

# Research on macroeconomic Forecasting model based on grey theory

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**Abstract:** In the modern economic innovation and development, the grey theory and BP neural network algorithm are used to build a new macroeconomic prediction model. On the one hand, the input data can be comprehensively preprocessed, on the other hand, the improved BP neural network algorithm can be used to predict the final results. This paper studies the feasibility and effectiveness of the new macroeconomic forecasting model based on the grey forecasting principle and BP neural network algorithm. The final results show that both grey prediction and BP algorithm can help the staff to predict and analyze the macro economy as soon as possible, so as to grasp more valuable data information and put forward targeted management decisions.

**Keywords:** Grey theory; BP neural network algorithm; Macro economy; Prediction model.

## 1. Introduction

Accurate prediction of economic indicators is the basic condition of the state's correct macroeconomic regulation. Macroeconomic system is a very complex system, which has the characteristics of clarity and nonlinear time variability during operation. In econometric theory, most macroeconomic models have linear characteristics, which play an important role at the same time, but also emerged many problems, the most critical is that it is difficult to control the nonlinear phenomenon in the macroeconomic system, which will inevitably increase the error of economic prediction. After decades of research, the academic community has improved the analysis of various linear models, such as piecewise linear model, parameter time-varying linear model, etc., but the final results are not ideal, which forces people to seek some nonlinear work for macroeconomic modeling. Macroeconomic forecasting is to regard the overall situation of the whole social and economic development as the object of investigation, focusing on the analysis of the connection and change between various indicators in economic development, so the forecast results of all economic indicators can provide effective basis for economic policies and departmental plans. Project, based on the theoretical analysis of macroeconomic development forecast research. There are two ways. On the one hand, it refers to the qualitative forecast, which will use the government's monetary investment, monetary interest rate, fiscal and tax policy adjustment to promote the gradual rise of the national economy. On the other hand, the prediction of specified quantity is mainly analyzed by mathematical statistics, which has the advantages of quantifiable and clear indicators.[1.2.3]

The grey system theory proposed in this paper refers to a discipline theory constructed by studying the ambiguous relationship between various factors in the system. Its correlation analysis method is based on the dynamic development trend of a factor, and it does not require too much on sample size, nor does it need to master the corresponding distribution law. From the perspective of practical application, the grey system prediction model can deeply excavate and apply all contents in the sample information, and obtain more accurate and perfect prediction results in the case of insufficient or irregular sample information. Since the grey system theory was put forward, it has been widely used in military, agriculture, environment, industry and other fields. In macroeconomic forecasting modeling process, the reasonable use of recycling system theory, the random disturbance factor will be seen as a certain range changes the amount of gray, choose the suitable way to transform the original grey data into the accumulation generation sequence, and the resulting has regularity of generating function, in order to break through the limitations of probability and

statistics, ensure the forecast results, can clear the generation of the rules. This not only reduces the number of calculations, but also improves the accuracy of the predictions. At present, domestic scholars use the grey system theory to predict the macro-economic development state at the same time, and integrate the BP neural network algorithm, and thus achieved excellent results. For example, Zhong Hongyan et al. used the grey system theory to analyze the advantages and concepts of various factors affecting macroeconomic development. Stone, Feng Zhi identity is proposed in the study, according to the theory of grey system and the BP neural network as the core of the macroeconomic forecasting model, the former needs less information modeling, the actual calculation is more convenient, the final accuracy is higher, and the BP neural network algorithm is effective in prediction of all historical data, and gradually improve the accuracy of the prediction results. Therefore, on the basis of understanding the macroeconomic forecasting model system, this paper conducts an empirical analysis on the constructed forecasting model according to the grey forecasting principle and BP network structure. The final results show that the integration of grey theory and BP neural network algorithm can predict the macroeconomic development more perfectly.[4.5.6]

## 2. Method

### 2.1 Overall Design

Macroeconomic forecasting model system refers to a group of dynamic recursive models with input-output model and artificial neural network model as the core and reasonable use of optimization technology. This model system needs to use the theory and method of systems engineering to conduct simulation analysis, so as to obtain the perfect national economy, simulation and prediction results, and provide decision-making basis for the country and the region to formulate effective development strategy. The specific model is shown in Figure 1 below[7.8.9]:

