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The Research on Energy Consumption Forecast Based on Trend Prediction Method in China

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Abstract: Trend prediction method is adopted to predict the total energy consumption in China in this paper, which is compared with the linear regression method. The empirical results show that the prediction error of the trend prediction method is smaller than that of the linear regression method.

Keywords Energy Consumption, Trend Prediction Method, Linear regression method, Forecast.

INTRODUCTION

Energy is the foundation of human economic and social development [Baca Ruiz et.al. 2016]. Energy demand is closely related to energy security and national economic development [Cao Ling *et.al.* 2016]. Reasonable analysis and prediction of the development trend of energy consumption can provide important references for the formulation of energy policies and the planning of energy construction projects [Dovzan *et.al.* 2016].

TREND PREDICTION METHOD

Trend prediction method is also called trend analysis method. Its independent variable is time , and its dependent variable is a function of time. Its main advantage is to consider the development trend of time series, so that the prediction results can be better. Depending on the degree of accuracy required, one or more moving averages can be selected for prediction [Zhou Ruijin *et.al.* 2013].

Take the second order adaptive coefficient method as an example:

(1) Set the initial value

setβ =0.1, $S_0^{(1)} = S_0^{(2)} = x_1$,

$M_0 = 0$, $E_0 = 0$, $\hat{x}_1 = x_1$.

(2) Calculate the adaptive coefficient α_t.

$$\begin{cases} e_t = x_t - \hat{x}_t \\ E_t = \beta e_t + (1-\beta) E_{t-1} \\ M_T = \beta |E_T| + (1-\beta) M_{t-1} \\ \alpha_t = |E_t| / M_t \end{cases}$$

Where, e_t is the prediction error, E_t is the first order exponential smoothing of the error sequence $e_1, e_2, \cdots, e_t$, M_t is the first order exponential smoothing of the error absolute value sequence

$$|e_1|, |e_2|, \cdots, |e_t|$$

(3) Use the following formula to make predictions

$$\left.\begin{array}{l} S_t^{(1)} = \alpha_t x_t + (1-\alpha_t) S_{t-1}^{(1)} \\ S_t^{(2)} = \alpha_t S_t^{(1)} + (1-\alpha_t) S_{t-1}^{(2)} \\ \hat{a}_t = 2S_t^{(1)} - S_t^{(2)} \\ \hat{b}_t = \dfrac{\alpha_t}{1-\alpha_t}\left[S_t^{(1)} - S_t^{(2)}\right] \\ \hat{x}_{t+1} = \hat{a}_t + \hat{b}_t \end{array}\right\}$$

From $t = 1$ to $t = T$, loop execution the two steps (2)and (3) to get the prediction。

EMPIRICAL RESEARCH

By consulting the China statistical yearbook, annual data for China's total energy consumption from 2000 to 2018 were collected. The second-order adaptive coefficient method is adopted and Matlab is used for prediction. The solver is as follows.

```
x=[146964 155547 169577 197083 230281 261369 286467 311442 320611 336126 360648 387043 402138 416913 425806 429905 435819 448529.1 464000];
s1(1)=x(1); e1(1)=0; m(1)=0; yc=x; m(1)=0;a(1)=x(1); s2(1)=x(1); yc(2)=x(1);beta=0.1;
for i=2:19
e(i)=x(i)-yc(i);
e1(i)=beta*e(i)+(1-beta)*e1(i-1);
m(i)=beta*abs(e(i))+(1-beta)*m(i-1);
alpha(i)=abs(e1(i))/m(i)
s1(i)=alpha(i)*x(i)+(1-alpha(i))*s1(i-1)
s2(i)=alpha(i)*s1(i)+(1-alpha(i))*s2(i-1)
a(i)=2*s1(i)-s2(i)
```

```
if alpha(i)==1
   b(i)=s2(i)-s2(i-1)
else
   b(i)=alpha(i)/(1-alpha(i))*(s1(i)-s2(i))
end
yc(i+1)=a(i)+b(i)
end
```

The calculation results are shown in table 1:

Table 1 The calculation table of second order adaptive coefficient method
units: ten thousand tons

