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Dynamic Evolution of Energy Efficiency Mechanism in China

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ABSTRACT: In this paper, the panel data model of the total factor energy efficiency (TFEE)is built to research on the dynamic evolution mechanism , using the panel data of China in 1991-2012, This paper test the relationship between the TFEE and effect factors by the method of panel co-integration, and calculated the contribution rate of every factor to the growth rate of TFEE by the panel data model. The empirical results shows that the TFEE and effect factors are co-integrated in the long run, it is clear that industrial structure, structure of energy consumption have negative influence on TFEE, and human capital quality, technical progress, the government influence have forward influence on TFEE, the human capital quality has the greatest contribution to the growth of TFEE. The TFEE will be pushed forward by these effect factors.

KEYWORDS: Energy Efficiency; Panel Co-integration; Contribution Rate; Evolution Mechanism.

INTRODUCTION

The double pressure of resources and environment based on the problem of energy efficiency has become an important strategic problem which restricts the sustainable development of China's economy. From the energy efficiency target, according to the NDRC announced the “eleven five year” period

Our unit of GDP energy consumption decreased by 19.1%, did not complete the 20% energy saving target to reduce the. The “Twelfth Five Year Plan” clearly stipulates that in the next 5 years, energy consumption per unit of GDP by 16%.

Influence and restriction of energy efficiency by the industrial structure, energy consumption structure, population quality, technology and a series of factors, is the result of a series of factors. Changes in these factors and China's energy efficiency has any relationship, and the mechanism of energy efficiency of dynamic evolution and how? The aim of this research is to proceed from these factors and the relationship between the energy efficiency and the dynamic evolution mechanism of empirical analysis of energy efficiency, to improve energy efficiency and provide scientific reference data and decision support.

According to the literature, the current research on China's total factor energy efficiency is a hot issue of concern to scholars, achieved fruitful results. The research methods and results in this paper are analyzed from the following aspects:

First, the two phase of the research method. Hu and Wang [1] (2006) put forward the concept of total factor energy efficiency and its measurement, has become a mainstream method of energy efficiency. Total factor energy efficiency reflects the input elements of capital, labor and energy between the mutual substitution effect, can better reflect the objective reality, the improvement of energy efficiency also rely in the improvement of total factor energy efficiency. Most of the domestic scholars use DEA model to measure the total factor energy efficiency, and then the influence factors of the Tobit model on total factor energy efficiency analysis. Yang Hong Liang, Stan (2008) [2] in empirical study of single factor method and total factor method of comparison is also found, total factor energy efficiency index in examining the effect of a regional resource endowments of energy efficiency has a advantage could not be replaced by the single factor method. The research model, Zhao Wei Chu, Shen Manhong (2007) [3], Xiao Ling Yuan, Baoshan, Wan Ping Yang (2009) [4], xiao-e Qu (2009) [5], 1989, Bao Chen Yang, Yang Li (2010) [6] etc. scholars using time series data, select the different indicators, on China's total factor energy efficiency and its influencing factors are studied. It is found that the change trend of China's energy efficiency is U-shaped, around 2000 inflection point, most of the researchers found was significantly negatively correlated with technological progress and government spending is positively related to total factor energy efficiency and industrial structure, energy consumption structure.

Second, co-integration analysis. There are some scholars using co-integration analysis method to research the relationship between China's energy consumption and other factors, Xiaotao, Zhang LED (2011) [7] research thinks,

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such as the existence of the one-way causal relationship between energy consumption and economic growth. Only using the time series data of deficiency of pseudo regression, col-linearity and other aspects, some scholars began to use panel data analysis method to study the energy efficiency problem. Ming - Feng hung (2004) [8] using panel data analysis method to prove the existence of Environmental Kuznets curve; bilateral, (2010) [9] uses panel co-integration analysis, the study found only between industrial solid waste emissions and per capital GDP of Environmental Kuznets curve; Zhou Jian (2008) [10] uses panel co-integration analysis method to study there is a long-term equilibrium relationship found between energy efficiency and economic growth, industrial structure, population, technology progress, the scholars by consumption per unit of GDP kwh electric as energy efficiency, in the reflected energy efficiency is not as good as the total factor energy efficiency more objectively.

Other research has representative is Stan, Wu Lixue, a, (2008) [11] scholars using stochastic frontier production function analysis of regional differences in energy efficiency, and variance decomposition method to calculate the contribution of each factor, think only to improve the efficiency of resource allocation in the Midwest and to promote inter regional technology diffusion is used to improve energy efficiency.

