Influence of external parameters on the dynamic behavior of resource-economic-pollution system

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Abstract

This paper discusses a new type of selective-constrained resource-economic-pollution (REP) system. Based on the nonlinear dynamics theory, the dynamic behavior of the new system is discussed. The genetic algorithm is used to identify the quantitative coefficients of the actual system. This paper further analyses the impact of state regulation, economic marketization management and green lifestyle on economic growth. Taking the actual situation into consideration in China, the empirical research is carried out by adjusting the parameters of the actual system. The dynamic evolution of real economic growth is observed which predicts future trends more realistically. The research shows that the introduction of state regulation into the REP system can promote economic growth quickly at a small rate in the short term. However, state regulation has little effect on economic growth in the long run. The impact of economic marketization management on the economy is moderate. A short-term, small-scale green lifestyle has little impact on system and economic growth because of China's large population base.

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1. Introduction

Economic growth usually refers to a sustained increase in a country's per capita output (or per capita income) over a long period of time. The level of economic growth rate reflects the growth rate of a country or region's economic aggregate in a certain period of time, and is also a measure of the growth rate of a country or region's overall economic strength [1]. Daniel et al explored the relationship between economic growth and environmental pollution in EU-28 countries. The results confirm the EKC hypothesis. EKC is the most famous theory about the relationship between economic growth and environmental quality, which refers to an inverted U-shaped relationship between economic output per capita and some measures of environmental quality [2].

A large number of researchers discuss factors related to economic growth [3, 4]. Different countries have different factors that affect economic development. In Pakistan, the agricultural sector is the backbone of the economy. Pakistan earned a handsome amount through exports of agricultural raw material and refined products [5]. In developing countries such as Qatar, energy conservation policies will have adverse effects on economic growth, and therefore alternative means must be undertaken to promote economic growth without damaging the environment[6]. In a report, the World Bank (2011) argues that, in developing countries, the joint effects of Information and Communications Technology (ICT) is the biggest driving force behind economic growth, serving as an engine of job creation, particularly among youth and women, and has also promoted trade and competitiveness through exports[7].

Since the reform and opening up, Chinese economy has been growing exponentially. However, it also faces many practical problems, resource savings and environmental protection etc. China's economic growth primarily depends on labor-intensive and energy-intensive production activities, mainly supported by a cheap labor force, natural resources, and natural environment[8]. For example, water shortages are one of the biggest challenges facing many countries, especially China's urban development. One study developed a water decoupling model and a water environment decoupling model to better understand the decoupling between urban economic growth and water use to promote economic growth without increasing water consumption[9]. Nevertheless, the element affecting economic growth is complicated and versatile in modern society. There may be other factors, such as state regulation, economic marketization management and green lifestyles et al.

In addition, the researchers used the theory of nonlinear dynamic systems[10, 11] to describe the relationship between resource, economic growth and pollution, and proposed a new three-dimensional REP chaotic system [12, 13], which shows that small changes in economic growth may cause catastrophic environmental damage through the use of The empirical data identifies system parameters to discover the folding relationship. Zhi-Nan Lu et al. studied the dynamic relationship between environmental quality, economic development and public health in China by establishing a simultaneous equation [14]. The impact of environmental pollution on public health and the economy was verified. A green lifestyle should be planned to promote a healthy life while the economy has also developed very well.

Fang et al. analysed a novel type of selective-constrained energy-saving emission reduction (ESER) chaotic system [15], analysing energy conservation costs (CCE), government control, low-carbon lifestyle and EER new technology investment on energy intensity and economic growth [16]. The actual system parameters are determined using an artificial neural network method. Focusing on the impact of government control and low-carbon lifestyles on energy intensity and economic growth, for China, government control can rapidly reduce carbon emissions and control energy intensity, but it has a specific inhibitory effect on economic growth. The low-carbon lifestyle does not affect economic growth while controlling energy intensity.

