ISSN : 0974 - 7435 Volume 10 Issue 12

2014

BioTechnology

An Indian Journal

FULL PAPER

BTAIJ, 10(12), 2014 [6032-6039]

Research on the evolution trends and influencing factors of the regional difference in China's energy consumption

Yan-dong Zhang*, Tao Zhao

College of Management and Economics,Tianjin University,Tianjin, (CHINA)

E-mail: yandongdeyouxiang@163.com

ABSTRACT

With the help of Theil index and panel data from 1986 to 2011, the evolution trends are comparatively researched, including three kinds of Theil index. The influencing factors of energy intensity are also studied by econometric model. The results show that Theil index from energy consumption and population continues to decline, becoming the smallest in the three, meaning that the match degree between energy consumption and population is increasing and the energy-saving targets of energy intensity is more challenging than the ones of energy consumption per capita. The difference from within region is the main resource to the overall regional difference. Western region is the main reason to the difference from within region exceeding the other regions. Urbanization is the key factor to the energy intensity difference. Further research needs to be done for western region because there is more unique characteristic.

KEYWORDS

Energy consumption; Regional difference; Theil index; Urbanization; Industrialization.

INTRODUCTION

With large energy consumption in Chinese economic development, the regional difference in energy consumption had attracted more attention of many scholars because of different regional economy existing. Owing to different economic development, industrialization and energy efficiency, the difference in energy consumption also exists in different regions[1]. Shaozhou Qi and Rowe[2] studied the difference of economic growth and energy consumption intensity in China, with the results that regional economic growth convergence speed was faster than energy intensity, showing great difference in the dependence on energy for all regions. Junwen Cao[3] studied the difference from 2000 to 2010 in China, with the index of the sum of squared deviation, finding that the difference showed growing trend, and that eastern region was the key force for the difference.

Urbanization and industrialization are two important features in China's economic development. The relationship between the two and energy has attracted the attention of scholars. Perry Sadorsky[4] believed that industrialization and urbanization had important influence on energy intensity in developing countries. By the panel regression analysis, results were that in the long run, coefficient of income elasticity was between -0.45 and -0.35, and that the elasticity coefficient of industrialization was between 0.07 and 0.12, and that urbanization had significant and complex impact on energy intensity. In order to analyze regional difference of energy consumption in China, Bo Li and Qingbin Li[5] established the semi log regression equation, with the per capita energy consumption as explained variable, and urbanization, industrialization, nationalization, openness, technological innovation capability and consumption of urban residents as explaining variables. Results were that urbanization and industrialization had significant impact on per capita energy consumption. All the researches show that there is significant relationship between energy consumption and the two features.

Due to the implementation of policy, China is seen to be divided into three regions, that is, eastern, central and western region. To better understand the regional policies, further researches are necessary about the evolution trends of regional difference in energy consumption and the impact of urbanization and industrialization on it.

LITERATURE REVIEW

Theil index was first proposed by Theil H[6], used to determine the difference degree of income among countries or regions. Because it could be decomposed and different index could be compared, it was introduced to the study of energy consumption and carbon emissions in recent years. With the method, Yuanxi Huang and Daniel[7] found that the efficiency of energy utilization was the fundamental cause of the difference. Duro and Padilla[8] did comparative analysis on energy intensity difference in some countries. Empirical research about China was did by Xiaojuan Kang and Dongmin Yang[9], showing that the difference mainly came from the within region, and that the contribution of eastern region was the biggest in the three regions. From three aspects including the level of energy consumption, energy consumption structure and efficiency of energy consumption, Jing Liang and Lixiao Zhang[10] studied the difference in Chinese capital cities. The regional difference in Chinese carbon emission were researched by Afton[11], Qian Yang and Huajun Liu[12]. The carbon productivity difference was studied by Jiahua Pan and Lifeng Zhang[13]. These researches were focused on the relationship between energy consumption and economic development, reflecting the energy intensity difference, so it can be further studied on the factors causing the energy intensity differences among the three regions.

In the aspect of researches on the factors of urbanization and industrialization, Han Sun and Jinhua[14] found that urbanization and industrialization owned strong impact sensitivity on energy demand. Heng Ma[15] studied the influence on Chinese energy consumption from urbanization,

industrialization, energy price and some other factors, finding that economic growth, industrialization and urbanization had positive effect. Also Zimin Wang and Conglai Fan[16] found that urbanization would cause rapid growth of energy consumption. All these researches discussed the effects of urbanization and industrialization on energy consumption, but how urbanization and industrialization will influence the difference is rarely involved.

