CSCanada
Studies in Sociology of Science
Vol. 4, No. 3, 2013, pp. 48-53
DOI:10.3968/j.sss.1923018420130403.Z502

ISSN 1923-0176 [Print]
ISSN 1923-0184 [Online]
www.cscanada.net
www.cscanada.org

Empirical Study on the Coordinated Development of Energy-Economy-Environment in Henan Province

LI Xiongyi[a]*; XUE Jingmin[a]

[a]College of Economics & Management, Zhongyuan University of Technology, Zhengzhou, China.
*Corresponding auhor.

Supported by the Science Fund Project of the Education Department of Henan Province "Study on Coordinated Development of the Tertiary Industry in Henan Province" (No.2011A790032), "Research of Science and Technology Innovation Platform Network Structure and Development Pattern" (No.12A630059), and the Soft Science Research Project of Zhengzhou "Study on Cultivation of the Strategy Emerging Industries in Zhengzhou" (No. 2010RKXYJ176).

Received 20 May 2013; accepted 25 July 2013

Abstract

This article establishes a comprehensive development index system of energy-economy-environment, and studies the 18 cities' 3E system in Henan province through principal component analysis. The results show that 3E system of each city in Henan province exists in lager discordance, which has become the bottleneck to restrain economic development. Based on the analysis results, this paper puts forward countermeasures and suggestions to promote energy, economy and environment systems' coordinated development.

Key words: 3E system; Principal component analysis; Coordinated growth

LI Xiongyi, XUE Jingmin (2013). Empirical Study on the Coordinated Development of Energy-Economy-Environment in Henan Province. *Studies in Sociology of Science, 4*(3), 48-53. Available from: URL: http://www.cscanada.net/index.php/sss/article/view/j.sss.1923018420130403.Z502
DOI: http://dx.doi.org/10.3968/j.sss.1923018420130403.Z502

INTRODUCTION

With the rapid development of economy as well as the fast progress of science and technology, energy becomes important material base of a region's sustainable development. Safe and reliable energy supply along with high efficiency utilization of energy is the basic guarantee to realize the sustainable economic development in society, so energy issues is a strategic problem of universal concern to each region (Gu & Wang, 2009). However, as countries to speed up the process of industrialization, the demand for energy increases day by day. In addition, due to energy from mining to final used the whole process will produce including solid waste pollution, water pollution, air pollution and other various kinds of environmental pollution, so as the growth of energy consumption, environmental pollution is also gradually serious (Zhao, 2009). And various energy environment problems not only influence the sustainable development of social economy, but also directly threat to human survival and development opportunities (Ren & Li, 2007).

In the view of energy, economy and environment are interrelated and interacted on each other, many scholars and research institutions come to realize the significance of linking energy, environmental, and economic up. Energy, environment and economy can be seen as a whole, namely the 3E system with which the internal relationship and development law were analyzed in order to achieve the optimality principle of 3E system development (Wang & Zong, 2010; Lü & Luo, 2009; Zhao & Li, 2008). In such a context, this article establishes a comprehensive development index system and studies the 18 cities'3E system in Henan province through principal component analysis, so as to provide fact for the realization of the 3E system coordinated development.

1. DESIGNING INDEX SYSTEMS

This paper is based on the following principles building environment, energy and economic indexes of subsystems so as to reflect more comprehensive and quantitative of 3E system. (a) Overall principle. Positive index and reverse index are selected to fully reveal the inherent law of the three subsystems on account of comprehensive evaluation index must complete. (b) Representative principle. Evaluation index should have the characteristics of identification so as to distinguish comprehensive score of the three subsystems in different regions. (c) Practical operability principles. On the premise of integrated and scientific index system, objective indicators should be obtained easily from current statistical data to ensure feasible operation,

This paper references research achievement at domestic and overseas of 3E system (Wang, Liu, & Ren, et al., 2009; Zhou, Liu, & Wang, 2011; Hanley, McGregor, Swales, & Turner, 2006), and sets up the evaluation index system. Then 3E system comprehensive indexes of 18 cities are calculated by measuring three subsystems comprehensive development level indexes with principal component analysis. Table 1 gives 3E system comprehensive development level index systems. Environment subsystem, including industrial waste water discharge, industrial waste gas emissions, sulfur dioxide emissions, industrial soot emissions, industrial dust emissions, industrial solid wastes produced and energy consumption per unit of GDP, electricity consumption per unit of GDP, energy consumption for unit add-value of industry are included in energy subsystem. All of these indexes are all reverse.

