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Evaluation and Recommendations on Energy Consumption Efficiency in Beijing-Tianjin-Hebei

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Abstract. Energy is the driving force of economic and social development, energy consumption in Beijing-Tianjin-Hebei is large and short of supply. Currently, there is less researches on energy consumption efficiency, energy consumption efficiency even does not have a standard definition. This paper definite energy consumption efficiency from three aspects that are social and economic benefits, energy planning and environmental benefits. Principal component analysis is used to evaluate energy consumption efficiency in this paper. Principal component analysis is an important method in the multivariate statistical analysis. Through the analysis we can see that Tianjin energy consumption is maximum efficiency in Beijing-Tianjin-Hebei region. In order to meet the requirements of Beijing-Tianjin-Hebei integration, Hebei should optimize their energy consumption, improve the quality of energy and rise the rate of clean energy consumption.

Introduction

Energy is an important material basis for national economic development and the basic conditions of human life, the relationship between energy consumption and economic growth has been a hot issue of economic study. Di (2013) used principal component analysis on the basis of per capita energy consumption survey, analyzed per capita energy consumption level of residents of different regions of China from 2001 to 2009, to find out the ability of China's per capita energy consumption and predict the level of China's per capita consumption of energy, presented a variety of views and opinions in environmental protection. Luo Guoliang, Zhang Yuanmin (2008) focused on China's rural energy consumption status and the changes in the structure of rural energy, found out the problems between rural energy consumption and put forward relevant proposals. Lin Jingwei (2013) based on the existing theories and used theoretical and empirical analysis to explore the relationship between energy consumption and economic growth in our country, the purpose was to find out reasonable policies and recommendations on achievement for China's energy conservation and energy fully used. Li Lei (2014) used factor analysis to evaluate the energy carrying capacity of Beijing-Tianjin-Hebeiregion, in order to rise up the carrying capacity these areas should transform economic development mode, adjust the industrial structure; increase energy industry investment; optimization of energy supply consumption structure; upgrade industrial technological innovation ability. World Energy Council Energy defined the energy efficiency

as the reduction of energy services provide the same energy input, this is the traditional definition of energy efficiency. Bosseboeu expanded the traditional definition in two ways, economic energy efficiency means with the same or less energy to get more output or better quality of life, technological energy efficiency means with the development of technology, changes in lifestyle and the management improving dues to the reduction of energy consumption.

Method

Design

This paper reference to the UK energy sector index system[11], EU Energy Efficiency Indicator System[12] and domestic Indicator System (References 1 to 5) to build index system. The system includes three guidelines: social and economic benefits, energy efficiency plan and environmental benefits. Social and economic benefits involve GDP growth rate and total import and export to represent its index. Energy efficiency plan has energy consumption per capita and proportion of renewable energy consumption on behalf of its system. Environmental benefits include carbon dioxide emissions to depute its index. Specific indicators of each index are described in Table 1.

Table 1. Energy consumption evaluation system.

Index Description	Index Description	Index Description	Calculations Description	Indicators Direction
Energy Consumption	Social and Economic Benefits	GDP growth rate(%)	Data Sources China Bureau 2014	+
		Total import and export (trillion yuan)	Data Sources China Bureau 2014	+
	Energy efficiency plan	Energy consumption per capita (million tec/person)	Data Sources<China Statistical Yearbook 2014>	-
		proportion of renewable energy consumption(%)	Data Sources<China Statistical Yearbook 2014>	+
	Environmental Benefits	carbon dioxide emissions (hundred million tons)	∑i kinds of Energy Consumption×Carbon emission modulus	-
*(+)Showing positive indicators,(-)Showing reverse indicators				

Table 2. Detailed data for each indicator.