Study on the factors above scholars focus on energy efficiency measure, convergence or influence, dynamic evolution mechanism fails to reveal the total factor energy efficiency in the research content and research methods. This paper constructs the total factor energy efficiency evolution of panel data model, the mechanism of the relationship and interaction effects of panel co integration analysis method and factors of energy efficiency and energy efficiency of the dynamic evolution mechanism. The advantages of this method in: (1) the total factor energy efficiency evolution of panel data model to measure the influence of different factors on the energy efficiency of the growth rate of contribution rate, in the analysis of influence factors and the mechanism of energy efficiency change more sensitivity and depth, the dynamic evolution mechanism and scientific analysis of energy efficiency; (2) the panel co-integration analysis method can overcome the shortcomings of time series analysis of multidisciplinary, spurious regression and other aspects, to provide more information, in the study on the relationship between influence factors and energy efficiency in the higher degree of freedom and higher estimation efficiency; (3) factors will be the level of management, energy saving consciousness hard to measure for the comprehensive factors, considering the influence of factors on energy efficiency changes, changes can be more comprehensive to reflect the energy efficiency.

This article research mentality is: first uses DEA model to measure the total factor energy efficiency in China, then using the panel data model of the evolution of total factor energy efficiency, the relationship of China's total factor energy efficiency and its influencing factors of panel unit root test and co integration test, estimation, analysis of the influencing factors and the energy efficiency and the relationship between the mechanism; best use of total factor energy efficiency growth equation, estimates the influence factors to the growth of total factor energy efficiency contribution rate, in-depth analysis of dynamic evolution mechanism of the energy efficiency, discover how to increase energy efficiency and the direction of approach.

METHODS

1 Dynamic Evolution Mechanism of Total Factor Energy Efficiency In China

Existing researches on China's total factor energy efficiency influence factors, factors of different scholars choose the same as [4], [5], [6] and other scholars have chosen the economic structure, the level of industrialization, marketization, technology progress、he degree of opening up to the outside world, the influence of government, energy prices and energy consumption structure factors.

This paper believes that in addition to be factors and energy factors, technological progress and other factors on economic development, but also should pay more attention to the quality of the labor force with different levels of impact on energy efficiency. Because of the quality of human capital in the grasp of energy saving, technology management consciousness and other aspects of energy efficiency improvement plays an essential role. The study found that the existing studies lack the quality of human capital on total factor energy efficiency influence research.

Based on the above analysis, in view of the adjustment of industrial structure in China, construction of low carbon economic and social status, the study selected choice of industrial structure (is), educational level (HC), energy consumption structure (ES), technical progress (TP) and the influence of government (GI), five factors of the dynamic evolutionary mechanism of the total factor energy efficiency in China empirical analysis.

Based on the Baltagi (2005) of the improvement of energy efficiency analysis framework proposed by [13], this paper constructs the panel data to improve China's total factor energy efficiency model, expressed as:

$$TFEE_t = IS_t^{\beta_1} HC_t^{\beta_2} ES_t^{\beta_3} TP_t^{\beta_4} GL_t^{\beta_5} e^{(\alpha+\varepsilon_t)} \quad (3)$$

Type (3), said the year t China's total factor energy efficiency, calculated by the formula (1) and (2); respectively in the year t of our country industrial structure, education level, energy consumption structure, technology progress and influence of government; comprehensive management level, energy saving awareness and other factors on total factor energy efficiency effect of elastic; represent our country industrial structure status, education level, energy consumption structure, technology progress and influence of government on China's total factor energy efficiency effect of elastic; random disturbance.

The type (3) on both sides of the logarithm form into a linear regression model can be obtained, the output elasticity of the influencing factors on the total factor energy efficiency, expressed as follows:

$$\ln TFEE_t = \alpha + \beta_1 \ln IS_t + \beta_2 \ln HC_t + \beta_3 \ln ES_t + \beta_4 \ln TP_t + \beta_5 \ln GL_t + \varepsilon_t \quad (4)$$

