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Research Article

Numerical Simulation-Based Model for Analyzing the Correlation between GDP Index and Quality of Life

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As the information carrier of the social economy, the quality of statistical data has become more concerned and sensitive in the society and the data quality of GDP, as one of the core aggregate indicators of national economic accounting, has received more extensive attention. Government statistical departments have placed data quality in a strategic position in the development of statistical undertakings, and the assessment of GDP data quality is an important part of their data production management process. This paper uses the livelihood index to represent the survey data of quality of life level and theoretically analyzes and empirically tests the importance of improving quality of life in the current development stage, the relationship between improving people's livelihood and economic development, and the population distribution of public service satisfaction and the influence of public service satisfaction on life satisfaction. In response to the major real-life problems in the development of economic and social quality of life, many research institutions have carried out in-depth survey and research work at various levels and in various fields, with large samples and a wide range, accumulating a large number of survey and research reports with detailed data and unique content, the same as thematic research reports with standardized analysis based on survey data. Taking mathematical economics as the basic starting point, this paper conducts an in-depth study on the relationship between GDP index and quality of life from the analysis of the operation law, inner operation mechanism, stability, and other relevant aspects of the model itself. Taking the classical endogenous economic growth model as the starting point, the endogenous theoretical nonlinear dynamical system of GDP index and quality of life, the nonlinear dynamical system of GDP index and quality of life, and the theoretical nonlinear system of GDP index and quality of life supply and demand are constructed; and the stability analysis is conducted for the constructed nonlinear dynamical system, the situation when the model starts to destabilize is discussed and the model is addressed. The theoretical analysis and numerical simulation results are presented for the conditions of existence, bifurcation direction, and stability of the bifurcation period solution of the Hopf bifurcation that may occur.

1. Introduction

In the context of economic growth, "people's livelihood" has become a buzzword in the political context, with a wide range of extensions that affect people's lives and ensure human development in all areas. In essence, "improving people's livelihood" means providing public services for "comprehensive human development," which is a fundamental part of national governance and one of the basic pillars of people's happiness and quality of life. To help provide a new research perspective, the value orientation of government performance evaluation roughly exists in three gradients: objective indicators, satisfaction, and happiness index, with the evaluation of government-oriented by objective indicators such as GDP and scientific development shifting to satisfaction maximization [1]. This shift is consistent with the concept of modern government governing for the people and also restrains the overdraft of economic growth on ecological environment and resources to a certain extent.

This paper mainly applies the economic cycle theory to guide the study of the level of GDP index affecting the quality of life on the time stage. Because of the different economic environment backgrounds in different regions, the level of macroeconomic development will have different effects on the GDP index. Regional unbalanced development theory guides the research of macroeconomic development level affecting GDP on spatial distribution, due to the obvious regional development imbalance in the investigated areas, the regional economic development level where each enterprise is located is different, which will affect the GDP level [2]. The economic cycle theory has been created by economists to discover and summarize the changes in economic trends, and to study the changes in macroeconomic indicators in most places. The economic cycle theory is of great relevance to help companies and countries predict future economic trends and make early responses. Industry cycle theory guides the research of macroeconomic development levels affecting enterprise profitability in different industry types. Each industrial industry has different roles for the national economy and is indifferent to industry cycles, and the impact of the GDP index on the quality of life will be different. Using time, space, and industry as different backgrounds, we explore the influence of macro GDP index development and quality of life growth, analyze the correlation between macroeconomic development and quality of life, and explore the different status of the correlation between macroeconomic development level and livelihood index in different time stages, different spatial regions, and different industry types [3]. A comprehensive analysis of the correlation between GDP index development and quality of life enriches the type of literature in this research area.

2. Related Work

In the study of the impact of macroeconomic cycles on firms, most scholars have empirically studied the quality of life performance of GDP in different economic cycles based on data from various countries and the characteristics of economic cycles. Ihsan and Aziz [4] confirm that economic expansion periods have a better quality of life by studying the relationship between macroeconomic fluctuations and quality of life. De-Nadai et al. [5] found procyclical effects of quality of life in periods of economic expansion. Literature [6] introduced autoregressive conditional heteroskedasticity (ARCH) models to describe volatility, and literature [7] extended such models to generalized autoregressive conditional heteroskedasticity (GARCH) models. To describe the asymmetry of stock returns, Loong et al. [8] introduced TGARCH and EGARCH models. A large number of studies on GDP and quality of life have shown that volatility is highly persistent, and the above ARCH-like models can better describe the persistent characteristics of stock market volatility. However, the traditional ARCH model family has a drawback: it does not take into account the fact that financial time random variables are subject to occasional and abrupt jumps, and these discontinuous jumps can undergo dynamic structural changes. Wang et al. [9] point out that the model shifts between high and low different stages of development. Many scholars have found that there is a Regime Switching process of correlation, where the release of macroeconomic information, disclosure of information about listed companies, and policy interventions can cause abrupt changes in the correlation between GDP index and quality of life, causing sudden jumps in time series fluctuations. To consider such nonlinear, dynamic, and sudden changes, literature [10] pointed out that the correlation can explain the characteristics of spikes and thick tails and mean recovery of the correlation between GDP index development and quality of life under different growth state transformations using the district system shift approach.

The study of GDP index development and quality of life growing in literature [11] showed that ARCH-type models have poor predictive power for volatility although they can better describe the persistent characteristics of volatility. To address the problem of overestimation of volatility persistence by ARCH-type models, literature [12] proposed an autoregressive conditional heteroskedasticity (SEARCH) model with zone shift, which decomposes the volatility persistence into different volatility zones, and achieved good empirical results. And literature [13] found that the Markov zone regime shift variance (MS-var) model has a better description of the heteroskedasticity of GDP and quality of life correlation fluctuations than the SEARCH model when the ARCH effect is not significant. Literature [14] further found that the Gibbs sampling estimation method has better identification of the fluctuating locus system than the great likelihood estimation method. Literature [15] gives the displayed solution of the Uzawa-Lucas endogenous growth model for human and physical capital and finds that the introduction of the livelihood index enables the social optimization of GDP index development and quality of life growth while ensuring the balance of payments for policymakers. Yang et al. [16] extend the Lucas endogenous growth model by adding sector-specific externalities as well as depreciation for all sectors and obtains the equilibrium growth path and the sufficient conditions for the existence of equilibrium. Peters et al. [17] argue that when technology obeys geometric Brownian motion, the value function should depend only on the state variables of the year. They obtained a different value function subject to some inequality constraints. Literature [18] and others studied the optimization strategy for the U-L model of human capital externalities when agents focus on consumption and leisure. This paper finds that the government can obtain the optimum when it gives the study through a fixed tax and forgoes the subsidy of income. In a study of the Uzawa-Lucas extension model of labor-loaf choice, Sinha et al. [19] and others find that sector-specific externalities of commodity production generate a market failure associated with socially optimal decisions. Ebrahimi and Pilevari [20] used the Uzawa-Lucas model as a basis for a study of the relationship between the development of the GDP index and the growth of quality of life, based on the relevant properties of the model.

