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ON ECONOMIC DATA PREDICTION BASED ON WAVELET ANALYSIS

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ABSTRACT

Using the least square method to deal with the abnormal data will have a great influence on its coefficient, which will result in inadequate fitting of the overall model. In this paper, the wavelet analysis method is firstly used to preprocess the economic data, then the least square method is used to conduct fitting and predicting the pretreatment data. Examples show that the results obtained by using the method presented in this paper are superior to those obtained using the least squares method, and it is further verified that the method can be further extended to the fields including stock forecasting, securities trading and other economic fields..

1 Introduction

The least square method is frequently used to estimate the parameters of the traditional linear regression model and AR model, the most prominent advantages of this method are that it is simple in modeling and fast in calculation, but it also has a big drawback, that is, abnormal data has a great effect on its coefficients, this will further affect the fitting degree of the whole model. Aiming at this shortcoming of the least square method, this paper proposes the method of multiscale wavelet analysis, some of the larger, bizarre, abnormal data are removed, and low-frequency information are obtained by wavelet analysis method treatment, then the least squares method is used for treating, this allows for better data fitting and prediction, thus, the whole macro trend will be better represented, thus the accuracy of the whole model can be further improved and the deviation can be reduced [1,2]. The wavelet analysis method can be used in time-frequency domain analysis of two fields, as well as partial analysis of the data, it can not only handle stationary signals, but also deal with irregular signals that change irregularly, that is to say, wavelet analysis can both reflect the macro characteristics and its microscopic characteristics of signals [3-5]. Therefore, the wavelet analysis method is better than the least square method for data fitting and prediction. In this paper, the generation and development of wavelet and its application in economy and finance are briefly introduced, and an applied example in economic time series analysis is also introduced [6].

2. ECONOMIC DATA PREDICTION BASED ON WAVELET ANALYSIS

2.1 Wavelet analysis

Wavelet analysis was firstly proposed by a group researcher, subsequently, the wavelet analysis method has been developed rapidly, and has become a hot topic that many mathematicians pay attention to and study, and it has also become a very popular subject of Applied Mathematics [7]. Many mathematicians believe that wavelet analysis is a completely new branch of Mathematics, and the perfect combination of numerical analysis, spline analysis, functional analysis and harmonic analysis, it is mostly used in speech analysis, signal processing, quantum physics, pattern recognition, image processing, and many nonlinear science fields, this is considered a major breakthrough in methods and tools in recent years, which has extreme elegant appearance and infinite charming [8-10].

In this paper, financial data is considered as a time series, and even a kind of non-stationary time series, that is, ordering x:x1, x2, x3,…, xn} is a non-stationary time series, marked as C0. Wavelet decomposition is conducted on original sequence by using Mallat algorithm:

$$\begin{cases} C_{j+1} = \sum h_{j-2k} C_j \\ d_{j+1} = \sum g_{j-2k}\, d_j \end{cases}$$

It can be simplified as $\begin{cases} C_{j+1} = HC_j \\ d_{j+1} = Gd_j \end{cases}$,j=0,1,…,J;

That is, the C0 is broken down into d1,d2,…,dj,Cj, then, signal after decomposition is reconstructed, marked as:
Cj=H*Cj+1+G*d j+1,j=J-1,J-2, …,1,0, where, H*, G* are dual operators.
After each layer is reconstructed, we gain D1, D2, …,DJ,CJ,D1={d11,d12, …, d1N},…,DJ={dJ1, dJ2, …, dJN},
CJ={CJ1, CJ2, …, CJN}.
Then: X=D1+D2+…+DJ+CJ,i
In the formula, D1+D2+…+DJ are respective the reconstructing results of detailed signals in 1st, 2nd, ...layer, XJ:{xJ,1,x J,2,x J,3,…, x J,N} is the reconstructing

result of approach signal in J layer, then:
$X_{J,1}=d_{1,i}+d_{2,i}+\ldots+d_{J,i}+C_{J,i}$
Supposing that the x_i value in $\{t_i/i\le M\}$ time is known, and to predict the status values after the K step, we must solve the value of x_{m+k}. According to this idea, the time series after decomposition can be treated as a stationary process, and AR, MA, or ARMA models can be used to predict it, and in this paper, the AR model is used as an example to illustrate this prediction:

The sequence after decomposition can be treated as a stationary process:
To establish AR model for each D_s:$\{d_{s,1},d_{s,2},\ldots,d_{s,M}\},1\le s\le J$ and C_J : $\{C_{J,1}, C_{J,2}, \ldots, C_{J,M}\}$, a total of J AR models, supposing:
$d_{s,t}=\varphi_1 d_{s,t-1}+\varphi_2 d_{s,t-2}+\ldots+\varphi_M d_{s,t-M}+\alpha_t,\{t=1,2,\ldots+M\},1\le S\le J$;
$C_{J,t}=\varphi_1 C_{J,t-1}+\varphi_2 C_{J,t-2}+\ldots+\varphi_M C_{J,t-M}+\alpha_t,\{t=1,2,\ldots+M\}$;
Using the known $x_i(i\le M)$ respectively to conduct parameter estimation and model checking on J AR models.
For AR model $x_t=\varphi_1 x_{t-1}+\varphi_2 x_{t-2}+\ldots+\varphi_n x_{t-n}+\alpha_t$, its best prediction formula is:

$$\hat{x}(l)=\begin{cases}\sum_{j=1}^{n}\phi_j\hat{x}_t(l-j) & l>n\\ \sum_{j=1}^{l-1}\phi_j\hat{x}_t(l-j)+\sum_{j=l}^{n}\phi_j x_{t+l-j} & 1<l\le n\\ \sum_{j=1}^{n}\phi_j x_{t+l-j} & l=1\end{cases}$$