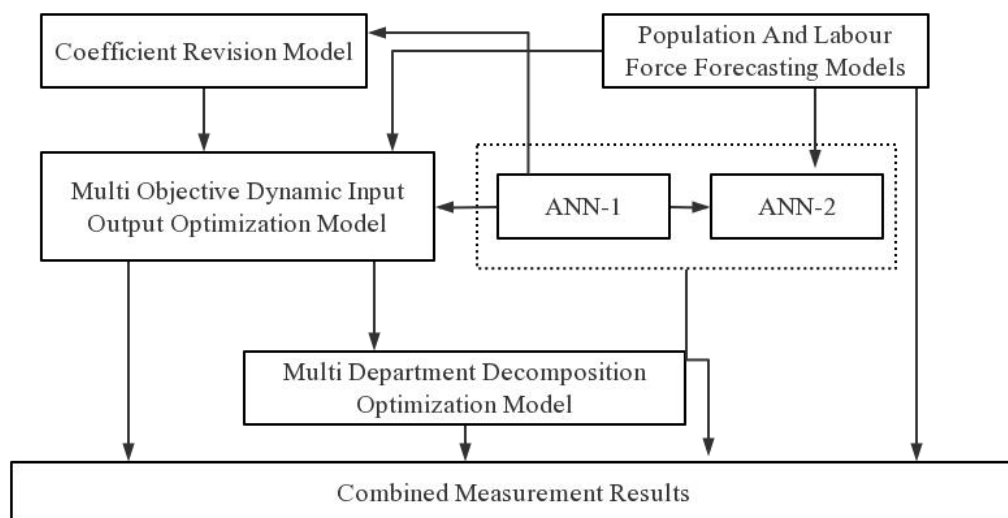


Figure 1 System design structure diagram

Combined with the above analysis, it can be seen that the model system includes artificial neural network module, population module and input-output module. As the core content of the overall system design, the input-output module can accurately predict the development scale and change speed of all sectors and industries.

## 2.2 Grey Theory

Grey prediction principle is to use time data series to build a dynamic model of the system. Random and scattered original data will be accumulated and generated to obtain a regular generated sequence, so as to reduce the randomness of the original sequence. The data generated by accumulation is used for modeling, and the predicted value is finally reduced by  $m$  times. The overall theoretical architecture is shown in Figure 2 below:

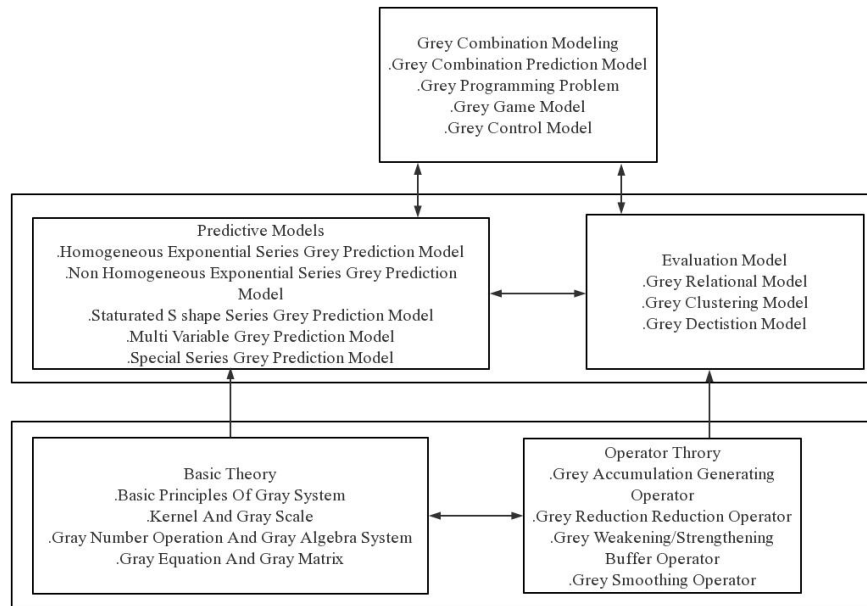


Fig. 2 Structure diagram of grey theory

Generally speaking, if the condition  $m=1$  is met, the sequence modeling GM (1, 1) is generated by an accumulation, and the specific steps are as follows:

First,  $Y(t)$  and  $Z(t)$  are generated by a single summation, assuming that the original data column is as follows:

$$X(t) = \{x(1), x(2), \dots, x(n)\}$$

$$y(t) = \sum_{i=1}^t x(i) \quad t = 1, 2, \dots, n$$

The original data column is used as a sum , and the specific results are as follows:

$$y(t) = \{y(1), y(2), \dots, y(n)\}$$

Then the sum sequence is:

$$x(t) = \frac{1}{2} [y(t) + y(t-1)]$$

$$t = 2, 3, \dots, n$$

Secondly, a linear linear differential equation of  $Y(t)$  is constructed, as shown below:

$$\frac{dy(t)}{dt} + ay(t) = u$$

The above formula represents the GM (1,1) prediction model. Solve the variable separation differential equation, the specific solution equation is as follows:

$$\hat{y}(t) = \left( x(1) - \frac{u}{a} \right) e^{-a(t-1)} + \frac{u}{a}$$

In the above formula,  $a$  and  $u$  represent undetermined coefficients, and the least square method is used to estimate parameter vectors for analysis. Assume that the parameter column satisfies the condition  $\hat{a} = (a, u)^T$ , and:

$$B = \begin{bmatrix} -\frac{1}{2}[y(1)+y(2)] & 1 \\ -\frac{1}{2}[y(2)+y(3)] & 1 \\ \vdots \\ -\frac{1}{2}[y(n-1)+y(n)] & 1 \end{bmatrix}$$

$$C = \begin{bmatrix} x(2) \\ x(3) \\ \vdots \\ x(n) \end{bmatrix}$$

Can be obtained according to the least square method:

$$\hat{a} = (a, u)^T = (B^T C)^{-1} B^T C$$

Combined with the matrix, the corresponding expression formula is calculated, as shown below:

$$a = \frac{1}{D} \left\{ (N-1) \left[ -\sum_{t=1}^n x(t)x(t) \right] + \sum_{t=2}^n x(t) \sum_{t=2}^n x(t) \right\}$$

$$u = \frac{1}{D} \left\{ \left[ \sum_{t=2}^n z(t) \right] \left[ -\sum_{t=2}^n x(t)z(t) \right] + \left[ \sum_{t=2}^n x(t) \right] \left[ \sum_{t=2}^n z^2(t) \right] \right\}$$

$$\text{other, } D = (n-1) \sum_{t=2}^n z^2(t) - \left[ \sum_{t=2}^n z(t) \right]^2$$

Finally, the estimated sequence is generated. The obtained estimated value (t) sequence is generated as a reduction reduction, and the estimated value  $\hat{x}(t)$  sequence of the original data X (t) is obtained, as shown below:

$$\hat{x}(t) = \hat{y}(t) - \hat{y}(t-1)$$

The sequence of estimated values is as follows:

$$\hat{X}(t) = \{\hat{x}(1), \hat{x}(2), \dots, \hat{x}(n)\}$$

After the reduction value is calculated by the model, the accuracy of the grey model must be checked and analyzed. Generally speaking, small error probability and post-swallow difference ratio should be used for model test and analysis, and those that meet the test requirements should be used for prediction and analysis, and the actual values should be combined for comparative study.

### 2.3 BP neural network algorithm

BP neural network is a hierarchical neural network containing two or more layers. The neurons between layers realize full connection, and each neuron in the lower layer and the neuron in the upper layer can carry out weight connection, but there is no connection between layer neurons. Combined with the analysis of the model structure diagram shown in FIG. 3 below, it can be seen that a typical BP network includes input layer, hidden layer, output layer and the third part structure.