3. Analysis of the Pattern of Correlation between GDP Index and Quality of Life

3.1. GDP Data Quality Study. Statistical data quality assessment methods are closely related to information technology and people's demand for data quality. Before entering the information society, the relevant technology was not particularly mature, and people's demand for information was low, so statistical data did not receive much attention, and their quality was largely understood at the stage of accuracy. In line with this, the technical methods of data quality assessment were mostly limited to the accuracy assessment, and the content of the assessment was mainly to check whether the statistical data violated specific logical relationships. With regards GDP data and quality of life assessment based on the perspective of data users, i.e., methods to assess the quality of published statistics, mainly including statistical model assessment methods (such as regression prediction, statistical diagnosis, structural equations), statistical index methods, four-level measurement methods, fuzzy comprehensive evaluation, indicator set methods, and user satisfaction surveys, the specific choice of methods can also be based on the corresponding data types. With the advancement of technology and the strengthening of information in society, information has become the basis for decision-making of various economic entities, and statistical data and their quality have been widely concerned by all sectors of society. Accordingly, the methods of data quality assessment have been developed, and the users of statistical data will carry out purposeful assessment according to the specific statistical data, and the number of assessment methods used has gradually increased, as shown in Figure 1, which shows the framework of GDP data quality research.

Economic cycles are fluctuations in national income and total output that lead to alternating economic expansion and contraction in the overall economic operation and show certain cyclical fluctuations. Economic cycle theory suggests that economic growth cannot be sustained in one state; it is necessary for a constant state of flux. The economic boom is exciting, but the boom is bound to be followed by a recession or even depression. Therefore, the macroeconomic operation is a cyclical fluctuation marked by expansion and contraction, and each economic cycle usually goes through four stages: boom, recession, depression, and recovery. Changes in aggregate national output, aggregate income, and aggregate employment cause economic variables to alternate between booms and busts repeatedly throughout the continuum.

The economic cycle theory was created by economists to discover and summarize the changes in economic trends and to study the changes in macroeconomic indicators in most places. The economic cycle theory is of great practical importance to help companies and countries predict future economic trends and make early responses. Even with all the facilities, data collection, and modern science and technology, economic cycle theory is still one of the most difficult problems in economics and poses a great challenge to researchers. Until now, economists have not reached a unified understanding of the causes of economic cycles. Based on a different understanding of the causes, economic cycle theory is broadly divided into five major schools: Keynesian economic cycle theory, New Keynesian rational expectations school, real economic cycle, and modern monetarism. Macroeconomic cycle fluctuations have traditionally received attention from both academic and governmental sectors. In describing the trends of economic cycles, the internationally used and relatively comparable GDP index, which reflects economic fluctuations and development trends, is usually used.

The econometric model analysis is a type of statistical data quality assessment method based on the establishment of econometric models to assess the data quality of relevant indicators [21]. In the data quality assessment of GDP by using econometric model analysis, we use GDP as the explanatory variable and construct an econometric model that can effectively portray the relationship between other statistical indicators and GDP through in-depth analysis based on the corresponding economic or statistical theories; on this basis, we analyze the agreement between GDP and the constructed assessment model based on the estimation results of the model that is mainly judged by the error rate. At the same time, it can also be done by assuming that GDP theoretically follows a particular statistical distribution $F(x|\theta)$. Whereas the statistical sample is realized as a sampling of the statistical aggregate, if the GDP sample data does not have accuracy problems, it is known by Glivenko's theorem that its empirical distribution function will converge to the aggregate distribution function according to the probability; the $F(x|\theta)$ formula is as follows:

$$\lim_{n \longrightarrow \infty} P\left\{ \sup_{x \in R} |F_n(x) - F(x|\theta) < \varepsilon \right\} = 1. \quad (1)$$

Based on this understanding, the values of the collected GDP are tested by a hypothetical statistical distribution to determine whether the GDP data are normal and credible at each point in time or a particular region.

From the perspective of quality of life, this paper will empirically study the satisfaction of public services from a micro perspective. The public service satisfaction, as well as the livelihood index, is used to represent the quality of life index. Statistical data quality assessment methods are closely related to information technology and people's demand for data quality. Before entering the information society, the relevant technology was not particularly mature, and people's demand for information was low, so statistical data did not receive much attention and their quality was largely understood at the stage of accuracy. The statistics of individual satisfaction are with four types of public services: compulsory education, medical and health care, ecological environment, social security, and overall life satisfaction. Considering the actual development gap between urban and rural areas, this paper presents the statistics by urban and rural samples separately. The measure of satisfaction refers to the proportion of the sample that expresses satisfaction, i.e., the proportion of the sample that answers "very satisfied" and "relatively satisfied." It should be noted that the calculation of life satisfaction is done in two steps: in the first step, the satisfaction level of urban and rural populations in each region is calculated separately; in the second step, based on the results of the first step, a weighted average is made based on the weight of urban and rural populations in each region relative to the national urban and rural populations.