From the above results, the relationship between energy consumption and economy growth is the focus, with little attention on the industrial added value and population, so the paper will compare the three differences, and discuss the impact of urbanization and industrialization on energy consumption difference through measurement model.

MODEL AND DATA PROCESSING

Theil index

According to the description and processing to Theil index of Theil H[6] and Qian Yang and Huajun Liu[12], Theil index is a dimensionless value. The larger value means the larger difference. The calculation formula of Theil index about energy consumption difference is as follow:

$$T = \sum_{i=1}^{N} (\frac{E_i}{E}) \ln(\frac{E_i / E}{X_i / X}) \quad \textbf{(1)}$$

Where T is Theil index. i is ith province. N is the total number of provinces. E is energy consumption. X are the variables to be discussed, including GDP, industrial added value(GI) and population(P). Three kinds of Theil index are T(GDP), T(GI) and T(P). When the X is the same, the smaller T means the smaller difference. When the X is different, the smaller T in the three kinds means the more match degree between energy consumption and X.

Theil index can be divided into the sum of T_w and T_b.

$$T = T_w + T_b \quad \textbf{(2)}$$

$$T_w = \sum_{j=1}^{M} (\frac{E_j}{E}) T_{wj} = \sum_{j=1}^{M} (\frac{E_j}{E}) \sum_{i=1}^{N_j} (\frac{E_{ij}}{E_j}) \ln(\frac{E_{ij} / E_j}{X_{ij} / X_j}) \quad \textbf{(3)}$$

$$T_b = \sum_{j=1}^{M} (\frac{E_j}{E}) \ln(\frac{E_j / E}{X_j / X}) \quad \textbf{(4)}$$

Where j is the jth region. N_j and M are the total provinces in jth region and the sum of regions. T_w and T_b are Theil index from within region and between region respectively. T_{wj} is Theil index in jth. E_{ij} is energy consumption in ith province in jth region. E, E_i and E_j are the total energy consumption, the energy consumption in ith province and in jth region respectively. X_{ij} is GDP, GI or P in ith province in jth region. X, X_i and X_j are the total, the amount in ith province and jth region respectively.

Theil index also can be used to analyze the contributions from within and between regions. They are contribution degrees of difference from within and between regions to the total difference. The contribution from between region is $W_b=T_b/T$. The one from within region is $W_w=T_w/T$. The contribution from every part within region is $W_j=(E_j/E)*T_{wj}/T$.

Data sources and processing

According to the classification standard from the National Bureau of Statistics, the eastern region owns 11 provinces, including Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan. The central region owns 8 provinces, including Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei and Hunan. The western region owns 12 provinces, including Sichuan, Chongqing, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang, Guangxi and Inner Mongolia. Due to the lack of energy consumption data in Tibet statistical yearbook, 11 provinces are considered as the western region.

The data used in the paper are from the "China statistical yearbook 2012","Chinese energy statistics yearbook 2012", "Beijing statistical yearbook 2012" and the yearbook in the other provinces. In order to ensure price comparability, according to the constant price GDP index in the statistical yearbook, GDP and industrial added value are converted into constant prices, with the 1986 as the base. Assuming in 1986, GDP of a province is GDP_{1986}, and constant price index is PI_{1986}, the price index for the convert year is PI_0, then GDP_0 will be $GDP_0= (GDP_{1986}*PI_0) /PI_{1986}$. In the same way, the data of constant industrial added value can be calculated.

THE EMPIRICAL ANALYSIS

The evolution trends of difference in chinese energy consumption

The evolution trends of T(GDP), T(GI) and T(P) from 1986 to 2011 as shown in Figure 1.

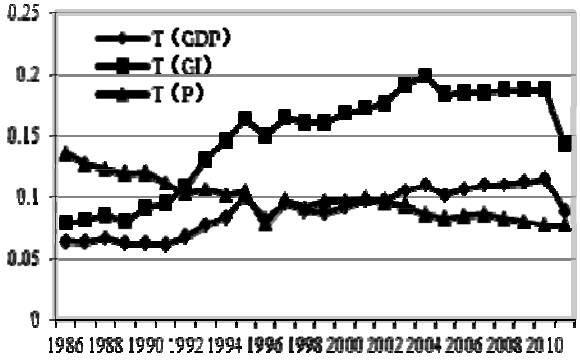

Figure 1 : The evolution trends of three kinds of theil index

(1)The Figure 1 shows that T(GDP) rises slightly from 1986 to 2011, but the overall trend evolves smoothly. T(GI) gradually levels off after a period of rapid rise. And T(P) presents a steady decline. After 2002, the trends are obvious different, reflecting that there is a difference among the match degree corresponding relationships. The three types of Tail index in 1996 have obvious decline because of the implementation of the "China energy-saving technology policy outline". It reduces the energy consumption difference and the influence of the policy can be also seen in other parts of the regional analysis. But the policy doesn't have sustained effect, and the indexes rebounds in 1997. The same situation appears again in 2011 because of the issue of the "twelfth five-year energy conservation and emissions reduction comprehensive work plan". Thus it can be seen that the degree of regional difference of energy consumption is affected by the policy. Industry adjustment, especially for energy-intensive industry policy arrangement, has important influence on the national energy consumption.