On both sides of the T(3) time derivative deformation, can get the total factor energy efficiency growth equation:

$$\frac{\Delta TFEE_t}{TFEE_t} = \alpha + \beta_1 \times \frac{\Delta IS_t}{IS_t} + \beta_2 \times \frac{\Delta HC_t}{HC_t} + \beta_3 \times \frac{\Delta ES_t}{ES_t} + \beta_4 \times \frac{\Delta TP_t}{TP_t} + \beta_5 \times \frac{\Delta GL_t}{GL_t} \quad (5)$$

Type (5), respectively, and the total factor energy efficiency

The growth rate, industrial structure change rate, education level, growth rate, energy consumption structure change rate, growth rate of technological progress and influence the growth rate of government;

Represent comprehensive factors, industrial structure, education level, energy consumption structure, technological progress and the influence factors of the total factor energy efficiency growth contribution, contribution were divided by can get the elements of the total factor energy efficiency in the contribution rate.

According to the model, this paper studies the dynamic evolution mechanism of total factor energy efficiency of China's.

ii Total Factor Energy Efficiency Measurement Model

In view of the advantage of total factor energy efficiency reflected in the energy efficiency, the dynamic evolution mechanism of the total factor energy efficiency research of China's energy efficiency improvement.Using variable returns to scale conditions based on the input oriented DEA model for measuring the total factor energy efficiency.DEA model is a kind of evaluation with the same types of input index and output of the multi index decision making units (decision making unit, DMU) the effectiveness of comprehensive evaluation method. Compared with representative of the DEA model C^2R and BC^2 model, C^2R model assumes constant returns to scale (CRS), for each decision making unit (DMU) of decision making units in the best production scale, more stringent requirements, banker, Charne and coo in this paper Per (1984) [12] in the C^2R model based on adding $\sum \lambda_{.} = 1$ constraint, the BC^2 model is presented in this paper, the variable returns to scale (VRS) was evaluated.

In this paper, China's annual total factor energy efficiency as a $DMU_j (j = 1,2\ldots,20)$, each DMU_j Use the M input, s output, The input output vector, respectively. $X_j = (X_{1j}, X_{2j},..., X_{mj})^T$, $Y_j = (Y_{1j}, Y_{2j},..., Y_{sj})^T$, The corresponding weight vector respectively V 和 u , $V = (V_1, V_2,..., V_m)^T$, $u = (u_1, u_2,..., u_m)^T$. So the J $(j = 1,2\ldots,20)$ total factor energy efficiency measurement model of decision units for:

$$\max h_j = \frac{\sum_{r=1}^{s} u_r y_{rj} - u_0}{\sum_{i=1}^{m} v_i x_{ij}}$$

$$s.t. \frac{\sum_{r=1}^{s} u_r y_{rj} - u_0}{\sum_{i=1}^{m} v_i x_{ij}} \le 1, j - 1,2,...,20 \quad (1)$$

$$v_i, u_r \ge 0, i = 1,2,...m, r = 1,2,..., s$$

Among them, h_i is DMU_i relative efficiency under the condition of variable returns to scale, h_i the greater ,Show that the higher the efficiency of DMU_i ; u_0 not by constraint, It reflects the characteristics of DMU_i scale return.When u_0=0, said DMU_i in the best production scale, which belongs to the constant returns to scale;When u_0>0, said DMU_j at the scale of decreasing state; When u_0<0, said DMU_j at increasing scale.

At the same time, the efficiency value of C^2R model is BC^2 model in total factor energy efficiency value (CE) , the efficiency of BC^2 model in the value of pure technical efficiency (PTE) and scale efficiency (SE) , the relationship between the three is:

$$TE = PTE + SE \quad (2)$$

iii Variables and Data Description

1) the total factor energy efficiency measurement model variables and data description

Based on related literature, this paper chooses GDP, capital stock, human capital and energy four input-output index of China's total factor energy efficiency were measured.

The variables in the data model and calculation method are as follows:

(1): GDP in 1993 can be said than the actual price of GDP, the unit for billion yuan.

(2) of the capital stock: the goldsmith (1951) [14] scholars to create a “perpetual inventory method to estimate the annual real fixed capital stock, referring to Zhang Jun (2004) [15] the research methods and results calculated for 1993 constant price said the 1993 - 2014 China fixed capital stock.

(3) Human Capital: reference Lin Bo (2003) [16], Guo Quan Xu etc. (2007) [17] scholars research the “by education years method” to estimate the 1993 - 2014 stock of human capital of China, the unit is: million people in.

(4) energy: energy input by “Chinese energy statistics yearbook > (1993 - 2014) total consumption data Chinese energy units” tons of standard coal.