3.2. GDP Index Development and Quality of Life Correlation. The relationship between GDP index development and quality of life growth has become the focus of research in economics, and the relationship between the two has

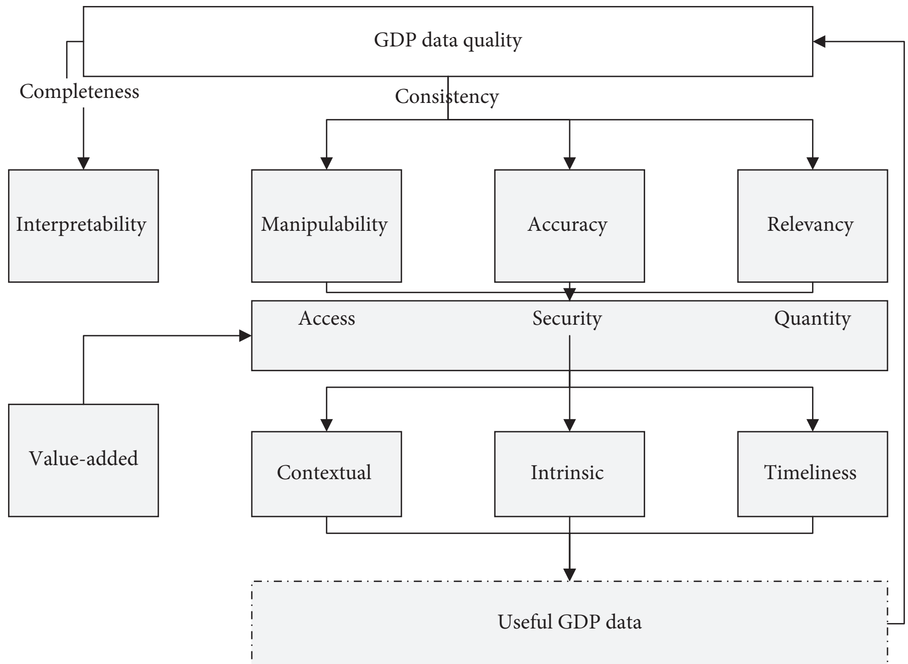

FIGURE 1: A framework of GDP data quality study.

become increasingly complex, showing more nonlinear and asymmetric characteristics. The correlation between GDP index development and quality of life is difficult to predict, but a series of studies have demonstrated that a large number of studies have managed to develop dynamic models to measure this correlation.

The discussion of GDP index development and quality of life growth has been gaining momentum globally, starting with the Romer and Lucas models, which are typical: the assumption that existing human capital is the only input to the education sector in the two-person model. The Restrepo-Ochoa model analyzes the cyclical nature of the generalized Uzawa-Lucas model. The components of the model are obtained through a series of decompositions, and the dynamic nature of the different cycles of these components is studied. The Rei*β* model and the Bethmann model, among others, solve an *N*-squared differential game optimization problem with a logarithmic objective function based on the Uzawa-Lucas endogenous growth model. They show that the effect of externalities will disappear rapidly along the equilibrium growth path as the number of participants increases.

The quality of life is set to consist of representative households and firms, and the results of the correlation analysis between GDP per capita and the quality of life level index are obtained in Figure 2. Representative households provide labor in exchange for wages, collect interest income on assets, purchase goods for consumption, and accumulate assets for savings. Through the BO-abandonment behavior of both sides of receiving and reporting data in the statistical data generation process, the GDP data and quality of life control system are designed based on the dynamic BO-abandonment model of violations. Firms produce goods, pay wages for labor inputs, and pay rents for capital inputs. To simplify the model calculation process, it is useful to assume that the GDP index is constant in society and that the utility function is a fixed intertemporal elasticity of substitution to maximize utility [22].

$$\max \int_{0}^{+\infty} U(c)e^{-(\rho-n)t}\mathrm{d}t. \quad (2)$$

c represents per capita consumption

P is the time preference rate

$U(c)$ is the utility function, which can be expressed as $U(c) = (c^{1-\sigma} - 1/1 - \sigma)$

4. Analysis of GDP Index and Quality of Life Based on Numerical Simulation Correlation

4.1. Qualitative Analysis of GDP Index and Quality of Life Assessment Based on Structural Correlation. The construction of a framework system for the assessment of GDP data and quality of life from a correlation perspective requires the identification of key elements in it, i.e., prerequisites, from a systems perspective, and these prerequisites include a methodological system, a quality control system, and an organizational system.

The first step is to establish a GDP data and quality of life assessment method system. Different GDP data and quality of life assessment methods are set up according to the data types. From the data types of continuous variables, there are mainly three types of data: cross-sectional, time series, and mixed types. Accordingly, it is necessary to combine other divisions of GDP data and quality of life assessment methods with data types, to form a library of GDP statistics and quality of life assessment methods adapted to the content of

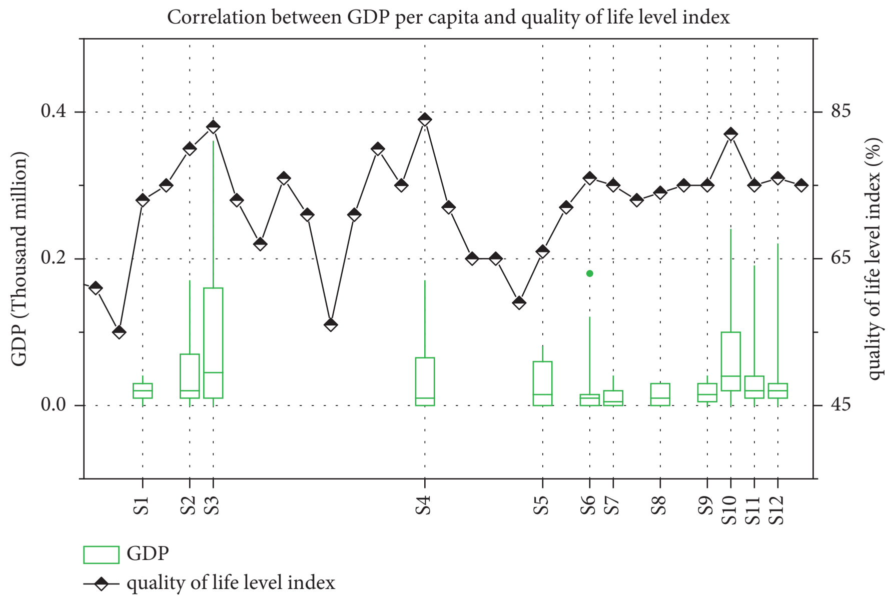

Figure 2: Correlation between GDP per capita and quality of life level index.

