dfrac{\alpha_1}{1+k_1}M_1 & -\dfrac{bB_1B_2\alpha_1x_1}{1+k_1} & -\dfrac{2\theta bB_1^2\alpha_1x_1}{1+k_1} & -\dfrac{\theta bB_1B_2\alpha_1x_1}{1+k_1} \\ -\dfrac{bB_1B_2\alpha_2x_2}{1+k_2} & 1 + \dfrac{\alpha_2}{1+k_2}M_2 & -\dfrac{\theta bB_1B_2\alpha_2x_2}{1+k_2} & -\dfrac{2\theta bB_2^2\alpha_2x_2}{1+k_2} \\ 1 & 0 & \theta & 0 \\ 0 & 1 & 0 & \theta \end{pmatrix} \tag{18}$$

As shown in Figure 1(B), starting from the adjustment parameter α_1 value of about 1.39, the controlled system enters a chaotic state. When the parameter set value $\left(a,b,B_1,B_2,c_1,c_2,\alpha_1,\alpha_2,\theta\right)=(5,1,0.6,0.8,0.3,0.5,1.426,2.2,0.5)$, the dynamic system (11) appears chaotic phenomenon. Under this set of parameter values, this paper obtains the expression of the Jacobian matrix (18) at the interior-point equilibrium E^* as:

$$J=\begin{pmatrix} 1-\frac{0.803313}{1+k_1} & -\frac{0.535542}{1+k_1} & -\frac{0.401657}{1+k_1} & -\frac{0.267771}{1+k_1} \\ -\frac{0.762667}{1+k_2} & 1-\frac{2.03378}{1+k_2} & -\frac{0.381333}{1+k_2} & -\frac{1.01689}{1+k_2} \\ 1 & 0 & 0.5 & 0 \\ 0 & 1 & 0 & 0.5 \end{pmatrix}, \quad (19)$$

We assume that the characteristic polynomial of matrix (19) is $P(\lambda)=\lambda^4+u_1\lambda^3+u_2\lambda^2+u_1\lambda+u_4$, then when its coefficients satisfy the stability conditional expression of the Schur-Cohn criterion, namely:

$$\begin{cases} \left|1+u_2+u_4\right|>u_1+u_3 \\ 1\pm u_4>0 \\ \left|1-u_4^2+u_2u_4-u_2u_4^2+u_1u_3u_4-u_3^2\right|>u_2-u_2u_4+u_4-u_4^3-u_1u_3+u_1^2u_4 \end{cases}$$

The eigenvalues of the time matrix (19) are all located in the unit circle on the complex plane, so the interior point equilibrium of the new system (17) is stable under the set of parameter values. Thus, the chaotic motion of the prime mover system (11) is controlled to the expected stable orbit. According to the above stability conditions, the value range of the feedback gain strength can be obtained.

The effectiveness of controlling the chaotic phenomenon of discrete dynamic system (11) is verified by Matlab simulation. Observing Figures 7 and 8, it can be seen that in terms of a single feedback gain intensity, if only the perturbation feedback control term $k_1\left(x_1(t)-x_1(t+1)\right)$ is added to the dynamic iteration Formula of the green drive product investment amount of the enterprise participant 1 in the controlled dynamic system (11), then the unstable orbit can be controlled as long as the feedback gain strength k_1 is greater than 0.2005 .

Fig. 9, Fig. 10 and Fig. 11 show the process of the evolution of the chaotic behavior of the controlled system from the initial value $\left(x_1(0),x_2(0),I_1(0),I_2(0)\right)=(0.94,0.87,1.56,1.44)$ to a stable orbit when the specific feedback gain strength is selected. Comparing these three graphs, it can be seen that the time for the state variable to reach steady state in Fig. 11 is shorter than that shown in Fig. 9 and Fig. 10.