The actual REP system should be a complex system that includes many variables and corresponding constraint conditions. This study introduces state regulation, economic marketization management and green lifestyle into the resource-economic-pollution (REP) system [12] as constraint conditions. In developing countries, state regulation is not merely an issue of the technical design of the most appropriate regulatory instruments, it is also concerned with the quality of supporting regulatory institutions [17] and capacity [11, 18]. An effective regulatory system can promote economic growth and development. Economic marketization management is the impact of the market on the economy according to price changes, which is an essential factor to economic growth [19]. Green lifestyle refers to a natural, environmentally friendly, frugal and healthy lifestyle, based on green growth, sharing and co-construction. The green lifestyle is a factor that needs to be highly valued by the current society [20–22], which can fundamentally reduce pollution, save resources, and promote long-term economic development in the long run.

Compared to the existing literature, the novelty of this study is primarily reflected in two aspects. (1) This study firstly introduces state regulation, economic marketization management and green lifestyle into the Resource Economic Pollution System (REP) system as constraint conditions by using the nonlinear dynamical system approach. (2) The genetic algorithm is used instead of the artificial neural network to obtain the actual parameters. This method calculates the whole of the three equations with a smaller error. The selective-constrained REP system is more reflective of the actual situation and more realistically predicts future trends.

The outline of this paper is organised as follows. Section 2 provides the establishment of this model. Section 3 is the dynamic analysis of the model. Section 4 identifies actual system parameters based on Chinese statistical data and scenario analysis of economic growth by constraints. The conclusions and outlook are finally presented in Section 5.

2. Establishment of the model

The Resource-Economy-Pollution dynamical system (REP) includes resource, economic growth and pollution and many other variables. Each variable in the actual REP system has many restriction conditions. The total resource consumed in a region during a given period has much to do with state regulation. Market economy control will affect the economy scale to a large degree, while green lifestyle will have certain impacts on pollution. In the three-dimensional REP system [12], it is assumed that REP, resource, economic growth and pollution are restrained by state regulation, market economy control, green lifestyle incentives respectively. The corresponding restriction conditions are assumed to be $F_1(x, y, z, t)$, $F_2(x, y, z, t)$ and $F_3(x, y, z, t)$. The selective-constrained REP system can be described by the following differential equations:

$$\frac{dx}{dt} = a_1 x + a_2 y - a_3 yz + F_1(x, y, z, t) \tag{1a}$$

$$\frac{dy}{dt} = b_1 x(1 - \frac{x}{M}) - b_2 y - b_3 z + F_2(x, y, z, t) \tag{1b}$$

$$\frac{dz}{dt} = c_1 xy - c_2 z + F_3(x, y, z, t) \tag{1c}$$

where $x(t)$ is the total resource consumed in a region during a given period, $y(t)$, of economy scale, $z(t)$, of pollution [12]. a_i, b_i, c_i, (i=1,...,3) are positive system parameters, and M represents the maximum value of resource consumption.

The dynamic system presented in Eq.1 is a complex nonlinear system, in which the evolutionary relationship between the variables is mainly embodied with the coefficients and the corresponding formulas [12]. Firstly, the rate of resource consumption increases with resource consumption. In that economic development results in resource consumption, the rate of change of resource consumption is positively proportional to the economy scale ($+a_2 y$). If part of waste can be recycled, it can save resources and reduce consumption. So we obtain the third term $-a_3 yz$. $F_1(x, y, z, t)$ is the time-dependent variable of state regulation. It has an outstanding effect on controlling $x(t)$; thus the restriction of $F_1(x,y,z,t)$ from $x(t)$ is simplified as the direct restriction $-a_4x$.

The second formula in Eq.1 Refers to the complex relationship between the economic rate of change the complex relationship between the rate of change of economy scale dy/dt, resource consumption and pollution. The rate of change in economic scale is related to both resource consumption $x(t)$ and the potential share of resources $(1-x/M)$, directly proportional to their products. When there are enough resources, i.e., $x < M$ and $1 - x/M > 0$, the economy develops very fast. However, when the resource consumption is insufficient, the resource consumption is inversely proportional to the rate, i.e., $x > M$ and $1 - x/M < 0$. The addition of the economy offsets the pace of change. So dy/dt is inversely proportional to $ey(t)$. The more serious the pollution, the slower the economic development. Therefore dy/dt is inversely proportional to pollution $z(t)$. $F_2(x,y,z,t) = b'_4(z-x)\cdot(d/1-(1-d)^{-t})$ is the time-dependent variable of market economy control. b'_4 is the adjustment coefficient of $F_2(x,y,z,t)$; d is an effective discount rate. t is an economic market regulation period. The effective discount rate refers to the ratio of the future limited period expected income to the present value, which is the effective rate of return under certain conditions. The development of $y(t)$ is restrained by $F_2(x,y,z,t)$. The intensity of $F_2(x,y,z,t)$ is decided by the selection between $z(t)$ and $x(t)$, the value of t and d.