This best prediction formula is used in the checked J AR models to predict each $d_{s,M+k}(s=1,2,\ldots,J)$ and $C_{J,M+k}$, and the predictive values $\hat{d}_{s,m+k}(s=1,2,\ldots,J)$ and $\hat{C}_{J,M+k}$ are gained, then, the predicted value of x_{m+k} can be gained as:

$$\hat{x}_{M+k}=\hat{d}_{1,M+k}+\hat{d}_{2,M+k}+\cdots+\hat{d}_{J,M+k}+\hat{C}_{J,M+k}$$

The above process is the application of wavelet analysis in the economic field. Then, this paper mainly analyzes a specific example of wavelet analysis applied in China's foreign trade.

2. AN APPLIED EXAMPLE OF ECONOMIC TIME SERIES ANALYSIS

This paper mainly analyzes the variation tendency of the proportion of domestic first industry in gross domestic product from 1959 to 2005 (figure 1, t=0 correspond to 1959, and the data are from China Statistical Yearbook 2006), data from the previous 40 years are used to construct model to predict the proportion of domestic first industry in gross domestic product 7 years later [11].

Economic signals can also be considered as a time series, which has the same characteristics with the signals used in wavelet analysis [12]. Therefore, economic time series can be regarded as economic signals, and the wavelet analysis method is used to analyze and predict its economic performance [13]. Aiming at the disadvantages of least square method, a method of multi resolution regression analysis for processing economic data is proposed in this paper, that is, the wavelet analysis method is firstly used to preprocess the economic data to get low frequency information that can reflect the trend of macro changes, then the least squares method is used to fit and predict it [14-16]. By comparing with the model established by the traditional least square method, it is found that the method adopted in this paper is better than the least square method.

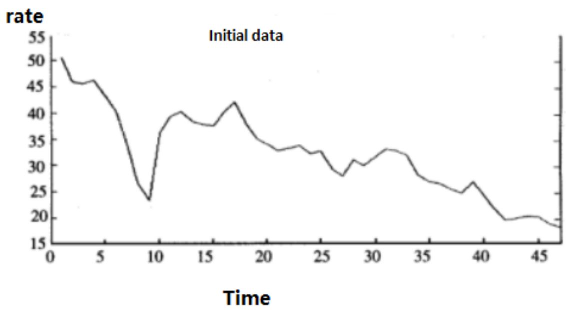

Figure 1: Initial data map from 1959 to 2005

Based on the original data, the least square method is used to construct model:

Original data: 21.8, 19.9, 20.2, 20.5, 20.4, 19.1, 18.4

The data of the first forty years are fitted by the least square method f (T), and a three-order prediction model is thus obtained:

$\hat{f}(t)=-0.0012t^3+0.0769t^2-1.7791t+48.5718$

Where, correlation coefficient R=0.7659, which confirms to equation and coefficient significance hypothesis test, and, the forecast data and actual data for the following seven years are as follows:

Predicted data: 22.1924, 20.5956, 18.7802, 16.949 ,14.8848 ,12.6504 ,10.2386

The deviation between raw data and predicted data: Q=153.8865

the general macro trend of the fitting data is good, however, due to the presence of non-normal data, the coefficients of the model are affected, and, the deviation is slight bigger

3. WAVELET ANALYSIS METHOD MODELING

The three scale wavelet is decomposed into low frequency A3 (T), high frequency D1 (T), D2 (T) and D3 (T) by DB4 wavelet, for simplicity, the main macro trend here is analyzed here, therefore, the high frequency D1 (T) and the D2 (T) are all set into zeros, the high-frequency D3 (T) is decomposed again by wavelet to gain a3'(t) and d3'(t), then d3'(t) is set to zero, and a3'(t) is modeled, then A3 (T) model results and A3 (T) and zero - set D1 (T), D2 (T) are conducted with wavelet reconstruction algorithm to get processed data, and a polynomial fitting model is established, the processed data is modeled by least square method:

f^(t)=-0.0003t3+0.0211t2-0.9937t+46.1990

Where, correlation coefficient R=0.9893, the t test is carried out on the sample mean, coefficient of significance is close to 1, confidence interval of mean 95% is [32.9834 36.4631], where, the forecast data and actual data for the following seven years are as follows:

Predicted value: 24.3501, 23.6576, 22.9317, 22.1706, 21.3725, 20.5356, 19.6581

The deviation between raw data and predicted data: Q=36.4652;

4. CONCLUSION

From the above analysis, it can be known that the wavelet analysis method can process the data from macroscopic and microcosmic aspects, this can smooth off singularities and anomalies, when compared with least square method, the method is most advantageous to the prediction of the model macroscopically with smaller deviation, and closest to 1 from the correlation coefficient, while the coefficient of significance is the highest. As seen from Figure 3, wavelet analysis method can smoothly smooth off singular data to better reflect the macro trend of the data.

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