Influencing Factors Analysis and Trend Forecasting of China's Total Energy Consumption

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Abstract. In order to answer following two questions, One is the influence factors and the influence degree of China's total energy consumption, Another is in the future five years China's total energy consumption trend prediction. This paper begins with a qualitative analysis of factors affecting China's total energy consumption, resulting in the classification of these factors according to their importance and significance by using the Grey Correlation Analysis method; Based on the fact China's total energy consumption system is gray, this paper established the Grey forecasting model GM (1, 1), 2015 ~ 2019 China's total energy consumption was forecast. This paper studies showed that China's total energy consumption is sub-health; As long as continue to strengthen the work of the use of natural gas, nuclear energy and renewable energy, in the next five years, Health controllable of China's total energy consumption will remain stable.

Introduction

In 2011, China's GDP surpassed Japan as the world's second-largest economy for the first time, GDP in 2015 reached $67.6708 trillion, increased by 6.9% than in 2014, But China's economic growth is built on the basis of a large number of energy consumption, China's energy consumption has accounted for over 20% of the total global energy consumption, and more than the United States. The present China is facing both development and reasonable challenge to reduce the consumption of energy, So this article choose to study in China's energy consumption. Our problem is China's energy consumption of health? Main influencing factors of is what? Effect how? During the 13th Five-Year Plan period, What is the trend of China's energy consumption? By using the gray correlation method and GM (1, 1) model, We discuss two problems , One is the influence factors and the influence degree of China's total energy consumption, Another is in the future five years China's total energy consumption trend prediction.

Gray Incidence Analysis of China's total energy consumption

Consider, China's total energy consumption is a Grey system, Influence China's energy consumption, there are many factors. Using Grey correlation method to study the correlation factor to affect the size of China's energy consumption, Thus to provide evidence for policy of China's total energy consumption.

Grey relational analysis.

Grey relational analysis is the main content of gray system theory of one,it is the foundation of Gray system analysis, forecast and decision . It according to the analysis of Grey system behavior factor and the system related behavior factor's closely degree, to judge the system caused by the development of the main factors and secondary factors.

The basic idea is: according to the time sequence of the factors of the curve of similar degree, to judge the geometric relationships between factors are closely; Curve the geometric shape, corresponding to the correlation between the greater the sequence; Otherwise the small.

Algorithm steps:

Step 1. Sure Yo(reference sequence) and Yi(compare sequences);

Step 2.For Reference sequence and the comparison sequence,do initialization；
Step 3.Calculating correlation coefficient:

$g(Y_0(k),Y_i(k)) = \frac{\Delta_{\min} + r \cdot \Delta_{\max}}{\Delta_{oi}(k) + r \cdot \Delta_{\max}}$, here r is distinguish coefficient， Usually, take for 0.5；

Step 4: correlation calculation： $g(Y_0,Y_i) = \frac{1}{n}\sum_{k=1}^{n} g(Y_0(k),Y_i(k))$

Step 5: sort order

Index selection

Based on the national bureau of statistics annual data, Reference index choose the composition of coal, oil, natural gas and electricity. This paper will discuss the relevance respectively.

The empirical analysis

Collect data (1996 ~ 2014), the arrangement to table 1（Data sources：The national bureau of statistics, the total energy consumption and composition in 1996-2014 communique）

Table 1 The total energy consumption and composition data of 1996-2014 Units: ten thousand tons of standard coal

	X1	X2	X3	X4	Y
1996	99366	25281	2433	8112	135192
1997	97039	27725	2446	8698	135909
1998	96554	28326	2451	8852	136184
1999	99242	30222	2811	8294	140569
2000	100670	32332	3233	10728	146964
2001	105772	32976	3733	13066	155547
2002	116160	35611	3900	13905	169577
2003	138352	39614	4533	14584	197083
2004	161657	45826	5296	17501	230281
2005	189231	46524	6273	19341	261369
2006	207402	50132	7735	21199	286467
2007	225795	52945	9343	23358	311442
2008	229237	53542	10901	26931	320611
2009	240666	55125	11764	28571	336126
2010	249568	62753	14426	33901	360648
2011	271704	65023	17804	32512	387043
2012	275465	68363	19303	39007	402138
2013	280999	71292	22096	42525	416913
2014	281160	72846	24282	47712	426000

where, Y、X1、X2、X3、X4 denote index of China's total energy consumption、the composition of coal, oil, natural gas and electricity power, respectively.