Formula.1c in Eq.1 indicates that the rate of pollution dz/dt. Resource consumption $x(t)$ and economic scale $y(t)$ affect pollution , and is positively proportionalc_1xy. The environment can slow down the pollution by its functions such as pollution filtering, waste sink, and waste decomposition. Therefore we get the $-c_2z$. $F_3(x, y, z, t) = c_3(y - x)$ is the time-dependent variable of green lifestyle. c_3 is the incentive coefficient. The impact of $F_3(x, y, z, t)$ on $z(t)$ depends on the change of $y(t)$ and $x(t)$.

Eq.1 can be written as follows:

$$\frac{dx}{dt} = a_1x + a_2y - a_3yz - a_4x \tag{2a}$$
$$\frac{dy}{dt} = b_1x(1 - \frac{x}{M}) - b_2y - b_3z + b_4'(z - x) \cdot (d/1 - (1 - d)^{-t}) \tag{2b}$$
$$\frac{dz}{dt} = c_1xy - c_2z + c_3(y - x) \tag{2c}$$

Let $b_4'(z - x) \cdot (d/1 - (1 - d)^{-t}) = b_4(z - x)$. Then Eq.2 can be simplified as:

$$\frac{dx}{dt} = a_1x + a_2y - a_3yz - a_4x \tag{3a}$$
$$\frac{dy}{dt} = b_1x(1 - \frac{x}{M}) - b_2y - b_3z + b_4(z - x) \tag{3b}$$
$$\frac{dz}{dt} = c_1xy - c_2z + c_3(y - x) \tag{3c}$$

3. Dynamic analysis of the model

When the coefficients of Eq.3 are given different values, the system presented in Eq.3 will exhibit different dynamic behaviors. It is found that when the parameters of Eq.3 are given in Table 1, the dynamic system presented in Eq.3 will display some interesting dynamic evolution behavior.

It is not difficult to find that this system has 5 balance points. And we find that although the number of equilibrium points varies with the parameters, there is always a balance point$S(0, 0, 0, 0)$. Then we calculate the Jacobian matrix of the Eq.3 at an equilibrium $S(x, y, z, w)$ is :

$$J = \begin{pmatrix} a_1 - a_4 & a_2 - a_3 z & -a_3 y \\ b_1 - b_4 - 2b_1 x/M & -b_2 & b_4 - b_3 \\ c_1 y - c_3 & c_1 x + c_3 & -c_2 \end{pmatrix}. \quad (4)$$

The characteristic polynomial of J at the equilibrium point $S(0, 0, 0, 0)$ is :

$$f(\lambda) = |J - I\lambda| = \lambda^3 + p\lambda^2 + q\lambda + r, \quad (5)$$

where I is the three-order unit matrix.

$$p = -a_1 + a_4 + b_2 + c_2$$

$$q = -a_1 b_2 - a_1 c_2 - a_2 b_1 + a_2 b_4 + a_4 b_2 + a_4 c_2 + b_2 c_2 + b_3 c_3 - b_4 c_3$$

$$r = -a_1 b_2 c_2 - a_1 b_3 c_3 + a_1 b_4 c_3 - a_2 b_1 c_2 - a_2 b_3 c_3 + a_2 b_4 c_3 + a_4 b_3 c_3 - a_4 b_4 c_3$$

In fact, the dynamic system presented in Eq.3 will have chaotic attractor and the corresponding dynamic evolution behavior when the system has another group of parameters. We find this group of parameters in the research. Based on the data in the system, the parameters in Table.1 are obtained during the process of parameter identification. These parameters reflect the properties of the system itself, rather than a simple dynamic behavior. From this viewpoint, the parameters Table.1 make the system closer to the actual one, being more convincing.

By the Routh-Hurwitz criterion, all real eigenvalues and all real parts of complex conjugate eigenvalues of Eq.5 are negative if and only if the following conditions hold: $p_1 > 0$, $p_3 > 0$, and $p_1 p_2 - p_3 > 0$. For some certain parameters, Eq.5 has unstable saddle-focus points.