Area	GDP growth rate(%)	Total import and export(trillion yuan)	Energy consumption per capita(million tec/person)	Proportion of renewable energy consumption (%)	Carbon dioxide emissions (hundred million tons)
Beijing	7.2	5.1	18.44	8.5	2.4
Tianjin	10.2	7.8	36.81	11.3	3.7
Hebei	5.7	7.2	17.85	7.6	13.2

In each index on the table, per capita energy consumption and carbon dioxide emissions are reverse indexes. In order to ensure the direction of indicators, we use the reciprocal date to calculate.

Procedure

Principal component analysis is an important method in the multivariate statistical analysis. In the study of multi indicator (variable), due to the large number of variables, and between each other a certain relevance existed, thus the observed data can not clearly reflect the information. Principal component analysis making the problem solved. In general, if the number of samples is n, and the indexes is p, they are X_1, X_2, ...X_p. After principal component analysis, they will be integrated into comprehensive variables, namely p:

$$\begin{cases} y_1=c_{11}x_1+c_{12}x_2+...+c_{1p}x_p \\ y_2=c_{21}x_1+c_{22}x_2+...+c_{2p}x_p \\ ... \\ y_p=c_{p1}x_1+c_{p2}x_2+...+c_{pp}x_p \end{cases} \quad (1)$$

And satisfying:

$$c^2_{k1}+c^2_{k2}+...c^2_{kp}=1,(k=1,2...p) \quad (2)$$

Wherein (Cij) is determined by the following principles:
(1)y_i and y_j ($i \neq j$; i, j = 1,2 ... p) are independent;
(2)y_1 is the biggest variance in the linear combinations of X1,X2...XP,y2 is the second biggest variance and not related to y_1.yp is not related to y1,y2...yp-1, and its variance is smallest in the linear combinations of X1.X2...XP.
y1,y2...yp is called first, second ..... Pth principal components, and their variance is decreasing.
Then calculate the correlation coefficient matrix:

$$R=\begin{bmatrix} r_{11}, & r_{12}... & r_{1p} \\ r_{21}, & r_{22}... & r_{2p} \\ r_{p1}, & r_{p2}... & r_{pp} \end{bmatrix} \quad (5)$$

Corresponding to the correlation matrix R, seeking characteristic equation with Jacobi method $|R-\lambda I|=0, \lambda_1>\lambda_2>\lambda_3>\cdots\lambda_p\geq 0$, corresponding to the eigenvalue, eigenvectors are $C^{(i)}=(C_1^{(i)}、\ C_2^{(i)}、\cdots C_p^{(i)});(i=1,2\cdots p)$.
Thus the new factors are:

$$\begin{cases} y_1 = C_1^{(1)}X_1 + C_2^{(1)}X_2 + \cdots + C_p^{(1)}X_p \\ y_2 = C_1^{(2)}X_1 + C_2^{(2)}X_2 + \cdots + C_P^{(2)}X_P \\ y_p = C_1^{(P)}X_1 + C_2^{(P)}X_2 + \cdots + C_P^{(P)}X_P \end{cases} \tag{6}$$

If the percentage of previous m principal components of variance calculate close to 1 (if selected), then take the first m factors.

Cumulative contribution rate:

$$a=\frac{\sum_{i=1}^{m}\lambda_i}{\sum_{i=1}^{p}\lambda_i} \tag{7}$$

Result

In this paper, SPSS software is used to calculate data. The results are as follows:

Table 3. The total variance explained.

ingredient	Initial eigenvalues			sum of square		
	total	The percentage variance	accumulation %	total	The percentage variance	accumulation %
1	3.314	66.274	66.274	3.314	66.274	66.274
2	1.686	33.726	100.000	1.686	33.726	100.000
3	7.288E-16	1.458E-14	100.000			
4	1.723E-16	3.447E-15	100.000			
5	-6.848E-17	-1.370E-15	100.000			

According to the data to calculate the total score for each area. Specific steps are as follows: through software we can get two principal components Y1 and Y2, according to the two main components of the corresponding eigenvalues we can get the cumulative percentage of the data, mathematical expression is as follows:

$$Z=\lambda_1 Y_1+\lambda_2 Y_2 \tag{8}$$

The results are showed in Table 4.