(2)Compared with the evolution trends of them, T(GI)>T(GDP)>T(P). T(GI) is the largest, which represents the lowest match degree between energy consumption and industrial production development. Industry has always been the main source of energy consumption. Regions or provinces with small total added value but large energy consumption proportion should be the focus of the adjustment. T(GDP) <T(GI), that is to say, the match degree of energy consumption and GDP is higher

than that with the industry added value. T(P) is the minimum and it reflects the highest match degree between energy consumption and population. It is more reasonable to set per capita energy consumption as energy saving goal.

(3)The current energy saving goal in China is to achieve energy intensity declining gradually. The planning and implementation of this goal has more challenge than that of per capita.

Decomposition analysis of theil index

(1) The decomposition results of T(GDP) are shown in TABLE 1.

TABLE 1 : The regional contributions of T (GDP) %

Year	Within region				Between region (W_b)	Year	Within region				Between region (W_b)
	eastern (W_1)	central (W_2)	western (W_3)	sum (W_w)			eastern (W_1)	central (W_2)	western (W_3)	sum (W_w)	
1986	50.0	26.5	9.4	85.9	14.1	1999	28.7	19.6	18.4	66.7	33.3
1987	49.2	25.4	7.9	82.5	17.5	2000	32.6	16.3	20.7	69.6	30.4
1988	45.5	28.7	7.6	81.8	18.2	2001	32.0	18.5	19.6	70.1	29.9
1989	43.5	30.7	8.1	82.3	17.7	2002	29.9	21.7	17.5	69.1	30.9
1990	43.5	30.7	8.1	82.3	17.7	2003	27.6	18.1	20.0	65.7	34.3
1991	39.3	27.9	8.2	75.4	24.6	2004	25.7	14.7	22.9	63.3	36.7
1992	35.8	25.4	7.5	68.7	31.3	2005	24.8	15.8	22.8	63.4	36.6
1993	39.0	24.6	7.8	71.4	28.6	2006	23.6	15.1	24.5	63.2	36.8
1994	35.7	23.9	7.1	66.7	33.3	2007	22.0	15.6	25.7	63.3	36.7
1995	30.0	30.0	8.0	68.0	32.0	2008	20.9	13.6	28.2	62.7	37.3
1996	33.3	23.5	-3.7	53.1	46.9	2009	20.5	13.4	30.4	64.3	35.7
1997	27.7	23.4	13.8	64.9	35.1	2010	19.3	12.2	32.5	64.0	36.0
1998	28.1	20.2	16.9	65.2	34.8	2011	25.8	16.9	28.1	70.8	29.2

As shown in TABLE 1, the difference of Chinese energy consumption is mainly from within region. The contribution has a maximum of 85.9% in 1986, and then begins to decline. It reaches a minimum of 53.1% in 1996, and begins to rise from 1997 again, gradually stabilizing around 63%, with upward trend in 2011. In the 26 years, the contribution between region gradually increased, but it is much less than the contribution from within region.

Among the Theil index from within region, the contribution of eastern region is relatively high. It shows a decreasing trend stably, which decreases from 50% to 25.8%. The contribution of central region is less than eastern region, which also shows gentler decline from 26.5% to 16.9%. The evolution trend of the contribution in western region can be divided into two stages. It is little change during 1986 to 1996. Then it presents a rapid upward trend starting from 1997, and exceeding eastern region to be the biggest contributor in 2006. It shows that with the development in western region, the gap of energy consumption and GDP is widening.

(2)The regional contributions of T(GI) and T(P) can be analyzed similarly. Although some differences existing in the value, all show the similar evolution trend. The contribution from within region is bigger than the one from between region. The contribution of western region exceeds the eastern and central regions to become the largest in 1999 and 2004 respectively. So conclusion can be got that difference in Chinese energy consumption is mainly from with region, and western region has replaced the eastern and became the largest contributor of regional difference.