Table 1: Parameters of Eq.3

Parameter	a_1	a_2	a_3	a_4	b_1	b_2
Value	0.065	0.035	0.065	0.04	0.5	0.088
Parameter	b_3	b_4	c_1	c_2	c_3	M
Value	0.06	0.06	0.468	0.06	0.001	10

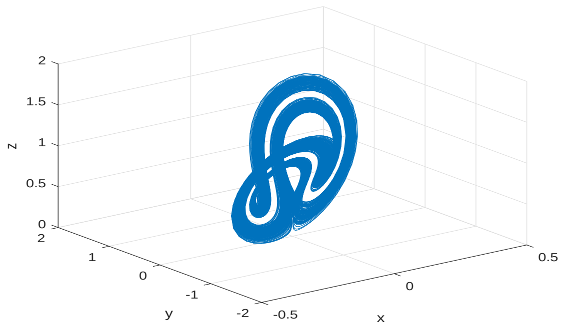
Table 2: Equilibrium points and their corresponding eigenvalues of Eq.3

Equilibrium point	λ_1	λ_2	λ_3	*Types*
$S_1(0, 0, 0)$	-0.0600	-0.1575	0.1336	saddle point
$S_2(0.1383, 0.6807, 0.7388)$	-0.1224	$0.0192 + 0.1406i$	$0.0192 - 0.1406i$	unstable saddle-focus point
$S_3(8.7274, 0.3601, 24.4412)$	0.8367	-0.7983	-0.1223	saddle point
$S_4(8.8697, -0.3512, -24.3707)$	-0.1179	$0.0170 + 0.8526i$	$0.0170 - 0.8526i$	unstable saddle-focus point
$S_5(-0.1364, -0.6928, 0.7327)$	-0.1232	$0.0197 + 0.1435i$	$0.0197 - 0.1435i$	unstable saddle-focus point

Divergence places an important role in the chaotic system. When there is unstable saddle-focus points, the restrained three-dimensional dynamic system presented in Eq.3 may be chaotic if the divergence is negative. Then we calculate the divergence of this three-dimensional dynamic system as follows:

$$\nabla V = a_1 - a_4 - b_2 - c_2 < 0. \tag{6}$$

We find a possible parameter set leading to chaos as shown in Table.1. Based on the parameters in Table.1, we have the equilibrium points and their corresponding eigenvalues as shown in Table.2. The different dynamic behaviors of the system are also presented.



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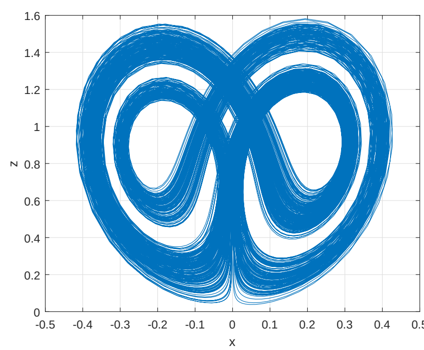

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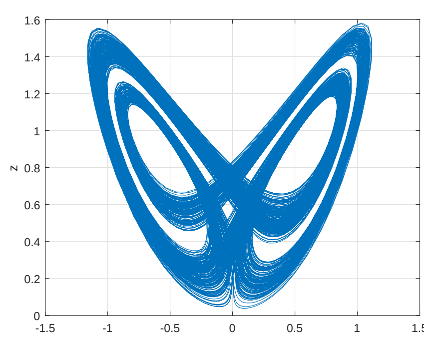


(c)

Figure 1: The 3D view of the selective constrained REP system. x : the total resource consumed y : the gross domestic product z : the pollution variable

When the parameters of Eq.3 are given in Table.1 and initials are given $[0.196, 0.36, 0.88]$, a chaotic attractor could be observed as shown in Fig.1. The corresponding time series of $x(t)$, $y(t)$, $z(t)$ as shown in Fig.2.