the study. For example, when assessing GDP data and quality of life from the perspective of data production and use in combination with data types, it is necessary to use GDP data and quality of life assessment methods based on the perspective of data producers, i.e., methods for assessing the quality of raw data and intermediate data during the data production process, which include traditional assessment methods (e.g., logic check method, correlation ratio method, trend and correlation method) and mathematical and statistical methods (e.g., statistical distribution test method, abnormal value identification method based on statistical distribution, and bias estimation based on post hoc repeated surveys). In the assessment process, the corresponding assessment methods are specifically selected for specific data types. The assessment of GDP data and quality of life based on the perspective of data users, i.e., the methods for assessing the quality of published statistics, mainly includes statistical model assessment methods (such as regression prediction, statistical diagnosis, and structural equations), statistical index methods, four-level measurement methods, fuzzy comprehensive evaluation, indicator set methods, and user satisfaction surveys, and the specific selection of methods can also be made according to the corresponding data types. The second is to establish a multidimensional perspective of GDP data and quality of life control system. For statistical data quality control, different studies have proposed different ways [23]. Different assessment models may overestimate or underestimate data quality, but if there is consistency among different models, it means that GDP data quality meets various assessment assumptions and criteria from a multidimensional perspective, so the higher the consistency of various models, the higher the data quality. And from the realistic operation, a multidimensional data quality control system needs to be established. The establishment of the control system: one is to establish the technical system from the system perspective; that is, the PDCA cycle theory can be assembled with the statistical work to design the cyclic control technical system of GDP data and quality of life, and at the same time, the theory of GDP statistics and quality of life management system including the quality assurance system is constructed according to the international standard of quality management. Secondly, the systemic problems are gradually solved according to the actual national conditions. Through the BO-abandonment behavior of both sides of receiving and reporting data in the statistical data generation process, the GDP data and quality of life control system are designed based on the dynamic BO-abandonment model of violations. Thirdly, the GDP data and quality of life control system is designed according to the data process; that is, the whole process of GDP data and quality of life control system is designed from survey capability, survey method, data collection, data processing, data release, etc.

Finally, it is to establish an organizational system of GDP data and quality of life assessment based on matching, as shown in Figure 3. Matching-based GDP data and quality of life assessment have a strong linkage with the government system, based on which the establishment of the corresponding organizational guarantee system is one of the key points of data and quality of life control. To establish the organizational system of matching-based GDP data and quality of life assessment, one is to organize practicing technicians who are familiar with the business to systematically control logical matching. The technical staff assesses GDP data and quality of life in terms of the standardization of statistical work, reliability of statistical bases, the accuracy of statistical reports, and legality of statistical data on the one hand. On the other hand, from the existence of direct or indirect intrinsic links and constraints between various statistical indicators reflecting the quantitative relationships of economic activities, a balanced audit is conducted to evaluate the statistics among them when they are

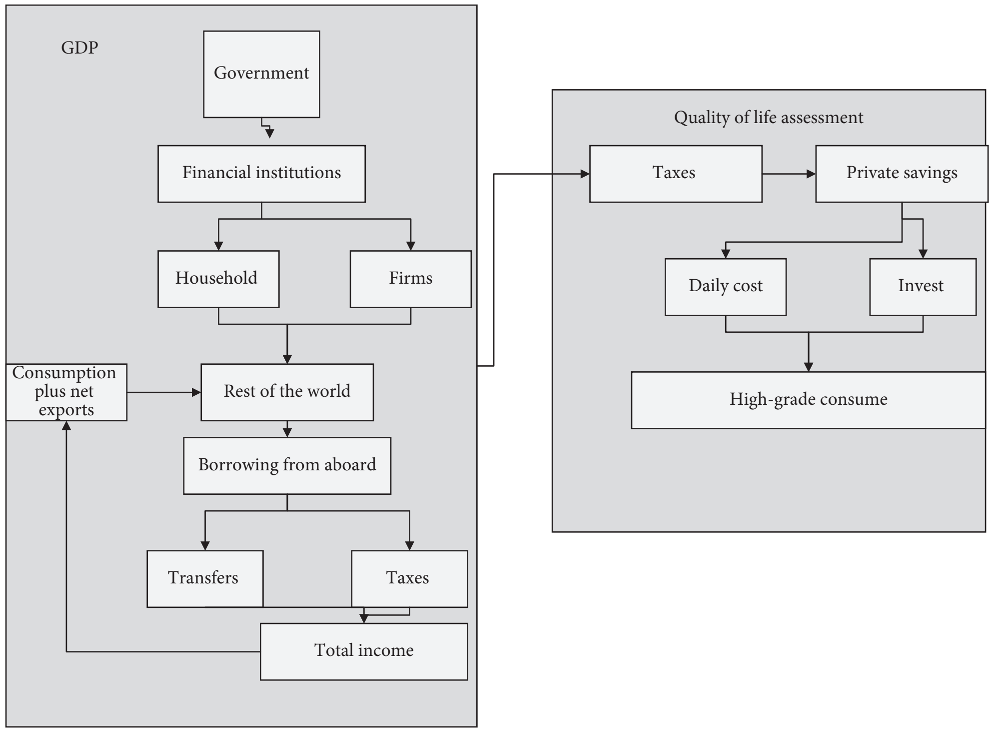

Figure 3: Tree diagram of causes and results of GDP.

contradictory, to test the rationality and reliability of the data in general, and to check whether the data are balanced with each other and whether they are logical. Second, we organize specialized theoretical and technical personnel to evaluate the data type matching between GDP data and quality of life. Economic development has its intrinsic regularity, and theoretical researchers use some theoretical formulas or empirical formulas formed by quantitative statistical methods to calculate the corresponding data, compare them with the prescribed standard values or compare them with the same indices of other countries or other regions, and evaluate GDP data and quality of life accordingly. Thirdly, the organizational system of comprehensive certification of statistical data quality is gradually formed. According to the gradual formation and improvement of the data quality evaluation method system and so on, the data and life quality system of GDP and other data will be formed [24].

The results of the data quality assessment based on the correlation model are obtained by its eliminating elements that are not directly related to the data quality assessment based on the full version, to provide survey leaders with tools to quickly assess data quality. The main goal of the inventory objectives is to assess the quality of data relevant to the survey process, with GDP being one of the main indicators of its assessment. The content covers the remaining five of the six quality dimensions defined by Eurostat, except availability and clarity. In the actual application of the GDP and quality of life correlation assessment, the survey leader assesses the responses to each question in the condensed list related to the survey he/she is responsible for, based on the information he/she has, and plots the results into a radar chart, as shown in Figure 4.

