Dynamic Network Model of Economic Indicators Based on Time Series Analysis

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Abstract. The new agenda of Sustainable Development Goals is broad and ambitious, addressing the sustainable development economic and financial resources. To better analyze the trend of economics development of the countries worldwide, the mixed linear effect model was proposed to quantify the indicators of each country, and obtained the quantified rate of the indexes through time series analysis, as well as establish a weighted complex network model. This paper also modelled the dynamical complex network, using a hierarchical approach to divide the countries into two intervals according to the SDG index. Without considering and with considering timestamps, static and dynamic analysis of complex networks in discrete time series differential methods were carried out respectively. Finally, the sensitivity of the model was analyzed, categorizing what needs to be realized, forecasting profits based on time series analysis.

Keywords: complex network, dynamical model, time series analysis

1 Introduction

The economic aspects of the Sustainable Development Goals address the needs of people in both developed and developing countries and emphasize that no one will be left behind[1]-[3]. The new agenda is broad and ambitious, addressing the economic, social, and environmental aspects of sustainable development[4]-[5].

Time series forecasting offers a solution to address temporal-spatial changes by conducting an analysis on the evolutionary history of events, enabling predictions to be made regarding future corresponding situations[6],[7]. So, to better analyze the trend of economic development of the countries worldwide, the mixed linear effect with time series forecasting model was used to quantify the indicators of each country, and obtained the quantified rate through time series analysis. Meanwhile, a weighted complex network model was established, the dynamic complex network with a hierarchical approach was also used to divide the countries into two groups. Also, the sales and profits based on time series analysis was forecasted. Once the priority is completed, the complex network that tends to reduce entropy will increase the path pass rate of the matter's nodes, suppress the path to other uncompleted nodes, and gradually converge

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the network structure to the completed priority while diverging from unfinished matters. The results indicate that the model presented in this paper can effectively help other companies and organizations prioritize their goals.

Above all, the mixed linear effect with time series forecasting model was used in this paper to quantify the indicators, obtained the quantified rate, forecasting the sales and profits conditions. Also, a weighted complex network model was established, the dynamic complex network with a hierarchical approach was also conducted to divide the countries into two groups, to effectively help companies and organizations prioritize the goals.

2 Model Construction

2.1 Grey correlation analysis

The analytical series were analysed. Taking Goal 11 as an example, the dimensionless processing for each data variable was conducted, as shown in formula(1).

$$x_i(k) = \frac{X_i(k)}{X_i(l)}, k=1,2,\cdots,30; i=1,2,\cdots,30 \tag{1}$$

And then, calculate the correlation coefficient between $y(k)$ and $x_i(k)$.

$$\phi_i(k) = \frac{\min_i \min_k |y(k) - x_i(k)| + \rho \max_i \max_k |y(k) - x_i(k)|}{|y(k) - x_i(k)| + \rho \max_i \max_k |y(k) - x_i(k)|} \tag{2}$$

In the formula (2), ρ is the resolution coefficient. In order to get a better correlation.

Finally, analyze the correlation degree and get the correlation strength relationship between each target. The following table is shown in Table.1:

Table 1. The relationship between correlation degree and correlation strength

Correlation degree	Correlation strength
0.8-1.0	Exceptionally strong correlation
0.6-0.8	Strong correlation
0.4-0.6	Moderate correlation
0.2-0.4	Weak correlation
0.0-0.2	Uncorrelated

From the table above, the greater the absolute value of the correlation coefficient, the stronger the interaction.

The model simulation is solved and the correlation degree between the 17 Sustainable development Goals in relatively developed, and relatively backward countries is obtained. Finally, the correlation degree obtained is written into the matrix of (17*17). In order to realize the visual analysis of the relationship between the goals, the correlation matrix into the form of heat mapwas shown in Fig.1, Fig.2.