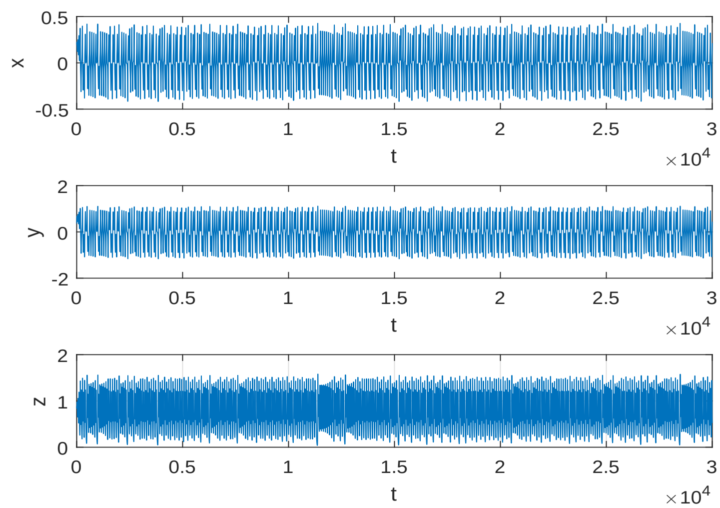


Figure 2: Time series of $x(t)$, $y(t)$, $z(t)$.

4. Scenario analysis

4.1. Statistical data and preliminary process

We have obtained the actual data by the China Statistical Yearbook (2007-2016). All data is standardized as $x(i) = (x(i) - \bar{x})/\sigma$, where $\bar{x}$ and σ represent the mean and the standard deviation of $x(i)$ respectively.

We choose the data of coal, oil, natural gas, and water resources as resources data, $x(t)$ are the linear sum of coal, oil, natural gas, and water resources. $y(t)$ (GDP) is the data of GDP. The amount of waste water emissions, waste gas emissions, and industrial solid waste emissions as envi-

Table 3: Data of $x(t)$, $y(t)$, $z(t)$.

Year	$x(t)$	$y(t)$	$z(t)$
2007	313339.01	270232.30	2946.94
2008	321114.08	319515.50	2741.00
2009	331735.48	349081.40	2620.57
2010	357653.50	413030.30	2547.55
2011	377788.09	489300.60	3269.37
2012	392657.49	540367.40	3216.01
2013	402345.73	595244.40	3032.43
2014	404956.82	643974.00	2933.81
2015	406362.60	689052.10	2828.04
2016	410478.40	744127.20	1502.52

ronmental data indicators. Because waste water and exhaust are difficult to be stored, emissions are adopted. Since tremendous amount of solid waste is stored instead of being discharged, production is employed. Considering China is a large developing economy, we use industrial waste water emissions, industrial exhaust emissions, and industrial solid waste production as indictors that influence the comprehensive evaluation variables of environmental quality. We put industrial waste water emissions as z_1, industrial exhaust emissions as z_2, industrial solid waste production as z_3. Analytic hierarchy process is used to acquire $z = 0.5788z_1 + 0.8059z_2 + 0.1247z_3$. Then we sort the data of $x(t)$, $y(t)$, $z(t)$ as shown in Table.3.

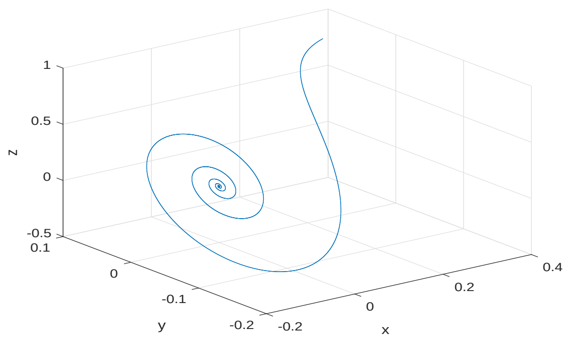
4.2. Parameter identification

The constraint-selective REP system Eq.3 is based on the complex relationship between resources, economic growth, pollution, and corresponding constraints that support each other and restrict each other. The determination of the parameters in the system is of great significance to the actual. This section starts with Chinese statistical data and uses genetic algorithms to derive parameters in actual systems. Genetic algorithm and back propagation neural network method is a random search method, which evolves from the evolutionary laws of biology with small errors. Firstly, we discrete Eq.3 and get the following difference equation:

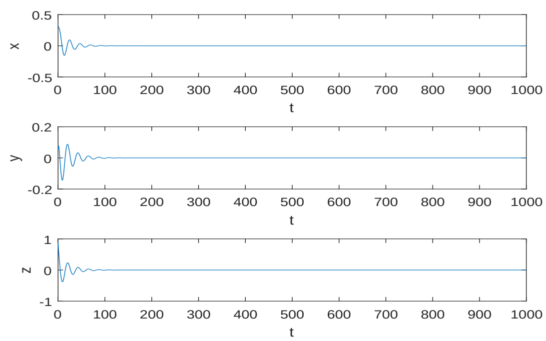
$$\begin{cases} x_{k+1} = x_k + T(a_1 x_k + a_2 y_k - a_3 y_k z_k - a_4 x_k) \\ y_{k+1} = y_k + T(b_1 x_k(1 - x_k/M) - b_2 y_k - b_3 z_k + b_4(z_k - x_k)) \\ z_{k+1} = z_k + T(c_1 x_k y_k - c_2 z_k + c_3(y_k - x_k)) \end{cases} \tag{7}$$

Select the previous $n-1$ sets of data as the input data, and the latter $n-1$ sets of data as the output data. The input and output variables are normalized in $x(i) = (x(i) - \bar{x})/\sigma$. Let crossover rate be 0.85, mutation rate is 0.06, and all the adjustable parameters be random. Comparing the data with output target and the error e is obtained and stopping the iteration procedure when e reaches 10^{-6}, the parameters of the actual system are obtained as shown in Table.4.

Choose the parameters of Eq.3 shown in Table.4, select the data [0.196,0.36,0.88] as the initial condition, and Obtain the actual phase diagram and time series diagram as shown in Fig.3, it can be seen that the actual system is steady state development, which is consistent with the actual situation.



(a)



(b)

Figure 3: (a) The phase diagram of the actual system. (b) The actual time diagram of the actual system .

Table 4: Parameters of actual system

Parameter	a_1	a_2	a_3	a_4	b_1	b_2
Value	0.0741	0.3939	0.0051	0.2207	0.0013	0.3784
Parameter	b_3	b_4	c_1	c_2	c_3	M
Value	0.0997	0.2681	0.2623	0.1386	0.5989	0.9011

4.3. The impact of state regulation on economic growth

Each parameter has its practical meaning in a selectively constrained REP system. Changing the value of each parameter indicates the evolution between the corresponding variables, which will lead to very complex dynamic behavior of the entire system. a_4 represents the national regulation coefficient, and Fig.4 shows the impact on economic growth when a_4 changes. Stable value 1 (referred to as curve 1) corresponds to the influence curve of $a_4 = 0.2207$, Stable value 2 (referred to as curve 2) corresponds to the influence curve of $a_4 = 0.5207$, and Stable value 3 (referred to as curve 3) corresponds to $a_4 = 0.9207$. Comparing and observing the three curves, it is found that when a_4 is gradually increased, the impact on the economy begins to be relatively large, which is reflected in Fig.4, that is, the difference between the peak value and the stable value is relatively large. However, with the evolution of the system, the impact on the economy tends to be stable, and the value after stabilization is above the zero-tick line, that is, it is always greater than zero, which promotes the economy; Curve 2 has been greater than zero for a short period of time, promoting economic growth. After a long enough time, it is located at the zero marks, which hinders economic growth. Curve 1 promotes rapid economic growth in a short period time, and then slowly promotes the economy, then suppresses economic growth, and then promotes economic growth. That is to say, the country's little regulation and control will have fluctuations in economic growth, and finally the economy will stabilise. The state should increase control over resources and pollution, establish and improve systems for resource protection, rationally use resources, and reduce pollution. The above analysis shows that when the state enhances macroeconomic regulation and control and plays a role in the system, it can promote economic growth in a small and rapid manner, in the short term. However, after a long period time, the impact on the economy was small and economic growth declined. For China's current national conditions, state regulation can promote economic growth in a small amount, and has little impact on the economy in the long run, and the economy will fall back. And can control system stability, and can appropriately regulate economic stability, appropriately increase state regulation and even promote economic growth. State regulation is a decisive factor for promoting stable economic growth.