Table 1
Evaluation Index System of Environment-Dndrgy-Economy (3e)

Environment system A	Energy system B	Economic system C
Volume of industrial waste water discharge (10000 tons) A1	Energy consumption for per unit of GDP (ton of SCE/10,000 yuan) B1	Per Capita GDP (yuan) C1
Volume of industrial waste gas emissions (10000 standard cubic meters) A2	Electricity consumption for per unit of GDP (kwh/10,000yuan) B2	Value-added of the tertiary industry (100 million yuan) C2
Volume of sulfur dioxide treated (tons) A3	Energy consumption for add-value of industry (ton of SCE/10,000yuan) B3	Per capita consumption (yuan) C3
Volume of sulfur dioxide emission (tons) A4	Overall energy balance sheet (10,000 tons of SCE) B4	Total investment in fixed assets in the whole country (100 million yuan) C4
Volume of industrial soot treated (tons) A5	Electricity consumption in above designated size industrial enterprises (100 million kwh) B5	Total value of imports and exports (USD 10,000) C5
Volume of industrial soot emission (tons) A6	Raw coal consumption (10,000 tons) B6	Ordinary budget financial revenue of the local government (100 million yuan) C6
Volume of industrial dust treated (tons) A7		Ordinary budget financial expenditure of the local government (100 million yuan) C7
Volume of industrial dust emission (tons) A8		
Volume of industrial solid wastes produced (10,000 tons) A9		
Volume of industrial solid wastes utilized (10,000 tons) A10		

2. INTRODUCTION THE PRINCIPAL COMPONENT ANALYSIS

Principal component analysis is a multivariate statistical method to study the correlation of multiple variables, which proposed by Karl Pearson in 1901 (Ma, 2011). The basic idea is studying how to select a few principal components to explain the internal structure among multi-variables. That is, a few principal components, which should keep the information of original variables as much as possible and be irrelevant to each other, are extracted from the original variables. The process of principal component analysis is as follows:

(a) Standardizing the original data. Original data should be standardized to make the comparison among variables more convenient and eliminate the influence of magnitude order as well as dimension sent. The calculation formula is:

$$xij* = (xij - \overline{xj}) / \sqrt{Sj}$$

Using x_{ij} to express the observed data of j index in i sample, $\overline{x_j}$ is the sample mean of j index, sj is the variance of j index. $\overline{xj} = \frac{1}{n}\sum_{i=1}^{n} xij$, $Sj = \frac{1}{n-1}\sum_{i=1}^{n}\left(xij - \overline{xj}\right)^2$;

(b) Correlation coefficient is calculated of standardized data to get relevant matrix; (c) Characteristic value, characteristic value contribution and total contribution are calculated of correlation matrix R; (d) Determining the number and expression of principal component. Elements are extracted according to the principle that characteristic value should be greater than 1, and then calculated the expression of the principal component; (e) Evaluating principal component. With variance contribution of each principal component as weight, comprehensive evaluation index function can be obtained by combining linear combination of expression, thereby evaluating value is calculated.

3. THE EMPIRICAL ANALYSIS PROCESS

First, three subsystems of environment-energy-economic are studied through principal component analysis, including 18 cities in Henan Province in 2010. Because evaluation index of 3E system consists of positive and reverse index in this study, and the measurement of the two indexes are different, the reverse index should be transformed into positive index. The specific means is appending a minus before reverse index. Economic subsystem is taken as an example to illustrate the process of principal component. Table 2 shows the standardized data of economic subsystem.

Table 2
Standardized Data of Economic Subsystem Economic Subsystem

City	C1	C2	C3	C4	C5	C6	C7	C8
Zhengzhou	1.85466	3.59074	3.08356	3.08091	3.52888	3.76756	3.06890	2.36450
Kaifeng	-0.66515	-0.18532	0.01633	-0.69942	-0.62949	-0.40236	-0.42577	-1.03400
Luoyang	0.78317	1.02490	0.15951	1.43154	0.47007	0.84932	0.86193	1.54264
pingdingshan	-0.03379	-0.13040	-0.12603	-0.35105	-0.47282	0.11683	-0.06376	0.60776
Anyang	-0.16043	-0.07248	-0.03404	-0.04419	0.49384	-0.06855	-0.15316	0.72927
Hebi	0.12911	-0.83061	-0.26796	-0.95319	-0.70940	-0.57976	-1.07108	-0.14289
Xinxiang	-0.53436	-0.07505	-0.21885	0.49009	0.12458	-0.00382	0.05943	0.30985
Jiaozuo	0.78362	-0.21036	1.04443	0.08434	0.60547	-0.08870	-0.36823	0.32880
Puyang	-0.48090	-0.62165	-0.69877	-0.65614	-0.42027	-0.48415	-0.72236	-0.09128
Xuchang	0.31047	-0.30558	0.14702	-0.15447	0.25243	-0.15892	-0.41687	-0.06972
Luohe	-0.01172	-0.71523	0.43339	-0.87269	-0.50098	-0.53231	-0.94902	-0.33235
Sanmenxia	1.09197	-0.47284	-0.45277	-0.41088	-0.69358	-0.25084	-0.66426	-0.16053
Nanyang	-0.71987	0.45729	-0.37827	0.79106	-0.02796	-0.02039	1.04558	-0.13113
Shangqiu	-1.08711	-0.17134	-1.63655	-0.12697	-0.71934	-0.33119	0.28970	-0.71846
Xinyang	-0.91968	-0.08458	-0.74747	0.18671	-0.53253	-0.43730	0.21898	-1.26070
Zhoukou	-1.28077	-0.19217	-0.82946	-0.18092	-0.50804	-0.38710	0.44418	-1.69842
Zhumadian	-1.17467	-0.14424	-0.50189	-0.42626	-0.63571	-0.40940	0.20322	-1.02943
Jiyuan	2.11544	-0.86106	1.00780	-1.18846	0.37486	-0.57893	-1.35742	0.78611