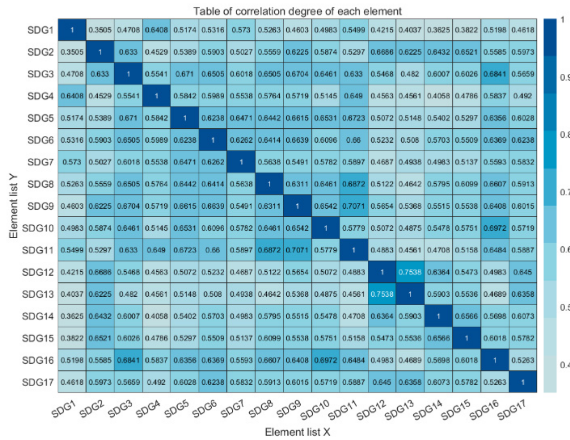

Fig. 1. Heatmap of the developed country

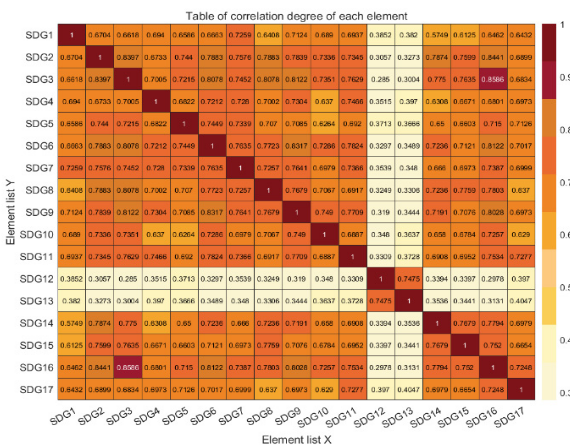

Fig. 2. Heatmap of the developing country

2.2 Time Series Analysis

In order to ensure that the time-lagged network is synchronized with the converged target network after the introduction of time variables, update the state estimator from above, so as to obtain the synchronization function update criterion for the asymptotic stabilization of the SDN in the discrete-time differential state and convergence to the differential form of the target network as formula(3) and (4).

$$s_{i,j} = \mu_k s_{i,j-1} + (1 - \mu_k) s_{i,j} \tag{3}$$

$$\eta_{i,j} = \sum_{i=1}^{m} \sum_{j=1}^{n} (G^* / n \cdot (n-1)) \tag{4}$$

From Fig.3, it can be seen that the change of priorities in the network is more in line with the actual situation when the influence brought by the time stamp is considered. the correlations return to normal due to the dynamic effects brought about by considering the time series difference and time lag effects.

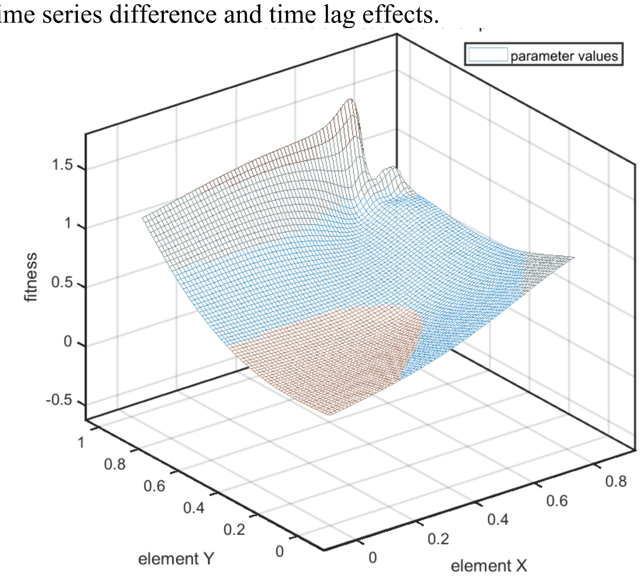

Fig. 3. Fitness surface diagram when test the correlation

In order to further shape a better world and improve the level of living environment for all human beings, as well as to verify the correctness of the model in this paper. Also, to quantitatively analyze and accurately calculate the accuracy of this model,open statistics were used to include the target.

$$\hat{s}_{i,j+1|j} = G^{*}\hat{s}_{i,j|j} + \sum_{k=1}^{n} \psi_{i,j} F_{i,j} \hat{s}_{j,k|k} \tag{5}$$

From formula(5), intuitively, the decadal change curves predicted by the model in this paper correlate significantly with the trends of the statistical curves of the World Bank, thus verifying the accuracy of the model in this paper.

2.3 Network Stability

To further quantify the impact of different international crises on the SDG network and the role on the priority and importance ranking of each matter. The stability of the initial network was assessed, by introducing a complex network stability judgment criterion. In this assessment criterion, the stability assessment difference function has higher accuracy. The criterion is as shown in formula (6).

$$\hat{V}(\hat{s}_{i,j}) - \hat{V}(\hat{s}_{i-1,j-1}) = -z_{i,j}\,\overline{g}\|e_{i,j}(t,\ G^{*})\|^{2} \tag{6}$$

The simulation results are shown in Fig.4.

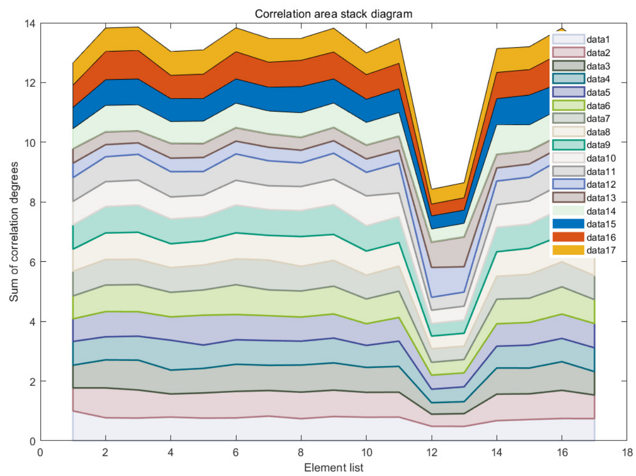

Fig. 4. Evaluation values of the complex network of different indexes

It is obviously that, either by static or dynamic methods, when the complex networks of SDGs are evaluated using our constructed complex network evaluation function, approximately consistent convergent evaluation effect values are finally obtained (drawing evaluation effect comparison tables, overlap plots, etc.). This verifies the rationality of the proposed complex network stability assessment method. And the network stability varies for network graphs with different levels of priorities. In general, the network stability is higher in countries with high SDG index, and the network stability is higher in the direction of "social livelihood" and "harmonious coexistence", and vice versa. The network stability is approximately equal for the network diagrams with the same level of priorities.