Table 4 Results.

Areas	Factor1	Factor2	Main ingredient1	Main ingredient2	Overall ratings
Beijing	-0.46083	1.05876	-0.84	1.37	-0.9
Tianjin	1.14733	-0.13029	2.09	-0.17	1.33
Hebei	-0.68650	-0.92847	-1.25	-1.21	-1.23

Conclusion

The results from the principal components analysis show that the concentration of original variables is high variance in the new variable. According to principal component requirements, this article take the first two principal components reflect the original five variables, the cumulative variance contribution rate of the first two variables has been greater than 90%, it is believed that the two main ingredients can reflect the region's energy consumption efficiency.

In the first principal component GDP growth rate, proportion of renewable energy consumption and Total import and export share big weights and this three indicators change in the same direction, reflect positive correlation, illustrate that there has similar reasons for the changes in these indicators, so we can put these indicators in one aspect, called: Economic Benefits. Similarly, we can name the second main component: Environmental Benefits. In summary, it usually uses economic benefits and environmental benefits to evaluate energy consumption efficiency. The table above shows that Tian Jin ranks first in Beijing-Tianjin-Hebei region.

Recommendations

1. Integrate investment resources to achieve economies of scale in energy using. To meet the requirements of Beijing-Tianjin-Hebei integration, Beijing-Tianjin-Hebei region should optimize the industrial structure, develop low-energy industry and make full use of energy. Beijing-Tianjin-Hebei region can establish an Energy Planning Department, unify planning and investment of energy to achieve energy economies of scale.
2. Hebei should optimize its energy consumption structure. Hebei consumed too many resources (especially energy) in the process of economic development, so it is not wise to increase energy investment. With the growing global concern on the environmental protection, the proportion of coal consumption has been decreased in the developed countries and areas. In view of this situation, Hebei should accelerate the development of high-energy, renewable energy, the government can put the appropriate policies to encourage government and enterprises, enterprises and universities to work together through technological innovation to increase renewable energy, clean energy in the energy consumption.

References

[1] Wang Yuan, Chen Hanping, Yang Hai-ping, Wang Xianhua, Zhang Shihong, Jin Hang. Comprehensive Evaluation of the use of biomass technology, J. Energy Engineering, 2009: 25-29.

[2] Wu Di, Wu Chun Evaluation Model of Energy Efficiency Based on DEA, J. Management Science, Jan. 2009: 103-112.

[3] Di. Analysis of per capita energy consumption based on principal component analysis, J. Energy and Energy conservation, 2013,02: 7-9.

[4] Xu Shan, Fan Decheng, Wang Shaohua. Evaluation of low-carbon energy structure in our country based on optimal evaluation method, J. Science and Technology Management, 2016,05: 186-192.

[5] Chai Jing. Rural Energy Evaluation Index System and Method, D. Lanzhou University, 2011.

[6] Wang Hui. Face recognition based on kernel principal component analysis, D. Hefei University of Technology, 2006.

[7] Wu Hong, Gu Shu Zhong, Zhou Hong, Wang Xingjie, Dongde Kun, Hu Yongjun Relationship between Hebei energy consumption, carbon emissions and economic growth ,J. Resource Sciences, 2011,10: 1897-1905.

[8] Xiao Jing. Energy consumption in carbon allocation under the Beijing, Tianjin, Hebei Industrial Synergy background, D. Tianjin University of Technology, 2015.

[9] Zhang Jiaqiang. Household biogas utilization and Benefit Evaluation of Ecological Environment: Evidence from Enshi, D. Huazhong Agricultural University, 2008.

[10] Long Xiao Yang. Evaluation regionalization energy applied research, D. Chongqing University, 2014.

[11]B.E. Apostolakis. Energy-Capital Substitutability Complementarity, J. Energy Economics, 1990(12):48-58.

[12]V. Baum. Energy Consumption Out Passes Growth, J. Petroleum Economist, 1998(9):306-308.