INFLUENCE FACTORS OF ENERGY INTENSITY

Because of the energy intensity targets for energy conservation in China, factors of regional difference should be further analyzed. Regression analysis is measured for three regions using panel data model.

Measurement model of energy intensity factors

Industrialization and urbanization have significant impact on energy intensity. At the same time, they cause the increase of industrial added value, affluence and city population. Therefore this paper constructes the following measurement model:

$$EI_{i,t} = \beta_0 + \beta_1 A_{i,t} + \beta_2 GI_{i,t} + \beta_3 IND_{i,t} + \beta_4 PC_{i,t} + \beta_5 PCI_{i,t} + e_{i,t} \quad \textbf{(5)}$$

Where i and t are ith province and year respectively. β_0 is the intercept. From β_1 to β_5 are the parameters of five explanatory variables that will be estimated. e is a random error term. EI is energy intensity, which is the ratio of energy consumption and GDP, with the unit tce per million. A is affluence, which is the ratio of GDP and population, with unit 10 thousand RMB per person. GI is industrial added value, with unit 100 million. IND is industrialization which is the ratio of industrial added value and GDP. PC is the urban population, with unit 10 thousand. PCI is urbanization, which is the ratio of urban population and total population.

Estimation of model parameters

In order to avoid spurious regression, with the help of Eviews 7.0, this paper tests unit root of panel data by LL test. The results show that the variables are the two order integration. Then Kao test is applied to verify the long-term cointegration relationship among variables. The results show that at the 5% significance level, cointegration relationship exists among variables. Test results are shown in TABLE 2.

By Hausman test, fixed effects models are used in eastern and central regions, while a random effect model is suit for western region It means that there are random influences of other factors besides the five factors described in this paper.

TABLE 2 : The estimation results of parameters in the three models

Explanatory variables	Energy intensity		
	Eastern	Central	Western
A	-0.000390*** [-14.04555]	-0.001186*** [-8.368869]	-0.001323*** [-6.228853]
GI	0.000944*** [9.513786]	0.002378*** [5.360327]	0.000359 [0.402798]
IND	-0.050970*** [-4.288278]	-0.015919 [-0.554977]	-0.138744*** [-2.871997]
PC	-0.002902*** [-8.365588]	-9.110005 [-0.081720]	-0.002967*** [-2.594707]
PCI	0.123384*** [6.168152]	-0.251038*** [-2.719141]	0.064526 [1.343784]
β_0	6.843041*** [12.08391]	17.22199*** [9.658770]	17.30710*** [9.816674]
Sample	286	208	286

Kao	-2.165168**	-1.639840**	-4.012298***
Hausman	34.146731***	18.143427***	8.587068

Note: *, and *** are 10%, 5% and 1% significance level.**
[ ] is T-statistics.

From TABLE 2, at 1% significance level, the parameter estimates in eastern have passed the test of significance, while 4 parameter estimates in central and western regions have passed significant test. It indicates that model fitting degrees in three regions are relatively good.

Analyzing the affecting relations, parameters of industrial added value in the models are positive, indicating that industrial added value has positive impact on energy intensity. With the increase of industrial added value, it will lead to higher energy intensity. The parameters of affluence, industrialization and urban population in the three models are negative which means these three variables have negative effect on energy intensity. As Chinese affluence rise, the dependence of the economic development on energy will decrease. Meanwhile, industrialization also shows energy saving feature and the increase of the city population will promote the development of non-energy dependent industries. The three estimations of affluence have passed significance test, showing that affluence and energy intensity have clear and necessary link. The influences of urbanization on the three models are different. In eastern and western regions, the improvement of urbanization leads to the rise in energy intensity, while negative impact in central region.

From numerical characteristics, the influence of urbanization on energy intensity is the largest followed by industrialization. Not only the symbols of urbanization are different, but also the difference degree of them is the biggest in three models. It can be seen that urbanization is the most critical factor to regional differences of energy intensity, followed by industrialization and urban population, while the difference of affluence and industrial added value are small.

CONCLUSIONS AND IMPLICATIONS

The economic development of China shows the obvious characteristics of regional difference, therefor the research on regional difference of energy consumption has the theoretical and practical significance. With Theil index and the data from 1986 to 2011, empirical comparative analysis on the evolution trends of energy consumption is done. The results as following:

First, during the period from 1986 to 2011, T(GDP) increases slightly, and the evolution trend remains relatively stable. T(GI) increase greatly, while T(P) decreases gradually and becomes the smallest one in the three. It illustrates that the match degree of energy consumption and population is more and more obvious. The implement of energy intensity target is much more challenging than the per capita energy consumption.