According to the assumption that the factor contribution structure is stable, the production function can be chosen as the basic form of analysis for theoretical model design. The production function model has been well written in the literature, but its basic form is based on the Douglas function, and the difference between various production functions is that the assumptions on the input factors are not completely consistent. Analyzing from the overall judgment, the judgment of GDP data quality through the matching between models is better than the judgment using the integrated error rate, and the judgment of matching GDP data quality through the integrated error rate is better than the judgment using a single model. In the process of quality assessment, the critical value judgment of whether it is abnormal or not will be involved. In this paper, based on the basic assumptions mentioned above and the length of time that data can be collected, the classical C-D production function, i.e., the Cobb-Douglas production function, is used as the basic theoretical model to assess the accuracy of GDP data:

$$Y = AK^{\alpha}L^{\beta}. \tag{3}$$

Y is output, in this case, GDP

K is the capital input

L is the labor input

Considering the nonlinearity of the production function, a linear transformation is performed, i.e., $Y = AK^{\alpha}L^{\beta}$, and taking the logarithm of both sides and adding the random error term ε, the theoretical model of the factor matching assumption is obtained as follows:

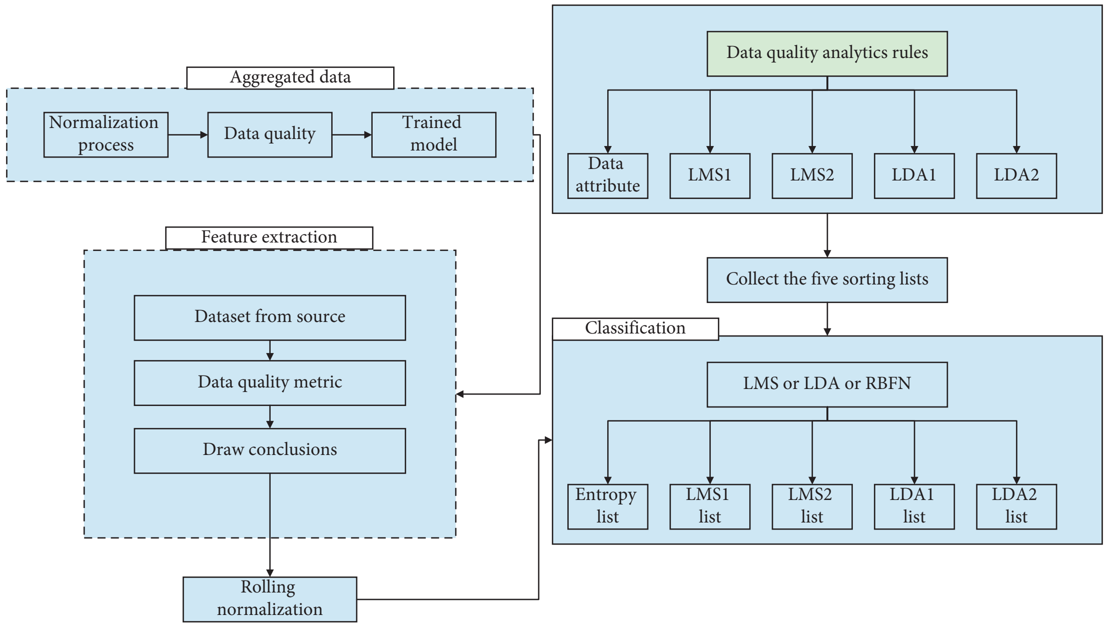

Figure 4: Results of data quality assessment based on the correlation model.

$$\ln Y = \ln A_0 + \alpha \ln K + \beta \ln L + \varepsilon. \quad (4)$$

Y is output, in this case, GDP

K is the capital input

L is the labor input

A_0 is the initial technical level

α and β are the capital input elasticity coefficient and labor input elasticity coefficient, respectively

According to equation (3), it is only necessary to obtain data on GDP, the amount of capital input, and labor input to build the regression model. With the help of this regression model, sample points are searched for when the economic system is at a certain correlated quality of life, and the real GDP statistics do not match the output of capital input and labor input at the given parameter levels.

Because the value indicator is equal to the product of the corresponding physical quantity indicator and the unit price of that product, the GAP statistics of a certain period must have a highly linear relationship with the output of industrial products and agricultural products in the corresponding period according to the assumption of physical quantity matching. Based on this, the linear regression model is used to find the sample points where the actual GDP statistics do not match with the physical quantity indicators under certain economic conditions. According to the theory related to regression analysis, its theoretical model is obtained as shown in equation (4).

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \varepsilon. \quad (5)$$

Y indicates GDP

X_1 is the output of industrial products

X_2 is the yield of agricultural products

ε is the random term error, indicating the portion of the dependent variable that cannot be explained by the independent variable

β_0, β_1, and β_2 are regression parameters

According to the basic assumption that the structure of the economic operation is stable over a relatively short period, there is a relatively stable correlation and interdependence between GDP, energy consumption, and goods turnover. The vector autoregressive model can better portray the systematic correlation between data, so it is an ideal method to evaluate the matching of GDP with energy consumption and goods turnover by using the vector autoregressive model (VAR). The vector regression model can then be used to find the sample points where the real GDP does not match the energy consumption and goods turnover indicators under certain economic conditions.

The micro-empirical study in this paper consists of two parts: (1) the characteristics of the population distribution of public service satisfaction and (2) the influence of public service satisfaction on life satisfaction. Compared with the existing quality-of-life related studies, the two-stage model in this paper is innovative; i.e., based on the uniqueness of people's quality-of-life index survey data (both objective indices and comparable subjective satisfaction survey data), public service satisfaction is taken as the research object, and the impact of public service satisfaction on life satisfaction is then analyzed. The measurement equation of the distribution characteristics of the population of public service satisfaction is set as follows:

$$PS_i^k = \alpha + \beta \times x_i + \varepsilon_i. \quad (6)$$

PS^k is the satisfaction level of public services of category k ($k = 1, 2, 3, 4$, corresponding to compulsory education, health care, social security, and ecological environment, respectively)

x is a series of variables reflecting individual characteristics, mainly including individual background (e.g., gender, educational background, marital status, and age), household demographic characteristics (e.g., whether living alone, household size), individual economic and social characteristics (e.g., hukou status, occupational characteristics), individual economic status (e.g., household income level), and the region where an individual resides (including urban and rural areas and the provincial administrative district)

β is the estimated coefficient of the explanatory variable

After the econometric analysis of the population distribution characteristics of public service satisfaction, we further conducted an econometric analysis of the determinants of life satisfaction. Among them, satisfaction with various types of public services is one of the explanatory variables, and the measurement equation is as follows:

$$\mathrm{LS}_i = \alpha + g \times PS_i^k + h \times x_i + \varepsilon_i. \quad (7)$$

LS_i is individual life satisfaction

g is the regression coefficient of PS^k

h is the estimated coefficient of x

In the questionnaire of this study, both public service satisfaction and life satisfaction were set using ordinal (ordinal). Based on such data type, a commonly used measure is the Ordered Probit regression model (OPM). Using this measure, the effect of the explanatory variables on the level of satisfaction can be judged by the regression coefficients and marginal effects of the explanatory variables. Another measurement method is to assign the respondents' responses according to their satisfaction level, consider the degree as the cardinal value (cardinal), and use the OLS model for econometric analysis. By this method, the regression coefficients of the explanatory variables can be used to determine whether the effect of the explanatory variables on the explained variables is significant, as well as the degree of the effect. The correlation analysis was conducted using the per capita income level, the level index and improvement index of the livelihood index, and the subjective index of quality of life constructed from the satisfaction with the quality of life survey.