3 Result analysis

The results of the analysis, discussion and prediction based on this model are generalizable. This is appropriate for companies or organizations that have many development variables, both explicit and implicit, to analyze and forecast using the model constructed in this paper.

In the case of selling cell phones, for example, in order for the brand to be successful, its development goals should not only be limited to sales and profits, but also other goals such as the brand's influence, market reputation and the quality of its products should be considered and prioritized, the criterion is as shown in formula(7).

$$\mathcal{Z} = z(cov(H, 0.5)) \quad (7)$$

Here, the goals that need to be accomplished for the open statistics were firstly classify to forecast one of the priorities of development goals, based on a time-series analysis, as shown in Fig.5.

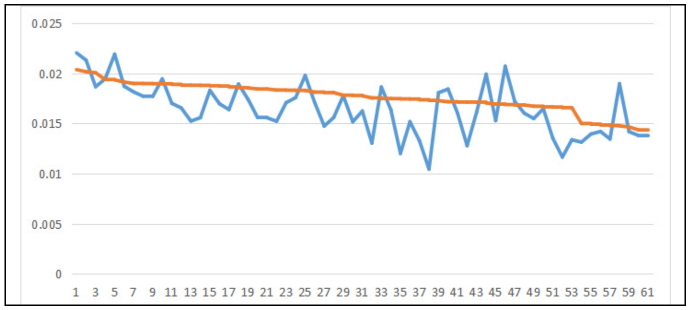

Fig. 5. Forecasting curve result

By using static and dynamic methods to analyze the sensitivity of the complex network, it is transparently that, with the constant iteration of the complex network and the increasing number of network nodes, the sensitivity of the model in this paper can be effectively reduced, as shown in Fig.6, thus reducing the negative impact of external disturbance factors on the solution of the model.

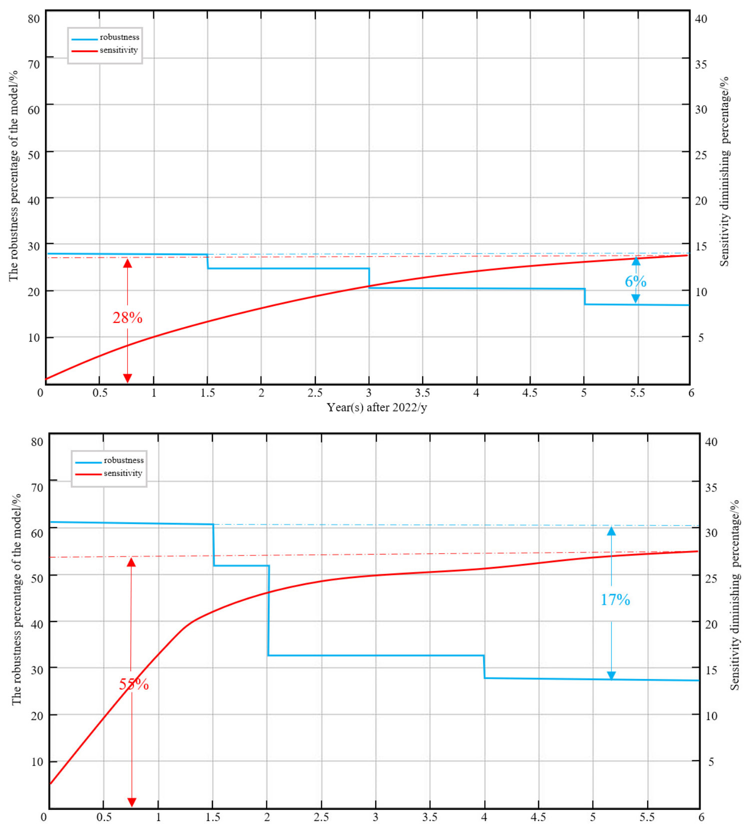

Fig. 6. Model Promoting Results

4 Conclusion

By using the mixed linear effect model to quantify the indicators of each country, the quantified rate of the SDGs through time series analysis was obtained, so as to get the correlation degree between several indexes and establish a weighted complex network model. Meanwhile, a thermal map and a network topology map based on this model visually represent the relationship. Without considering and with considering timestamps, static and dynamic analysis of complex networks in discrete time series differential methods was carried out respectively. Finally, the statistics were used to quantify new targets so as to analyze the changes and impacts on complex networks as a whole.

When crises are achieved specifically, the network stability will converge faster than it should to be, and policy laws as well as measures will unpredictably impact the company's development. This indicates that the model presented in this paper can effectively help other companies and organizations prioritize their goals.

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