Second, from the perspective of contribution, the contribution from within region is greater than the one from between region. The contribution from within region is the major cause to regional difference of energy consumption. The contribution to Theil index in western region is more than the other regions and becomes the key source of Theil index.

Third, through the analysis of effect factors on energy intensity, it can be found that the urbanization is the main cause of regional difference of energy intensity, followed by the industrialization. The affluence has inevitable and explicitly linked with energy intensity.

Fourth, the energy intensity in western region shows different development trend from the other. Because of policy support and the rigid requirements of economic development, it makes the gap between proportion of the energy consumption and the one of economy enlarge. And it becomes the main source of regional difference of energy consumption.

The difference of regional energy consumption should be considered in energy saving policy making. The improvement of energy utilization efficiency in western region plays an important role in reducing the energy consumption difference. It means that western region should pay more attention to achieving the goal of sustained drop in energy intensity. More measures should be taken to promote the development of non-energy dependent industries. It also means the rule of western region development energy intensity needs further follow-up study. In addition, affluence should be continued to improve. The negative effect of the affluence to energy intensity should be used to achieve energy saving target. Industrialization shows characters of energy conservation. So further enhancing the proportion of non-energy dependence industry and industrial technology will reduce energy intensity. The influences of urbanization in various regions are different. Therefore, greater efforts should be made to guide consumption in the process of development in eastern and western regions.

ACKNOWLEDGEMENTS

The paper is funded by Tianjin University Independent Innovation Foundation (60304002), the views expressed are the authors' alone.

REFERENCES

[1] Jun Chen, Jinhua Cheng, Qiaosheng Wu; "The energy consumption and the level of industrialization among regional differences in China", China population, Resources and Environment, **17(5)**, 59-64, **(2007)**.

[2] Shaozhou Qi, Wei Luo; "Regional economic growth and differences of energy intensity in China", Economic Research Journal, **7**, 74-81 **(2007)**.

[3] Junwen Cao; "Spatial differences of energy consumption and its causes in China", Statistical Research, **29**,10, **(2012)**.

[4] Perry Sadorsky; "Do urbanization and industrialization affect energy intensity in developing countries", Energy Economics, **37**, 52-59 **(2013)**.

[5] Bo Li, Qingbin Li; "Development and explanation of regional inequality in per capita energy consumption in China, An analysis based on shapley value decomposition", Resources Science, **35(6)**, 1194-1201 **(2013)**.

[6] H.Theil; "Economics and information theory", Amsterdam, North Holland, **(1967)**.

[7] Yuanxi Huang, Daniel Todd; "The energy implications of chinese regional disparities", Energy Policy, **38(11)**, 7531-7538 **(2010)**.

[8] Juan Antonio Duro, Emilio Padilla; "Inequality across countries in energy intensities, An analysis of the role of energy transformation and final energy consumption", Energy Economics, **33(3)**, 474-479 **(2011)**.

[9] Xiaojuan Kang, Dongmin Yand; "An analysis on the difference of regional energy consumption in China based on the method of the theil index", Resources Science, **32(3)**, 485-490 **(2010)**.

[10] Jing Liang, Lixiao Zhang, "The measure and analysis on the spatial inequality of urban energy consumption in China based on theil index", China population, Resources and Environment, **20(3)**, 85- 88 **(2010)**.

[11] Afton Clarke-Sather, Jiansheng Qu, Qin Wang, Jingjing Zeng, Yan Li; "Carbon inequality at the sub-national scale, A case study of provincial-level inequality in CO2 emissions in China 1997–2007", Energy Policy, **39(9)**, 5420-5428, **(2011)**.

[12] Qian Yang, Huajun Liu; "Regional difference decomposition and influence factors of China's carbon dioxide emissions", The Journal of Quantitative & Technical Economics, **5**, 36-49, **(2012)**.

[13] Pan Jiahua, Lifeng Zhang; "Research on the regional variation of carbon productivity in China", China Industrial Economics, **5**, 47-57, **(2011)**.

[14] Han Sun, Jinhua Cheng; "China energy demand forecast and analysis in the process of industrialization and urbanization ", China population•Resources and environment, **21(7)**, 7-12, **(2011)**.

[15] Heng Ma; " Influence of urbanization and industrialization on China's energy consumption", Chinese soft science, **1**, 176-182, **(2012)**.

[16] Zimin Wang, Conglai Fan; "The empirical research on the relationship between energy consumption and urbanization"Urban Problem, **8**, 8-14, **(2012)**.