4.2. Quantitative Analysis of GDP Data and Quality of Life Assessment Based on Structural Correlation. The basic idea of judging the match between GDP data and quality of life from a qualitative perspective: different assessment models may overestimate or underestimate the data quality, but if there is consistency among different models, it means that the GDP data quality meets various assessment assumptions and criteria from a multidimensional perspective, so the higher the consistency of various models, the higher the data quality.

The quantitative perspective is based on spatial matching GDP data quality assessment criteria, which are single-model data quality assessment and comprehensive data quality assessment. After the system loses its local stability, the following situations occur: first, the system operation enters into violent oscillations and thus gradually diverges; second, along with the system operation, the three main variables of the system begin to oscillate with equal amplitude, while an obvious circular curve appears in the phase diagram of the system; i.e., the system forms a growth cycle; third, the system enters into a state of disorderly oscillation; i.e., the chaos phenomenon occurs. The basic idea of single-model data quality assessment is as follows: using the model, by parameter estimation, and using the model to forecast GDP for past years, the forecast error rate is calculated based on the actual value of

$$P_t = 100\% \times \frac{\mathrm{GDP}_t - \widehat{\mathrm{GDP}}_t}{\mathrm{GDP}_t}. \quad (8)$$

That is, it is a single model error based on structural matching as a quality assessment criterion, and when the absolute value of the model error rate exceeds a set threshold value, the data quality is considered suspicious for that year. While a negative value of the error rate is a possibility of underestimation, a positive value is a possibility of overestimation. The basic idea of the combined error rate judgment is as follows: the error rates obtained from the three models are combined, and the combined error rate is calculated. Because its R^2 is a part that reflects that the explained variables can be partially explained by the regression and is one of the indicators of the good or bad effect of the model, R^2 is selected as the weight, normalized, and calculated, and then the weighted average of the prediction error rates of the three models is used as the standard for quality assessment, and the specific calculation is shown in equation (8).

$$\overline{P} = \sum_{i=1}^{3} P_n \times \frac{R_i^2}{R_1^2 + R_2^2 + R_3^2} (i = 1, 2, 3). \quad (9)$$

$\overline{P}$ is the combined error rate.

Matching-based GDP data quality assessment criteria need to be handled according to the target recurrence relationship. Analyzing from the overall judgment, the judgment of GDP data quality through the matching between models is better than the judgment using the integrated error rate, and the judgment of matching GDP data quality through the integrated error rate is better than the judgment using a single model. Following the process of quality assessment, the critical value judgment of whether it is abnormal or not will be involved. According to the guidelines of error recognition, 5% is selected as the standard for assessing the quality matching of GDP data; that is, whether the GDP error rate is obtained from a single model or the comprehensive error rate is obtained after weighting, the absolute value exceeds 5%, the GDP data of the year is considered abnormal, and the size of the abnormal value is the size of the error rate.

The data collection process involves several dimensions of time, space, and frequency. From the data time dimension, it is a total of 33-year annual data; from the spatial analysis of data, this part only involves the internal structure of the system, so the data only involves the overall data, and the specific indicators involved include the following: in the model design of factor contribution matching, the amount of capital input is selected as the total investment in fixed assets of the whole society, and the amount of labor input is selected as the number of employed persons at the end of the year. In the model design of matching physical quantity, the output of industrial products is based on the output of major industrial products announced by the National Bureau of Statistics, including the output of raw coal, crude oil, natural gas, raw salt, power generation, finished sugar, and other 34 products; the output of agricultural products is based on the output of major agricultural products, major forest products, storage products, and aquatic products announced by the National Bureau of Statistics. In the model design for matching the economic structure stability, the selected indicators are the total energy consumption as well as the turnover of goods. The frequency of data is selected as annual data. The data are obtained from the statistical yearbooks of each year. To avoid the influence of price changes and to maintain consistency, the current price values in the yearbooks are used for this part of the data.

The assessment criteria of GDP data quality based on correlation need to be processed according to the target recurrence relationship. Analyzing from the overall judgment, the judgment of GDP data quality through the correlation between models is better than judging by using integrated error rate, and the judgment of matching GDP data quality through integrated error rate is better than judging by using a single model.

The process of quality assessment will involve the judgment of the critical value of whether it is abnormal or not. According to the guidelines of error recognition, 5% is selected as the standard for assessing the quality matching of GDP data; that is, whether the GDP error rate is obtained from a single model or the comprehensive error rate is obtained after weighting, the absolute value exceeds 5%, the GDP data of the year is considered abnormal, and the size of the abnormal value is the size of the error rate.

5. Experimental Verification and Conclusion

Based on the above stability analysis of the system near the equilibrium point, along with the change of the system parameters α, σ, the system will cross a critical condition and enter into an unstable state. After the system loses its local stability, the following situations will occur: first, the system will enter into a violent oscillation and thus gradually diverge; second, along with the system, the three main variables of the system will begin to oscillate with equal amplitude, and an obvious circular curve will appear in the phase diagram of the system; i.e., the system will form a growth cycle; third, the system will enter into a disorderly oscillation; i.e., the chaotic phenomenon will occur. To investigate whether the GDP index and the quality of life system can form a growth cycle, it will be examined whether the system generates an exponential growth cycle near the equilibrium point $E(x_1^*, x_2^*, x_3^*)$ and whether this exponential growth cycle is stable. Therefore, the existence and stability analysis of the Hopf bifurcation is a key tool to investigate whether the GDP index and the quality of life system can generate a growth cycle, as shown in Figure 5, which shows the results of the correlation study between the subjective quality of life index and the quality of life improvement index.