Year	Actual value	S1	S2	a	b	Alpha	Predicted value
2000	146964	146964	146964	146964	0	0.0000	146964
2001	155547	155547	155547	155547	8583	1.0000	146964
2002	169577	169577	169577	169577	14030	1.0000	164130
2003	197083	197083	197083	197083	27506	1.0000	183607
2004	230281	230281	230281	230281	33198	1.0000	224589
2005	261369	256641	252633	260650	22352	0.8479	263479
2006	286467	282484	278498	286470	25865	0.8665	283002
2007	311442	305752	300397	311107	21900	0.8035	312335
2008	320611	308524	301914	315135	1516	0.1866	333007
2009	336126	322068	311803	332333	9890	0.4907	316651
2010	360648	346543	333842	359244	22038	0.6344	342223
2011	387043	373557	360333	386782	26491	0.6670	381282
2012	402138	384957	370154	399759	9821	0.3988	413273
2013	416913	399725	383820	415630	13667	0.4622	409580
2014	425806	409766	393810	425723	9989	0.3850	429297
2015	429905	415041	399371	430712	5561	0.2619	435712
2016	435819	420283	404646	435919	5275	0.2523	436272
2017	448529	429961	413320	446602	8674	0.3427	441195
2018	464000	444707	426917	462497	13597	0.4332	455277
2019							476093

Linear regression is one of the statistical analysis methods, it applies mathematical statistics to determine the interdependent quantitative relationship between two or more variables [Li Nan *et.al.* 2011]. This paper also adopts the linear regression method to predict the total energy consumption in order to make comparison with the trend prediction method.

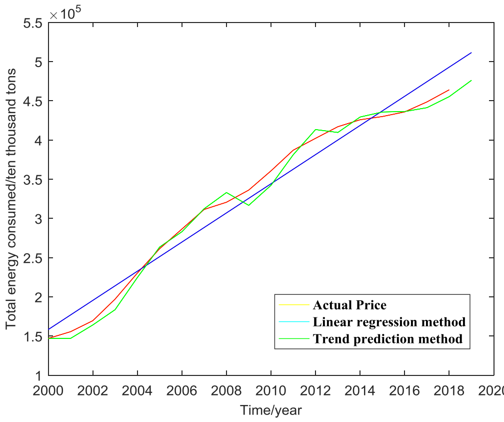

Figure 1 the prediction results of trend prediction method and linear regression method

As can be seen from Figure 1, the prediction results of the trend prediction method are closer to the original data, and the fitting degree is better than that of the linear regression method.

For the purpose of measuring prediction performance, three commonly used error criteria were proposed to test the accuracy of two prediction models—relative error (RE), mean absolute percentage error (MAPE), the root mean squared error (RMSE).

$$RE = \frac{y_i - y_i^*}{y_i}$$

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{y_i - y_i^*}{y_i}\right| \times 100\%$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left|\frac{y_i - y_i^*}{y_i}\right|^2}$$

where n is the number of training samples, and y_i and y_i * are actual and predicted values, respectively.

Table 2 The RE of two methods

Linear regression	Trend prediction
-0.0771	0.0000
-0.1371	0.0552
-0.1527	0.0321
-0.0861	0.0684
-0.0103	0.0247
0.0388	-0.0081
0.0581	0.0121
0.0739	-0.0029
0.0424	-0.0387
0.0313	0.0579
0.0457	0.0511
0.0627	0.0149
0.0517	-0.0277
0.0407	0.0176
0.0171	-0.0082
-0.0168	-0.0135
-0.0457	-0.0010
-0.0575	0.0164
-0.0623	0.0188

Table 3 The MAPE and RMSE of two methods

	Linear regression	Trend prediction
MAPE	0.0583	0.0247
RMSE	0.0156	0.0073

It can be seen from table 2 and table 3 that both RE, MAPE and RMSE of the trend prediction method are smaller than that of linear regression method, which can prove that the trend prediction method is more suitable for the prediction of total energy consumption. The reason is that the linear regression method is simply supposes the relationship between the annual total energy consumption and year is linear, which lacks theoretical support, so its error is larger than the trend prediction method [Qian Qing *et.al.* 2018].

CONCLUSIONS

The trend prediction method can achieve better results in predicting the total energy consumption,. However, the total energy consumption in a given year is not only related to the total energy consumption in previous years, but also related to other factors, such as GDP, industrial development level, even climate change and other random factors [Song Kwonsik et.al. 2017]. This will be the author's next research direction.

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