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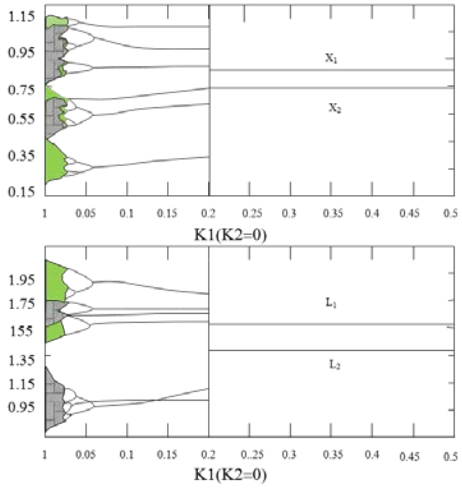

Figure 7 Bifurcation diagram of system (17) with respect to the change of feedback gain strength k_1 (k_2=0)

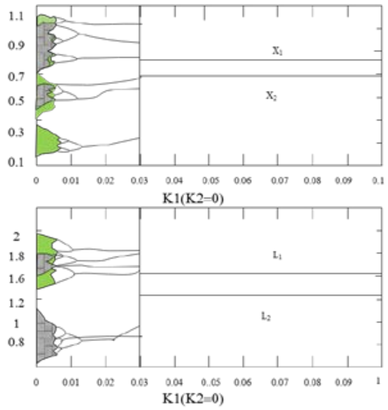

Figure 8 Bifurcation diagram of system (17) with respect to the change of feedback gain strength k_2 (k_1=0)

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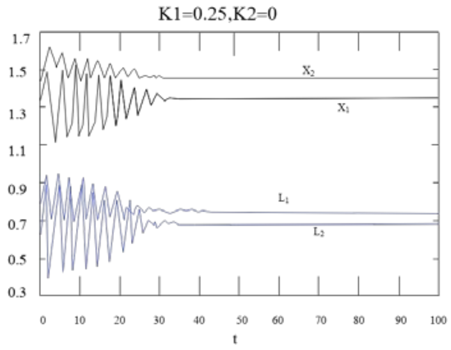


Figure 9 Evolution path of system (17) when $k_1=0.25,k_2=0$

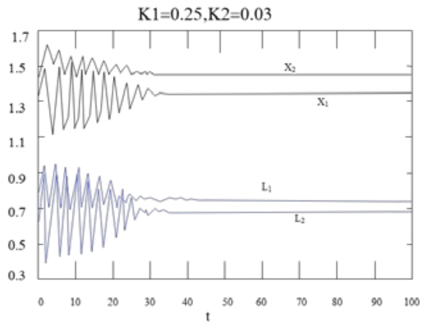


Figure 10 Evolution path of system (17) when $k_1=0,k_2=0.03$

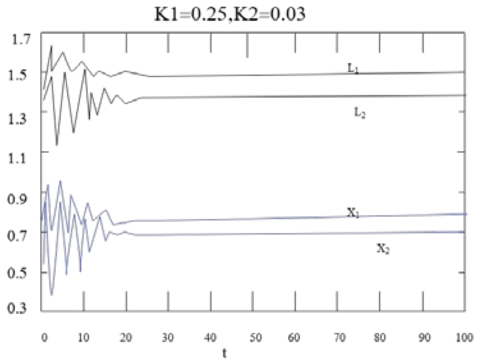
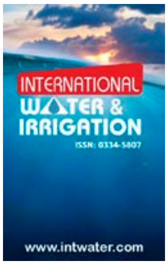


Figure 11 Evolution path of system (17) when $k_1=0.25,k_2=0.03$



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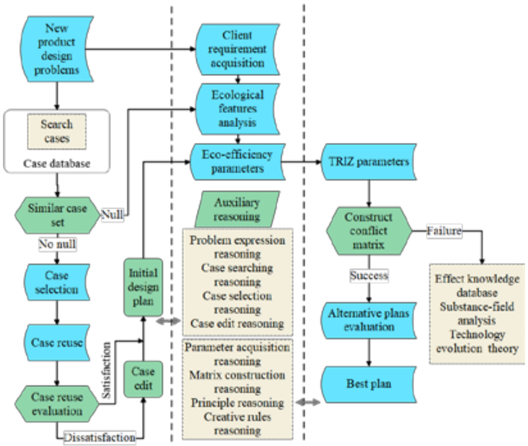
3 RESEARCH ON THE VALUE CREATION MECHANISM OF GREEN-DRIVEN PRODUCTS IN THE INTERNET+ ERA