2) the total factor energy efficiency improvement of panel data model and variable data

(1) the total factor energy efficiency (TFEE), obtained by the total factor energy efficiency measurement model of DEA measurement;

(2) industrial structure (IS): the total output value of China's second industries accounted for the proportion of GDP said;

(3) educational level (HC): considering the requirements of energy saving and emission reduction on the cultural level of the population, represented by the educated population of more than 9 years accounted for the proportion of the total population; the 1991 - 1995 population by lack of education data, this paper according to the 1990 census data and 1996 data by interpolation method was calculated.

(4) the energy consumption structure (ES): the amount of coal consumption in China accounted for the proportion of the energy consumption of total consumption said;

(5) technological progress (TP): China's R&D investment accounted for the proportion of GDP said;

(6) the influence of government (GL): government spending accounted for the proportion of GDP said;

In the two models are based on data from 1993 to 2014 statistical yearbook China < > and < > Chinese energy statistical yearbook obtained.

(1)GDP:In 1993 can be said than the actual price of GDP, the unit for billion yuan.

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In the two models are based on data from 1993 to 2014 statistical yearbook China <China Statistical Yearbook > and < CHINA ENERGY STATISTICAL YEARBOOK> Chinese energy statistical yearbook obtained.

RESULTS-EMPIRICAL RESEARCH

i Measurement of Total Factor Energy Efficiency Chinese

According to the construction of total factor energy efficiency measurement model by software Deap2.1 measurement of total factor energy efficiency in our country, using panel data in finishing, in China from 1993 to 2014 during total factor energy efficiency can be obtained, As shown in Table 1.

Table 1. Chinese total factor energy efficiency and its decomposition.

YEAR	TE	PTE	SE
1993	0.488	1	0.488
1994	0.53	0.988	0.537
1995	0.568	0.957	0.594
1996	0.607	0.94	0.646
1997	0.63	0.929	0.679
1998	0.673	0.939	0.716
1999	0.732	0.958	0.764
2000	0.787	0.996	0.791

2001	0.821	1	0.821
2002	0.86	0.988	0.87
2003	0.901	1	0.901
2004	0.927	1	0.927
2005	0.885	0.939	0.942
2006	0.839	0.878	0.955
2007	0.844	0.883	0.956
2008	0.868	0.893	0.972
2009	0.914	0.932	0.981
2010	0.934	0.952	0.992
2011	0.951	0.964	0.995
2012	0.963	0.978	0.997
2013	0.989	0.993	0.999
2014	1	1	1

ii Total Factor Energy Efficiency Panel Data Co-Integration Analysis In China

1) The panel unit root test

Test method for comprehensive scholar in the panel unit root test research, this paper adopts the same root of unit root test LLC (combined with the Levin Lin - Chu) test and different root unit root test Fisher ADF test, if in the two test were denied the existence of the null hypothesis of unit root, it is considered that the sequence is stable, otherwise it is not smooth. Lag item automatically selected by the software eviews6.0, (4) regression panel data model variables of the ADF test results are shown in Table 2 shows:

Table 2. Panel unit root test statistics and results.

Variable	LLCtest		Fisher-ADFtest		Conclusion
	Test System Metering	The Value of P	Test Statistics	The Value of P	
LNTFEE	-1.6676	0.0477	2.66381	0.2640	Non stationary
LNIS	-0.5608	0.2875	6.5491	0.0378	Non stationary
LNHC	-0.6996	0.2421	0.4397	0.8026	Non stationary
LNES	-1.0129	0.1555	2.0474	0.3593	Non stationary
LNTP	1.4732	0.9297	0.0353	0.9825	Non stationary
LNGI	0.9141	0.8197	0.2362	0.8886	Non stationary
△LNTFEE	-2.9301	0.0017	6.9021	0.0117	stationary
△LNIS	-6.3394	0.0000	19.5103	0.0001	stationary
△LNHC	-6.5193	0.0000	20.3925	0.0000	stationary
△LNES	-4.9511	0.0000	18.4207	0.0001	stationary
△LNTP	-4.0382	0.0000	12.8208	0.0017	stationary
△LNGI	-3.4814	0.0000	12.4570	0.0020	stationary

Note: the representation of △ first-order differential operator

Panel by Table 2 shows that constitute the total factor energy efficiency model of six variables panel data level value of the t statistic of two kinds of test methods common in 10%, 5% and 1% significant level cannot be denied the existence of the panel unit root hypothesis; and the first-order differential data test statistic of P values in the two test methods are approximate to zero, a highly significant to reject the null hypothesis. Comprehensive test results, six variables panel data are I (1) process generation. Test results show that China's total factor energy efficiency and related factors of non stationary characteristics, based on China's total factor energy efficiency improvement of panel data model Type of co-integration test and estimation.