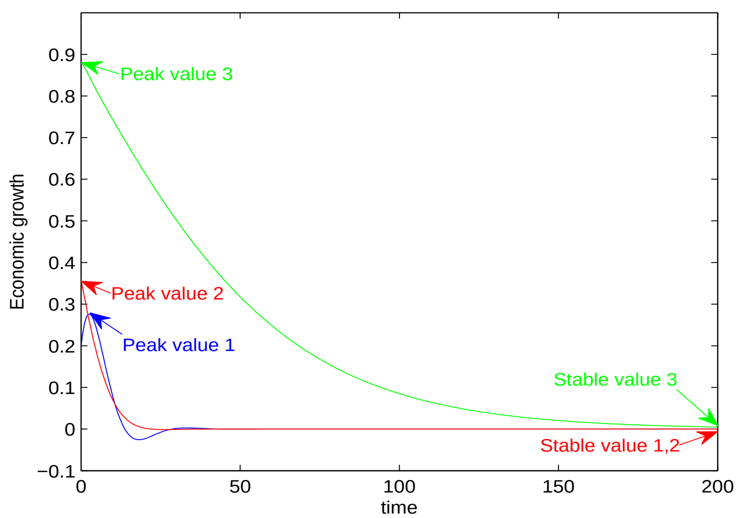


Figure 4: The evolution tendency of economic growth when a_4 changes. base case: $a_4 = 0.4207$ strong case 1: $a_4 = 0.5207$ strong case 2: $a_4 = 0.9207$

4.4. The impact of economic marketization management on economic growth

b_4 is the economic marketization management coefficient. In the constraint conditions $F_2(x, y, z, t) = b_4(z - x)$, attention should be paid to the influence of the state's regulation of such rigid administrative means b_4 on the current market-oriented economy. Fig.5 shows the change in the corresponding economic growth when b4 changes. Stable value 1 (referred to as curve 1) corresponds to economic growth when $b_4 = 0.2681$, stable value 2 (referred to as curve 2) corresponds to economic growth at $b_4 = 0.5681$, stable value 3 (referred to as curve 3) corresponds to economic growth at $b_4 = 0.68681$ economic growth. Comparing the three curves, it is found that when b_4 gradually becomes larger, the initial stage of the economic growth curve multiplies under the influence of market regulation. As the growth is too fast, the state's regulation and control will gradually increase, which will slow down the rate of economic growth to a certain extent, prevent inflation, and finally the economic growth tends to be stable. The stability value is far greater than zero. The greater the economic economy control management coefficient, the faster the growth. In the long run, it is conducive to economic growth. The above analysis shows that the greater the economic marketization management coefficient, the faster the economic growth. For the current situation in China, economic market-oriented management has a significant effect on controlling system stability and promoting economic growth. That is, economic market-oriented management has a great influence on the current China REP system and is an important factor in promoting economic growth.

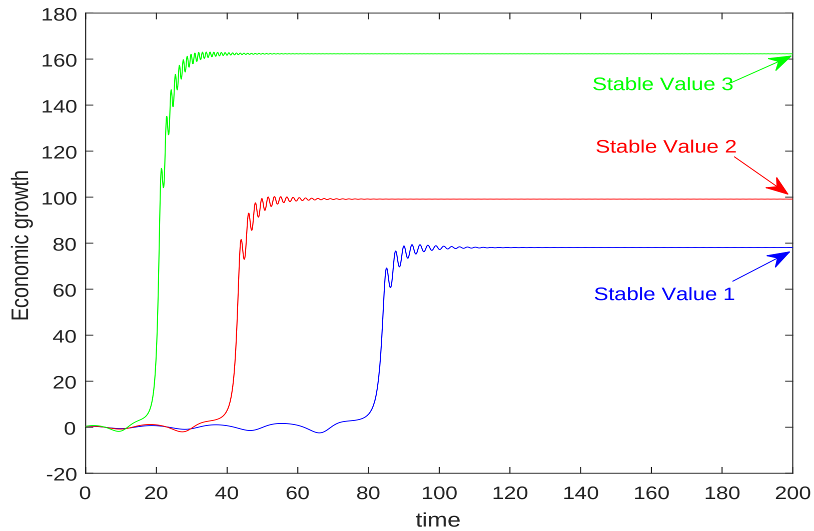


Figure 5: The evolution tendency of economic growth when b_4 changes. base case: $b_4 = 0.2681$ strong case 1: $b_4 = 0.5681$ strong case 2: $b_4 = 0.8681$