The product green design process model mainly includes the following three stages (Figure 12(a)). The first stage is the preliminary scheme acquisition stage. It retrieves and filters similar instances according to customer requirements, takes design instances similar to customer requirements as reused instances, and forms a preliminary scheme through modification. The second stage is the ecological improvement stage. It selects TRIZ engineering parameters from the correlation table according to the eco-efficiency parameters to be improved, constructs conflicts and uses TRIZ tools to resolve design conflicts, and the third stage is the scheme evaluation stage. It evaluates design options. The main steps of the active remanufacturing green innovation design process model are as follows (Figure 12(b)). ①The model maps the remanufacturing customer requirements to the redesign manufacturing parameters, and applies the TRIZ technology conflict resolution principle to improve the design of the remanufacturing structure by transitioning from the redesign manufacturing parameters to the TRIZ engineering parameters. ②The model resolves design conflicts through the principle of physical conflict resolution. ③ The model evaluates the green innovation design scheme of active remanufacturing.



(a) Green-driven product eco-design process model

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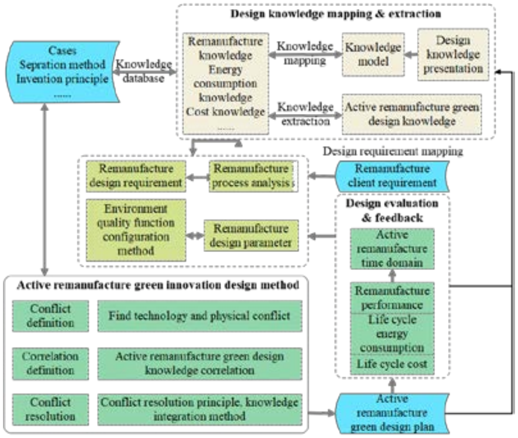

(b) Green innovation design process model for active remanufacturing

Figure 12 Value creation mechanism of green-driven products in the Internet+ era

After constructing the above green-driven product value creation mechanism, the effect verification of the green-driven product value creation mechanism proposed in this paper is carried out, and the verification results in Table 1 are obtained.

Table 1 Value creation mechanism of green-driven products

Num	Value Creation	Num	Value Creation	Num	Value Creation
1	86.281	16	89.630	31	86.722
2	84.661	17	82.335	32	86.165
3	87.860	18	84.443	33	88.452
4	82.264	19	87.042	34	86.639
5	88.423	20	82.830	35	83.479
6	82.075	21	82.883	36	87.155
7	86.781	22	87.113	37	87.650
8	88.417	23	89.160	38	88.154
9	89.856	24	88.337	39	86.617
10	88.957	25	89.308	40	89.810

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11	86.326	26	83.570	41	83.647
12	85.382	27	85.221	42	89.838
13	86.965	28	82.803	43	85.379
14	85.559	29	83.345	44	85.674
15	83.212	30	85.566	45	86.732

Through the above analysis, it can be seen that the value creation mechanism of green-driven products proposed in this paper can effectively promote the value of green-driven products.

4 CONCLUSION

In traditional new product development, the advancement of product technology plays a leading role, while less consideration is given to the needs of the market and customers. With the advent of the era of mass customization of products, customer needs are showing a development trend of personalization and diversification, and the speed of demand change is also accelerating. Therefore, the technology-oriented product development model in the past has been replaced by a customer-driven model. Moreover, the basis for corporate decision-making has changed from what products can be "produced" to what products can be "sold". In terms of marketing concepts, the original emphasis on "production-oriented" has been changed to "customer-driven". It can be seen that, In contemporary times, enterprises can only maintain their competitive advantage in the market by planning the direction of new product development based on the needs and expectations of customers. This paper studies the value creation mechanism of green-driven products in the Internet+ era. The experimental analysis shows that the value creation mechanism of green-driven products proposed in this paper can effectively promote the value of green-driven products.

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