2) the panel co-integration test

Variables panel data unit root test conclusion for this article of panel co-integration tests provide the basis. The proposed by pedroni (1999) [19] seven test statistic and Kao (1999). The ADF test statistic to test the co-integration relationship between total factor energy efficiency improvement of panel data model variables. Use the eviews6.0 software to carry on the test. Test results are shown in Table 3.

Table 3. Panel co-integration test method, statistics and results.

Test Method	Statistic Name	Statistic Value	The Value of p
Kao Test	ADF	-6.1823	0.0000
Pedroni Test	Panel V-Statistic	1.2993	0.0189
	Panel Rho-Statistic	-3.1547	0.0012
	Panel PP-Statistic	-5.981	0.0000
	Panel ADF-Statistic	-7.8353	0.0000
	Group Rho-Statistic	-0.03712	0.0289
	Group PP-Statistic	-6.9906	0.0000
	Group ADF-Statistic	-7.1446	0.0000

From table 3 shows, under the two testing methods of ADF values at 5% significant level under reject the null hypothesis, so there is a panel co-integration relationship, i.e. total factor energy efficiency (TFee) and industrial structure (is), educational level (HC), energy consumption structure (ES) and technical progress (TP), between the impact of the government (GI) exist long-run equilibrium relationship.

3) the estimation and analysis of Panel Co-integration

On the basis of the co-integration test of China's total factor energy efficiency panel data model excoriates, the [19] proposed fully modified ordinary least squares (fmols) of model (4) of co-integration estimation, the estimated results are shown in Table 4 shows:

Table 4. The estimation results of panel co-integration FMOLS.

Co-integrating Vector	The Estimated Value	The Value of t
α	0.1765	0.3466
β_1	-1.2191	-1.6680
B_2	0.2503	1.2088
B_3	-3.5054	-5.9599
B_4	0.0029	0.0179
B_5	0.0919	0.3007

From table 4 the estimation results can be:

(1) From the point of view of the size of the effect on China's total factor energy efficiency, order from big to small, energy consumption structure and industrial structure, education level, management level and awareness of energy conservation and emission reduction and other comprehensive factors, the government's influence and technology progress, reflecting the progress of energy efficiency in our country several factors play a role. In China's energy consumption structure, coal has long occupied the dominant position, coal energy utilization efficiency become an important factor restricting the increase of total factor energy efficiency in China. Secondly, comprehensive management level and awareness of energy conservation and emission reduction and other factors in the improvement of total factor energy efficiency of China's influence coefficient for 0.1765 in improving energy Efficiency in the role should not be underestimated, with large mining space. Finally, the technical progress can not in improving energy efficiency play its due role and value, influence coefficient is minimal, reflecting the lack of China to invest in research and development, is the next important improvement areas.

(2) Mechanism from the point of view, the energy consumption structure and industrial structure as the negative effect, that is, the greater the proportion of coal accounted for, the proportion of the second industry is more energy

lower. The research conclusions are in line with the literature [3], Li Guozhang, Huo Zongjie (2009) [21] and other scholars of the same conclusion, which reflects the China coal is dominant energy consumption structure and current situation of the industrial structure is not conducive to the improvement of energy efficiency. And the level of education, comprehensive management level and awareness of energy conservation and emission reduction and other factors, the influence of government and the development of technology is improving energy efficiency to positive effect, in these areas to strengthen is conducive to China's energy efficiency will Improved.

(3) From the view point of improving energy efficiency, energy consumption structure and industrial structure influence coefficient maximum and negative effect. Therefore, improving energy utilization efficiency of key is to adjust the structure of energy consumption, change the situation of China's current dominance of coal, reduce the proportion of coal consumption in energy consumption, and industrial structure adjustment and optimization, rely on technological progress and institutional innovation to upgrade the industrial structure, reduce the energy consumption of high energy consuming industries.

iii Analysis of Total Factor Energy Efficiency Chinese Dynamic Evolution

In this paper, the total factor energy efficiency growth rate as explanatory variables, the industrial structure (is), the level of Education (HC), energy consumption structure (ES), technical progress (TP), the influence of government (GI) and integrated elements, etc. contribute to the growth of total factor energy efficiency rate as explanatory variables. The effects from 1991 to 2012 period total factor energy efficiency of China's dynamic evolution mechanism.