Correlation between China's total energy consumption and four types of indicators

According to the data table 1, The following correlation coefficients is obtained by using Data processing system（DPS）： r(Y,X1)= 0.83955, r(Y,X2)= 0.76202 ; r(Y,X3)= 0.55780, r(Y,X4)= 0.67217.

Conclusion1:

Surface the composition of coal, oil with China's total energy consumption index is the highest correlation, correlation value of 0.83955,0.76202 ,respectively. The power consumption is the third, correlation value of 0.67217. Explanation: Total power consumption of China's energy consumption also has a great role in promoting, The promoting function of gas consumption in China's energy consumption is the smallest.

Conclusion2:

On the whole, The correlation of China's total energy consumption index and gas consumption is the lowest, Correlation value was 0.55578. This is not quite normal, according to the normal structure of energy consumption of developed countries, the correlation of gas consumption should be in the top three. And nuclear energy and renewable energy consumption also accounted for 4% to 8%,So China's energy consumption depends on healthy growth to speed up the use of natural gas, nuclear energy and renewable energy.

Overall, China's energy consumption growth is sub-health, remains dependent on oil consumption and coal consumption on the high side, Must pay attention to and accelerate the use of natural gas, nuclear energy and renewable energy.

Forecast of China's total energy consumption and coal consumption

Now Consider, China's total energy consumption and coal consumption evaluation system is a Grey system， And many influence factors, This article will use the Grey forecasting model GM (1, 1) make prediction research。

GM (1, 1) Model

GM (1, 1) Model is 1 order equations 1 variables Grey Model, Hypothesis: n observation value of the original data set of the sequence $X^{(0)}$ is: $X^{(0)} = \{X^{(0)}(1),..., X^{(0)}(n)\}$.

The basic steps of GM (1, 1) model:

Step1. Through the accumulation generation new sequence $X^{(1)}(k) = \sum_{m=1}^{k} X^{(0)}(m)$;

Step2. Structure accumulate matrix B and constant term vector Y_n ;

Step3. Using least square to solving the estimated parameters vector $\hat{a} = (B^T B)^{-1} B^T Y_n$ 即 $\hat{a} = \begin{pmatrix} a \\ b \end{pmatrix}$;

Step4. Will Grey parameters go into Whitenization differential equations:

$$\frac{dX^{(1)}}{dt} + aX^{(1)} = b \ ;$$

Step5. Solving differential equation to obtain time response and forecast model.

$$\text{Time response}: \begin{cases} \hat{X}^{(1)}(k+1) = \left(X^{(0)}(1) - \dfrac{b}{a} \right) e^{-ak} + \dfrac{b}{a} \\ X^{(0)}(1) = X_0, \quad \dfrac{b}{a} = k_0 \end{cases} \quad (\text{k=0,1,2,…,n})$$

Forecast model: $\hat{X}^{(1)}(k+1) = \left(X_0 - k_0 \right) e^{-ak} + \mathrm{k}_0$;

Step6. The model test and forecast

Method 1. Residual inspection (table 2)

Table 2 GM（1，1）Model Residual Inspection

Observation value	Fitted Value	Residual error	Relative error
$X^{(0)}(k)$,k=1…n	$\hat{X}^{(0)}(k)$,k=1…n	$e(k) = X^{(0)}(k) - \hat{X}^{(0)}(k)$, k=1…n	$\Delta_k = \dfrac{\lvert e(k) \rvert}{X^{(0)}(k)}$, k=1…n

Method 2. Mean square error ratio and Small error probability inspection

$$C=\frac{S_2}{S_1} \ , \ P = p\{\left|\Delta^{(0)}(i) - \bar{\Delta}^{(0)}\right| < 0.6745 S_1\} \ , \ S_1 = \sqrt{\frac{\sum[X^{(0)}(i) - \bar{X}^{(0)}]^2}{n-1}} \ , \ S_2 = \sqrt{\frac{\sum[\Delta^{(0)}(i) - \bar{\Delta}^{(0)}]^2}{n-1}}$$

Here C is Mean square error ratio, P is Small error probability.