According to the theory of non-linear dynamics, if the characteristic equation of a system has a pair of conjugate purely imaginary characteristic roots, the system undergoes Hopf bifurcation near its equilibrium point. Therefore, the bifurcation equation of the system can be obtained in the following form:

$$\lambda^3 + C\lambda^2 + D\lambda + E = 0. \quad (10)$$

Assume that $\lambda_{1,2} = \pm i\omega$ is a pair of conjugate purely imaginary characteristic roots of the characteristic equation of the system, and $\lambda = i\omega$ substitutes into the characteristic polynomial of the system such that $f(\omega) = 0$ can be obtained

$$\begin{aligned} D\omega - \omega^3 &= 0, \\ -C\omega^2 + E &= 0. \end{aligned} \quad (11)$$

To visualize the theoretical part of this paper, numerical simulations of the Hopf bifurcation behavior of the GDP index and the quality of life model will be conducted based on the parameters taken from the literature. The parameters may be taken as follows:

$$\begin{aligned} B &= \frac{1}{20}, \\ \rho &= 0.0505, \\ n &= 0, \\ \delta &= 0. \end{aligned} \quad (12)$$

And then, the existence of the Hopf bifurcation of the system when fixing α and observing how the system varies with the parameter σ will be discussed, as shown in Figure 6(a).

When $\alpha = 0.5$, the above equation can $\sigma \approx \sigma_0 = 0.02$ easily prove that the system is always stable near $\sigma \in [0, \sigma_0)$ the equilibrium point when, no matter how the parameters change, $E(x_1^*, x_2^*, x_3^*)$, and when $\sigma \in [\sigma_0, 1)$, there is a $\sigma_0(\alpha)$ place where the system undergoes Hopf bifurcation and then changes from the stable to the unstable state.

Taking $\alpha = 0.5$, the time course and phase diagram state of the system when observed $\sigma = 0.12$ are shown in Figure 6(b). Since the value of σ is less than the critical value $\sigma_0 = 0.02$, as mentioned before, the system is always stable near the equilibrium point regardless of the parameter changes, $E(x_1^*, x_2^*, x_3^*)$, and when $\sigma = 0.01$, $\sigma \in [0, \sigma_0)$, $\sigma \in [\sigma_0, 1)$, there exists a $\sigma_0(\alpha)$ place where the system undergoes Hopf bifurcation and then changes from the

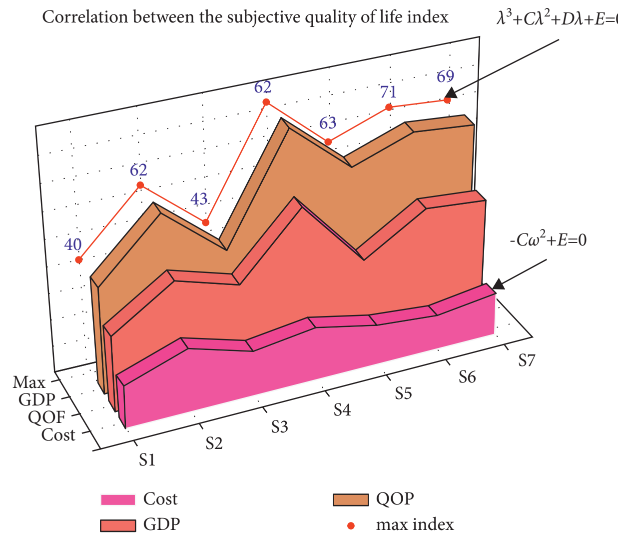

Figure 5: Correlation between the subjective quality of life index.

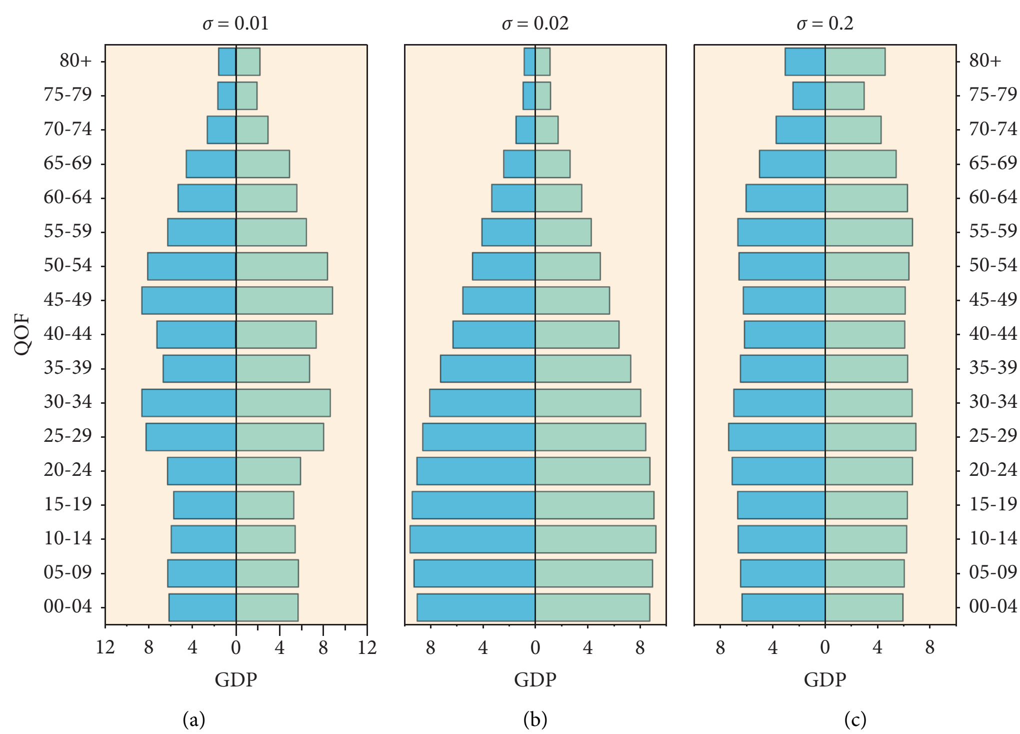

Figure 6: Time history of the system.

stable to the unstable state. When regressing data samples using fixed-effects regression models and random-effects regression models, there may be problems of biased and inconsistent estimates, leading to unreliable data results; when dynamic panel regression models are used in the analysis, lagged terms of the explanatory variables are introduced, which may also bring about problems of endogeneity of the explanatory variables.