4.5. The impact of green lifestyle on economic growth

c_3 is the adjustment factor for the green lifestyle, and Fig.6 shows the impact on economic growth when c_3 changes. Stable value 1 (referred to as curve 1) corresponds to the influence curve of $c_3 = 0.1989$, Stable value 2 (referred to as curve 2) corresponds to the influence curve of $c_3 = 0.5989$, and Stable value 3 (referred to as curve 3) corresponds to $c_3 = 0.9989$. Comparative observation of the three curves found that when c_3 changes gradually, in a small range, there is no obvious effect on promoting economic growth. When c_3 increased to 0.9989, due to the regulation of the state and the adjustment of the economic market, the economy first fluctuated and grew steadily. The impact on the economy is obvious. The above analysis shows that short-term, small-scale green lifestyles have little impact on system and economic growth, and even unfavorable situations. Because the country has a large population base and increased regulation of green travel, it may help economic growth, energy conservation and environmental protection. However, this will also cause shocks to the social economy, in that too much green travel may lead to lower efficiency in all aspects. Therefore, we must choose the right coefficient to promote economic growth, so that the economy does not produce too much shock. We need to understand it correctly. The more people choose green lifestyles and reduce pollution, our living environment will be even better, the goal of promoting stable economic growth will be easier to achieve.

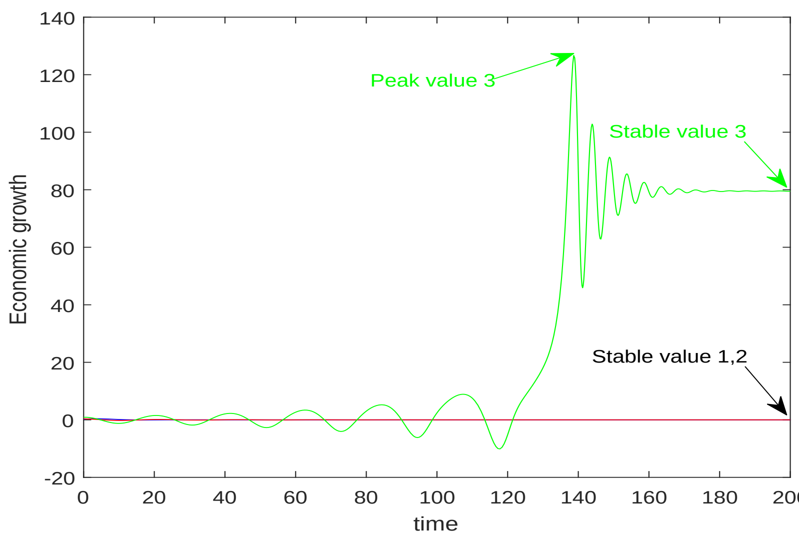


Figure 6: The evolution tendency of economic growth when c_3 changes. base case: $c_3 = 0.1989$ strong case 1: $c_3 = 0.5989$ strong case 2: $c_3 = 0.9989$

5. Conclusions

A new type of selective constrained REP dynamic evolution system is proposed, which analyses the impacts of state regulation, economic marketization management and green lifestyle on economic growth. The decisive factor for promoting stable economic growth is state regulation. Economic marketization management has a great impact on China's current REP system and is an important factor in promoting economic growth. The selectively constrained REP dynamic evolution system is more realistic and easier to control.

The results of the scenario analysis show that in the early stage, due to the lack of sound resources protection and other systems, the economic growth is volatile, and the state regulation is introduced into the REP system. The state allocates resources rationally, reduces pollution and waste, and finally promotes stable economic growth, that is, the decisive factor for promoting steady economic growth is state regulation. Economic marketization management has a great impact on China's current REP system and is an important factor in promoting economic growth. The short-term green lifestyle has little effect on the system and economic growth, and even has an unfavorable situation. We need to understand it correctly and continue to practice the concept of green lifestyle in practice. Through the above analysis, today's social pollution is getting more and more serious. The selective binding REP system provides a good solution for reducing pollution and green development. When resources are scarce and pollution is severe, the implementation of urgent green lifestyle and then control the government and adjust the economic market appropriately. The actual REP system is related to China's national conditions, economic and cultural background. The results of the theoretical analysis of data may be slightly different from the real situation.

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