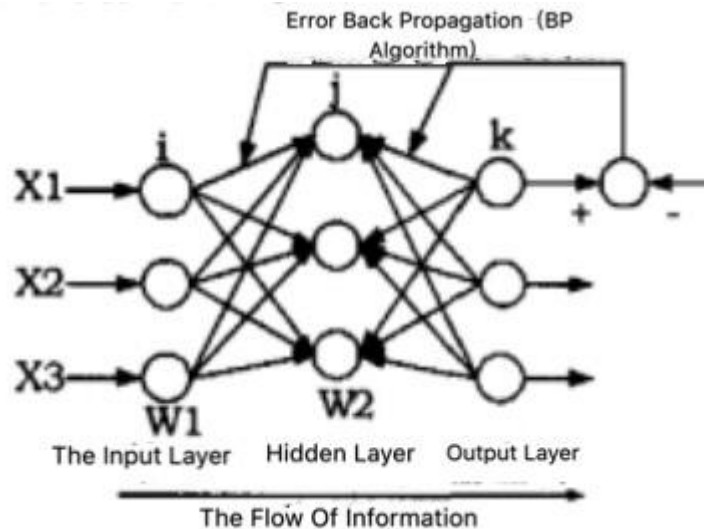


Figure 3. Model diagram of BP neural network

BP neural network is a multi-layer precursor network with error back propagation. The information processing mechanism it has will be analyzed according to the network topology structure and activation characteristics of neurons. The activation function of neurons is a nonlinear function, and the overall network structure is the forward connection of nodes at one layer. Compared with traditional application methods, BP neural network will conduct deep research according to training when solving problems. When the BP neural network algorithm is sufficiently trained to allow the algorithm to learn the basic principles contained therein, the model can solve the same problem at the end of the training. BP algorithm is the fundamental method to train artificial neural network, and its basic idea is the least square method. It will use gradient search technology to ensure that the mean square error value of the actual output value and the expected output value of the network can be minimized.

### 3. Result analysis

Combined with the operation flow chart shown in FIG. 4 below, check and forecast the national economic development indicators of a certain region in 2019. The specific modeling steps involve the following points:

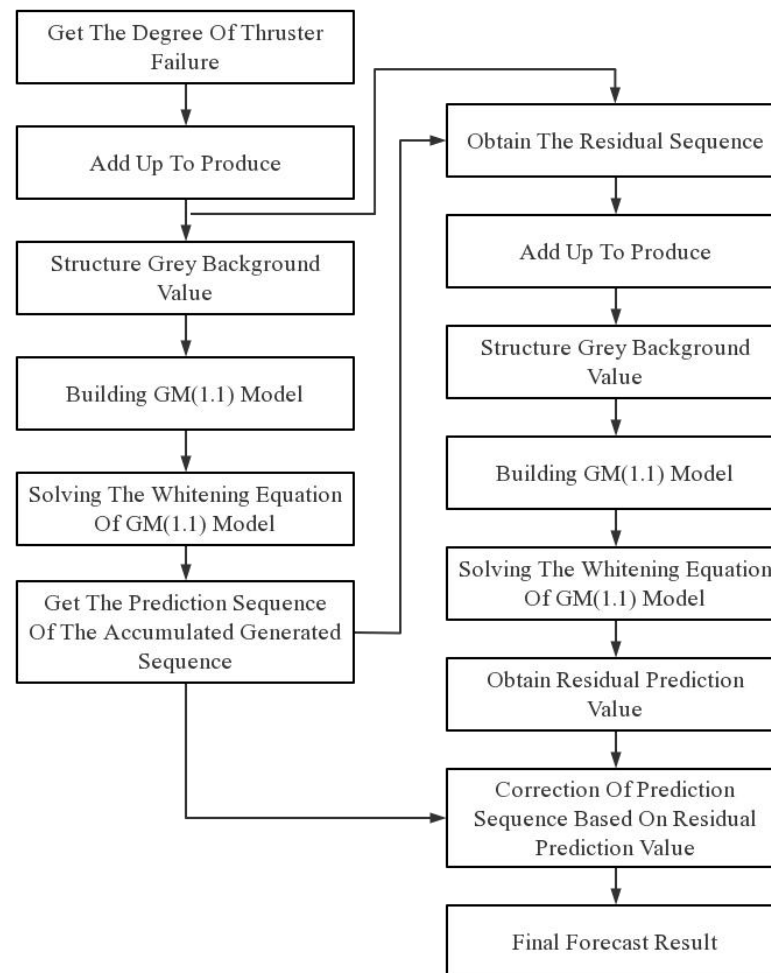


fig. 4 Model flow chart

Firstly, six indicators of national economic development including GDP are selected respectively, and statistical data within five years are obtained, and six predicted data sequences are obtained by modeling.