Taking $\alpha = 0.5$, the time course and phase diagram state of the system when observed $\sigma = 0.20$ are shown in Figure 6(c).

From a lot series of experiments, a nonlinear model of GDP index development and quality of life growth is developed. First, by solving the model, this paper obtains the unique positive equilibrium point of the system and then, based on the detailed analysis of the equilibrium point, calculates the path that enables the GDP index development and quality of life system to achieve equilibrium growth. Secondly, the stability domain of the growth system is obtained by using the capital-output elasticity α and the intertemporal elasticity of substitution constant σ as bifurcation parameters. Thirdly, this paper obtains the

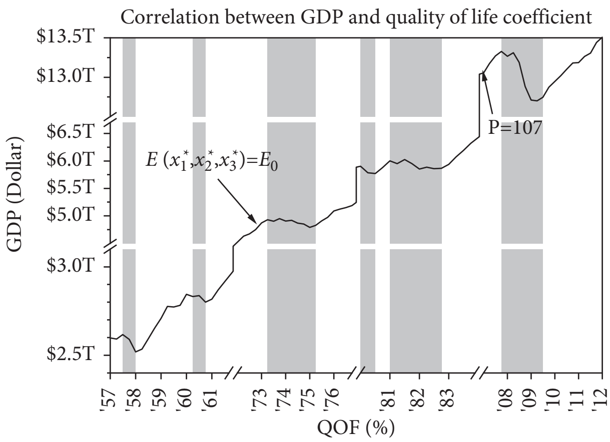

Figure 7: Results of correlation between GDP and quality of life coefficient.

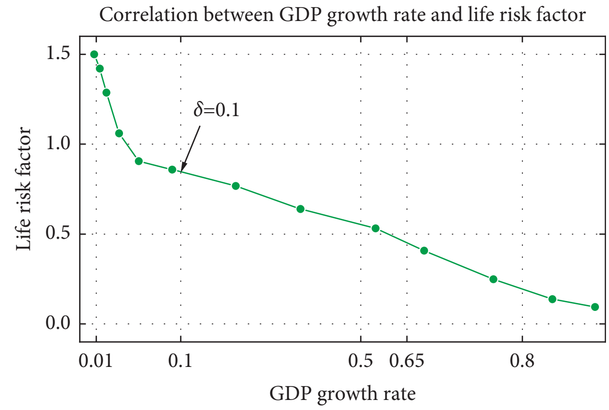

Figure 8: Results of the correlation between GDP growth rate and life risk factor.

conditions that the system needs to satisfy to generate the growth cycle, i.e., the conditions that can be derived for the GDP index development and quality of life growth system to generate the growth cycle; and for this condition, this paper discusses the stability of the growth cycle. Finally, the operation of the economic growth system is simulated dynamically through numerical simulation.

The joint quality-of-life correlation data and GDP correlation data from the concurrent set were taken as input, and correlation analysis was performed by the multivariate association analysis model MGAS. The genome-wide significance threshold was adjusted to $E(x_1^*, x_2^*, x_3^*) = E_0$ using the raw false discovery rate. 363 significant impact factors were detected by the model. The top region with higher significance at the MGAS raw statistical association test p value of $P < 107$ contained 26 impact factors, as shown in Figure 7.

When regressing the data samples using fixed-effects regression models and random-effects regression models, there may be problems of biased and inconsistent estimates, leading to unreliable data results; when using dynamic panel regression models in the analysis, lagged terms of the explanatory variables are introduced, which may also introduce endogeneity problems in the explanatory variables. Comparing the results of the fixed-effects model, the dynamic panel model concludes that the growth rate of GDP leads to a reduction in the risk of living, which is significant at the $\delta = 0.1$ level. The acceleration of economic growth will have some dampening effect on the lifetime risk to some extent, but the dampening effect is not very significant, as shown in Figure 8.

The nonlinear GDP index development and quality of life growth model developed in this chapter can embody rich dynamical behavior. The analysis and calculation results in this chapter are of crucial theoretical and practical significance both for the nonlinear analysis of the economic growth system and for the formulation of macroeconomic policies and can provide a strong theoretical and practical basis for the government's macroeconomic regulation and policy formulation. The regression results from the data of the nonlinear GDP index development and quality of life growth model show that there is indeed a correlation between GDP index development and quality of life, but the degree of correlation varies across time and regions.

6. Conclusion

The relationship between GDP index development and quality of life growth is studied in detail and carefully, both theoretically and empirically. The full paper first constructs a nonlinear dynamical system of financial development and economic growth based on the endogenous economic growth model, while later, using actual data, the financial development index is constructed, and the relationship between GDP index development and quality of life growth is analyzed and discussed through empirical research. In this paper, a three-dimensional nonlinear model of financial sector development and economic growth is developed. A comprehensive analysis of the correlation between GDP index development and quality of life enriches the type of literature in this research area. By solving this model, this paper obtains that the GDP index development and quality of life growth system have a unique positive equilibrium point, and the GDP system is subject to cyclical or non-cyclical economic fluctuations under certain conditions, thus obtaining the equilibrium growth path of the financial sector and the economic growth system. In this paper, the stability domain of the economic growth system is obtained using the capital-output elasticity α and the intertemporal elasticity of substitution constant σ as bifurcation parameters, and the stability region boundary is discussed for the stability region. A method for determining the stability threshold of the financial development and economic growth system is given. The Hopf bifurcation analysis of the proposed system is used to obtain the conditions that need to be satisfied for the system to generate a growth cycle; i.e., the conditions for the financial sector and the economic growth system to generate a growth cycle can be found according to the theorem; and the stability of the growth cycle is discussed concerning this condition. Finally, the operation of the economic growth system is simulated dynamically through numerical simulation.

However, most of the studies on both nonlinear dynamical systems and stochastic nonlinear dynamical systems take integer-order systems as the initial point of study. In future studies, a fractional-order nonlinear dynamical system model can be established to discuss and analyze the relationship between GDP index development and quality of life growth in-depth, to put forward feasible policy suggestions for the country and the government. The theories related to nonlinear dynamical systems and stochastic nonlinear dynamical systems can be applied to more economic environments so that the inner laws of GDP index development and quality of life growth can be studied more deeply. After obtaining the flow thresholds of GDP index development and quality of life growth at certain ratios, correlation analysis and causality analysis can be conducted on the model of GDP index development and quality of life growth using relevant data to find out the intrinsic link between GDP index development and quality of life growth.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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