According to the Grey forecasting theory, when P>0.95 and C<0.35， Model is very reliable for level I； when P>0.8 and 0.35<C<0.5， Model is reliable for level II； when P>0.7 and 0.5<C<0.65， Model is reliable for level III.

Forecasts of China's total energy consumption and coal consumption

If 19 years from 1996 to 2014 in China's total energy consumption (see table 1), Using GM (1, 1) model to predict the total energy consumption in China, from 2015 to 2018 were respectively 502615.2, 540326.8, 580868, 624451, 671304, China's total energy consumption will be sustained and rapid rise significantly, Is too high ,This does not accord with China for nearly five years

development clearly. Its reason, because of the extensive economic growth since China's reform and opening up. China's "twelfth five-year" (2011-2015), since the Chinese economy into the new normal, Shift and slow economic growth, Energy consumption appear new changes during this period , Therefore need to be on the basis of 2011 ~ 2014 in China's energy consumption and coal consumption data (see table 3) to predict will become more scientific, Use the GM (1, 1) model, we predicts 2015 ~ 2019 China's total energy consumption and coal consumption index.

Here the original series $X^{(0)}$ represent for China's energy consumption and coal consumption index, data see table 3.

Table 3 China's energy consumption and coal consumption data Unit: ten thousand tons of standard coal

index	2011	2012	2013	2014
China's energy consumption	387043	402138	416913	426000
coal consumption	271704	275465	280999	280060

Data sources: The national bureau of statistics, the total energy consumption and composition in 2011-2014 communique

According to the data table 3, The following results is obtained by using Data processing system （DPS）（GM（1,1）model）,respectively.

The forecast analysis of China's total energy consumption

The output of DPS is

Model parameters:

a=0.028681，b=386290

$x(t+1)=13855685e^{0.028681t}-13468642.27$

Table 4 Residual Inspection of China's total energy consumption index

No.	Observation value	Fitted Value	Residual error	Relative error
X(2)	402138	403144.2	-1006.257	-0.25023
X(3)	416913	414874.1	2038.879	0.48904
X(4)	426000	426945.2	-945.275	-0.22190

The evaluation of the Model:

C=0.096<0.35,P=1.0000>0.95,Model is very reliable for level I.

The future five time prediction:

X(t+1)= 439367.65
X(t+2)= 452151.47
X(t+3)= 465307.24
X(t+4)= 478845.796
X(t+5)= 492778.267
Qmin=-1006.25703

Conclusion：Predictive values of 2015、2016、2017、2018、2019 China's total energy consumption index is 439367.65、452151.47、465307.24、478845.796、492778.267, respectively，China's total energy consumption will continue to rise, slowly to predict more objectively.

The forecast analysis of coal consumption

The output of DPS is

Model parameters:

a=0.010166，b=272207.67

$x(t+1)=27048587.37e^{0.010166t}-26776883.368$

Table 5 Residual Inspection of coal consumption index

No.	Observation value	Fitted Value	Residual error	Relative error
X(2)	275465	276372.1	-907.1389	-0.329312
X(3)	280999	279196.0	1802.996	0.641638
X(4)	281160	282048.7	-888.722	-0.316091

The evaluation of the Model:

C=0.3202<0.35,P=1.0000>0.95,Model is very reliable for level I.

The future five time prediction:

X(t+1)= 284930.59
X(t+2)= 287841.9
X(t+3)= 290782.96
X(t+4)= 293754.068
X(t+5)= 296755.535
Qmin=-907.13893

Conclusion：Predictive values of 2015、2016、2017、2018、2019 China's total energy consumption index is 284930.59、287841.9、290782.96、293754.068、296755.535, respectively，China's coal consumption will continue to slowly rising.

The prediction results and the economic up state, the supply side, and much starker choices-and graver consequences-in 6% GDP growth target is adapted.

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