The estimation results using the FMOLS panel, according to equation (5) can get all elements of the China contribution rate of economic growth.

The regression model, the period of 1993 to 2014, China's total factor energy efficiency growth rate and the factors of total factor energy efficiency growth rate contribution rate are shown in Table 5, the dynamic change trend, as shown in figure 1:

Table 5. The total factor energy efficiency growth rate and contribution rate of each factor.

YEAR	TFEE	IS	HC	ES	TP	GL	ESSENTIAL FACTOR
1994	0.086	-0.561	0.135	0.214	-0.001	-0.113	1.326
1995	0.072	-1.023	0.092	0.646	-0.005	-0.07	1.36
1996	0.069	0	0.237	-0.205	-0.008	-0.114	1.09
1997	0.038	-0.418	0.122	0.493	0	-0.16	0.963
1998	0.068	-0.137	0.1	0.757	0.009	-0.009	0.28
1999	0.088	-0.001	0.881	-1.142	0.686	0.851	-0.275
2000	0.075	0.453	0.823	-0.673	0.603	0.115	-0.321
2001	0.043	0.278	0.151	0.343	0.014	0.318	-0.104
2002	0.048	-0.089	1.157	-1.333	0.983	0.972	-0.69
2003	0.048	0.481	0.792	0.956	-0.003	0.148	-1.374
2004	0.029	0.247	0.294	0.534	0.013	0.201	-0.289
2005	-0.045	0.708	0.951	-1.048	0.894	0.936	-1.441
2006	-0.052	0.131	-0.474	-0.29	-0.005	0.032	1.606
2007	0.006	-1.049	0.686	-1.003	0.036	0.458	1.872
2008	0.028	-0.527	-0.535	-0.522	0.505	0.561	1.518
2009	0.053	-0.293	0.301	-0.1	0.286	0.404	0.402
2010	0.055	-0.097	0.295	-0.213	0.483	0.508	0.024
2011	0.037	-0.192	0.444	-0.134	0.596	0.406	-0.12
2012	0.028	-0.121	0.235	-0.109	0.439	0.381	0.042
2013	0.031	-0.093	0.342	-0.217	0.379	0.393	0.103
2014	0.052	-0.032	0.217	-0.224	0.531	0.439	0.572

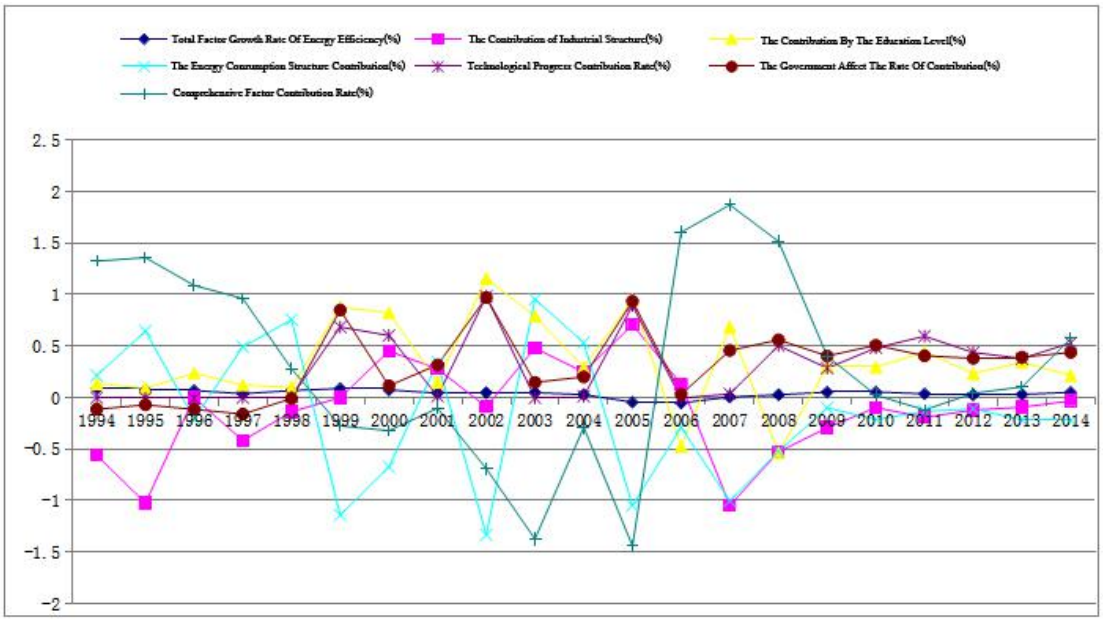

Figure 1. The dynamic changes of total factor energy efficiency of China's evolution.