Secondly, according to the obtained six modeling prediction data sequences, they are regarded as the input vector  $P$  of BP neural network, and the corresponding actual data sequence is taken as the target vector  $T$  of BP neural network.

Third, according to the  $P$ - $T$  pair, the initial weight, threshold, training parameters and network structure of the network are assumed. Fourthly, in the process of network training, if the network performance meets the standard, weight values and thresholds of corresponding neuron nodes can be obtained. At this time, the neural network model has been built, and the corresponding prediction tasks can be completed in an orderly manner.

Fifthly, the predicted values not involved in network training are regarded as the input content of the network, and the corresponding output results are obtained after simulation, which is the final prediction result of macroeconomic indicators.

In the combined prediction model, Matlab software was used to complete the programming analysis, wherein, THE B-P network contains three layers of neurons, the input layer has six nodes corresponding to six model prediction data sequences, the hidden layer contains ten nodes, the output layer contains six nodes, and the selected transfer functions are Tansig and Purelin. Levenberg-marquardt optimization algorithm is used to train and analyze the network. When the learning rate reaches 0.01, the network performance within 100 steps meets the standard. The final prediction results are shown in Table 1 below:

Table 1 Comparative analysis of model prediction results

| Economic indicators                                       | The actual value | CM model predicted value | Relative error of CM model (%) | Combined model predicted value | Combined model equivalent error (%) |
|---|------------------|--------------------------|--------------------------------|--------------------------------|-------------------------------------|
| 1. GDP of Qinghai Province (100 million Yuan)             | 543.3            | 533.5                    | 1.80                           | 550.6                          | 1.34                                |
| 2. Retail Sales of social consumption (100 million yuan)  | 160.5            | 150.6                    | 6.17                           | 154.4                          | 3.82                                |
| 3. Regional investment in fixed assets (100 million Yuan) | 367.2            | 373.0                    | 1.58                           | 362.1                          | 1.39                                |
| 4. Local budgetary revenue (100 million yuan)             | 63.3             | 59.3                     | 6.32                           | 66.0                           | 4.31                                |
| 5. Per capita disposable income of Urban residents (YUAN) | 8058.0           | 7859.0                   | 2.47                           | 8255.3                         | 2.44                                |
| 6. Per capita net income of Rural residents (YUAN)        | 2165.1           | 2133.0                   | 1.48                           | 2196.2                         | 1.43                                |

Compared with the prediction result of single model in the traditional sense, the prediction value of all macroeconomic indicators in the comprehensive model is more accurate. At the same time, the average value prediction of the relative error and absolute value of the sequence of the single model is 3.30%, while the combined model can reach 2.45%. It is proved that it is feasible to use grey forecasting principle and BP neural network in macroeconomic forecasting model.[10]

#### 4. Conclusion

To sum up, the prediction model combined with grey prediction theory and neural network algorithm can more accurately study the development and changes of macro economy. At the same time, the relationship between data sequences can be fully considered according to the prediction of multiple related sequences, so as to improve the accuracy of prediction and reduce unnecessary data missing. Therefore, in the construction and research of macroeconomic prediction model, China should focus on the analysis of grey prediction theory and BP neural network algorithm, in order to solve the previous technical problems, at the same time, quickly grasp the relationship between various data indicators, to provide effective basis for the economic regulation and decision-making in the new era. At the same time, to strengthen the training of technical personnel, and actively learn the advanced research results at home and abroad, to encourage the support of government departments, universities, research institutions, etc., in building a good cooperation at the same time, the deep discussion on the grey theory as the core of the macroeconomic performance prediction model, which not only can master more technology theory knowledge, still can further enhance, China's macroeconomic forecast management level, for the study of China's macroeconomic data to provide effective technical support.

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