From table four and figure 1:

1) from the total factor energy efficiency growth trend, 1993 - 2014 period generally maintained growth, with an average annual growth rate of 4.14%, while the overall energy efficiency is low, with an average of 0.781. value 2014 total factor energy efficiency (TE), pure technical efficiency values (PTE) and scale efficiency value (SE) were 1, reach the efficiency frontier. From the point of view of dynamic change, change is "U" tortuous changes state, 1993 - 2000 growth rate higher average annual growth rate was 7.1%, 1999 - 2006 in the doldrums, the average annual growth Growth rate of 1.3%, 2007 - 2012 and has returned, the average annual growth rate of 4.8%. Changes of dynamic mainly from changes in the technical efficiency of. Approximation and the changes in reference [4], Wang Qun Wei, Zhou Dequn (2008) [22] and other scholar's research conclusion. The reason can be attributed for the same period in China's industrial development policy, energy consumption structure and other factors.

2) from the factors of total factor energy efficiency improve the contribution rate of size, level of Education (HC) annual average contribution rate is 35.84%, the maximum contribution rate and indicated that increased investment in education, improve the level of education and is an important way to improve energy efficiency; integrated elements of the contribution rate of 32.37%, the contribution rate of the second, indicating that the management level, management system and energy-saving awareness of energy efficiency improve played a huge role. Government influence (GI) annual average contribution rate is 30.24%, indicating that the government in the formulation of energy-saving emission reduction policies, and actively advocate, has played a leading role; technical progress TP) annual average contribution rate was 28.26%, to improve energy efficiency in the future has great potential for mining; industrial structure (is) and energy consumption structure (ES) annual average contribution rate were -11.61%, -15.11%, up to the negative effect, indicating that the industry in our country at present, node structure and energy consumption structure greatly hinders the improvement of energy efficiency.

3) from the factors of total factor energy efficiency improve the contribution rate of change trend, industrial structure (is) the contribution rate from 1993 to 2004 was winding up form, from 2004 to 2006, straight down, and in the rising state, but the contribution rate is still negative, whole hindered the improvement of energy efficiency; education level (HC) contribution rate with the exception of the 2006-2008 were higher than 0, contributed greatly to the overall instability, finally is on the rise; energy consumption structure (ES) for most of the years of contribution rate is less than 0, change.

More severe, 2009 - 2011 gradually stabilized, there is an upward trend; similar changes trend of technical progress (TP) and the influence of government, after 1998, the contribution rate of change in the above 0, there is an upward trend; comprehensive factor contribution rate showed a "W" shape change, 1999 - 2006 in low valley. Finally, a slight downward trend.

On the whole, the influence factors of total factor energy efficiency of China's contribution rate basically in the rising form, will promote China's energy efficiency improvement.

CONCLUSIONS

Using 1993 - 2014 years of panel data, the DEA model to measure the total factor energy efficiency in our country, construct the panel data model of the evolution of total factor energy efficiency, panel co-integration test and estimation of the relationship between energy efficiency and its influencing factors, analyzes the internal mechanism of the evolution of total factor energy efficiency. The main conclusions are as follows:

First, Law of the evolution of China's total factor energy efficiency: improving energy efficiency changes in a U-shape, in an upward trend in average annual growth rate 4.14%. At the same time, the overall value of energy efficiency is low, with an average of 0.781, did not reach the efficiency frontier, energy efficiency needs to be improved.

Second, Total factor energy efficiency (TFee) and industrial structure, level of education, the factors influencing the energy consumption structure, technological progress, government influence of panel co-integration relationship. Through the panel co-integration the fools method measuring the mechanisms of these factors on energy efficiency improvement, industrial structure, energy consumption structure is negative to the role. Other factors have positive effect, the effect degree of the level of education, reveals the direction and the way of improving energy efficiency.

Third, Total factor energy efficiency evolution of panel data model to estimate the results show industrial structure, level of education, energy consumption structure, technological progress, government influence and integrated elements of energy efficiency improve the average annual contribution rate were -11.61%, 35.84%, -15.11%, 28.26%, 30.24%, 32.37%, from the point of view of the trend, these factors on the energy efficiency to improve the contribution rate of overall was rising trend, this will promote China's energy efficiency will continue to progress, pointed out the trend of the evolution of China's energy efficiency.

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REFERENCES

[1] Hu J L, Wang S C. Total-factor energy efficiency of regions in China. Energy Policy, 2006, 34(17): 3206-3217.

[2] Yang Hongliang, Stan. Comparison of. economic theory and economic management, energy efficiency and energy efficiency methods China 2008 regions, (3):12-20.

[3] Wei Chu, Shen Manhong. The energy efficiency and its influence factor: DEA empirical analysis based on the. management world, 2007, (8): 66-76.

[4] Yuan Xiaoling, Zhang Baoshan, Yang Wanping. Based on environmental pollution Chinese. total factor energy efficiency research Chinese industrial economy, 2009251 (2): 76-86.

[5] Qu Xiaoe. China provincial total factor energy efficiency change decomposition Malmquist index An Empirical Study of the number of. technology economy, based on the 2009 (8): 29-43.

[6] Wang Keliang, Yang Baochen, Yang Li. Considering the environmental effect of China provincial total factor energy efficiency of. management science, 2010, 23 (6):100-111.

[7] Xiao Tao, Zhang Zongyi and VECM. The cointegration relationship between energy consumption and economic growth--Based on the experience of Chinese research from 1990 to 2008:. soft science, 2011, 25 (2): 7-10.

[8] Hung M F, et al. Economic growth and the environmental kuznets curve in Taiwan: A simultaneity model analysis. Human Capital, Trade and Public Policy in Rapidly Growing Economies: From Theory to Empirics. UK, Edward Elgar, 2004: 269-290.

[9] Guo Junhua, Li Bangyi. China economic growth and environmental pollution in the cointegration relationship on 1991 2007. provincial panel data based on mathematical statistics and management, 2010, 29 (2): 281-293.

[10] Zhou Jian. China's regional economic growth and improving the efficiency of energy utilization of the dynamic evolution mechanism of Provincial Panel Data Cointegration Model an empirical study of. based on quantitative and technical economics, 2008, (9):3-16.

[11] Stan, Wu Lixue, Fu Xiaoxia et al. Regional differences in energy efficiency China and genesis of the variance of the stochastic frontier production function decomposition based on. management world, 2008, (2): 35-43.

[12] Banker R D, Charnes A, Cooper, W W. Some models for estimating technical and scale inefficiencies in data envelopment analysis. Management Scinece , 1984, 30(9): 1078-1092.

[13] Baltagi, B. H. Econometric analysis of panel data. 3rd edition, John Wiley, Chichester, 2005.

[14] Goldsmith, Raymond W., A Perpetual Inventory of National Wealth. Studies in Income and Wealth, ed., M.R. Gainsburgh, Princeton, 1951: 14:5-61.

[15] Zhang Jun, Wu Guirong, Zhang Jipeng. Estimation of Chinese provincial capital stock: 1952-2000. economic research, 2004, (10):35 44.

[16] Lin Boqiang. Electricity consumption and economic growth: Chinese production function research based on. management world, 2003, (11): 18 - 27

[17] Xu Guoquan, Liu Zeyuan. 1998 - 2005 Chinese total factor energy efficiency of regions of. China science and technology forum, 2007, (7):68-72.

[18] Hall, R. E. and Jones, C. I., Why do some countries produce so much more output per worker than others?. Quarterly Journal of Economics, 1999, 144: 83-116.

[19] Pedroni, P. Critical values for cointegration tests in heterogeneous panels with multiple regressions. Oxford bulletin of economics and statistics, 1999, 61: 653-670.

[20] Kao, C. Spurious regression and residual-based tests for cointegration in paned data. Journal of econometrics, 1999, 90: 1-44.

[21] Li Guozhang, Huo Zongjie. Chinese total factor energy efficiency, convergence and its influencing factors analysis based on the 1995 - 2006 panel data empirical. economic review, 2009, 6: 101-109.