3.1 Extracting Principal Component

After applying KMO test and Bartlett sphericity test to data in Table 2 with SPSS software, we find principal component analysis is a suitable method. Table 3 gives characteristic value, variance contribution rate and total variance contribution of each component.

From the Table 3, it is known that there are two components with characteristic value greater than 1, so the two principal component variables are extracted and named F_{C1}, F_{C2}.

Table 3
Total Variance Explained

Component	Initial eigenvalues			Extraction sums of squared loadings		
	Total	% of Variance	Cumulative%	Total	% of Variance	Cumulative %
1	5.912	73.902	73.902	5.912	73.902	73.902
2	1.549	19.369	93.271	1.549	19.369	93.271
3	0.287	3.592	96.863			
4	0.122	1.521	98.384			
5	0.065	0.811	99.194			
6	0.039	0.490	99.684			
7	0.020	0.251	99.934			
8	0.005	0.066	100.000			

3.2 Ensure Principal Component Expression

Using SPSS software analyzes the extracted principal component variables F_{C1}, F_{C2} to obtain component matrix, as shown in Table 4:

Table 4
Component Matrix

	Components	
	1	2
Zscore (C1)	0.595	0.761
Zscore (C2)	0.942	-0.316
Zscore (C3)	0.829	0.424
Zscore (C4)	0.897	-0.383
Zscore (C5)	0.963	0.105
Zscore (C6)	0.976	-0.132
Zscore (C7)	0.800	-0.588
Zscore (C8)	0.813	0.413

Table 4 shows that the first principal component can represent all the indexes and the second principal component can represent C_1, C_3, C_5, and C_8. Component matrix in the Table 4 divided by the square root of the corresponding principal component characteristic value is each index's coefficient. The linear combination of 8 variables can be expressed by the two main components, F_{C1} and F_{C2}. The expressions are as below:

$$F_{C1} = 0.101X_{C1} + 0.159X_{C2} + 0.140X_{C3} + 0.152X_{C4} + 0.163X_{C5} + 0.165X_{C6} + 0.135X_{C7} + 0.137X_{C8}$$

$$F_{C2} = 0.491X_{C1} - 0.204X_{C2} + 0.274X_{C3} - 0.247X_{C4} + 0.067X_{C5} - 0.085X_{C6} - 0.379X_{C7} + 0.267X_{C8}$$

Repeating the above steps, which will get linear combination of environmental and energy subsystem, that is:

$$F_{A1} = 0.046X_{A1} + 0.151X_{A2} - 0.056X_{A3} + 0.148X_{A4} - 0.133X_{A5} + 0.128X_{A6} - 0.130X_{A7} + 0.136X_{A8} + 0.158X_{A9} - 0.141X_{A10}$$

$$F_{A2} = 0.444X_{A1} + 0.100X_{A2} + 0.403X_{A3} - 0.193X_{A4} + 0.163X_{A5} - 0.256X_{A6} - 0.118X_{A7} + 0.206X_{A8} - 0.026X_{A9} - 0.216X_{A10}$$

$$F_{B1} = 0.222X_{B1} + 0.244X_{B2} + 0.218X_{B3} - 0.234X_{B4} - 0.195X_{B5} - 0.204X_{B6}$$

$$F_{B2} = 0.364X_{B1} + 0.138X_{B2} + 0.389X_{B3} + 0.341X_{B4} + 0.447X_{B5} + 0.159X_{B6}$$

3.3 Calculating the Comprehensive Score

Function expressions of comprehensive integral are received of every subsystem with principal component variance contribution rate as weight.

$$F_A = 0.6098F_{A1} + 0.1659F_{A2},\ F_B = 0.5729F_{B1} + 0.2586F_{B2},$$

$$F_C = 0.7390F_{C1} + 0.1937F_{C2}$$

Environmental pollution, energy consumption and economic growth are important guarantee for a region's healthy development, so we should consider the weight of environment- energy-economic as equal. Comprehensive development level index should be calculated of 3E system in each region by $F=\beta 1F_A+\beta 2F_B+\beta 3F_C$, and $\beta 1$ $\beta 2$ $\beta 3$ are weighting coefficient of environment, energy as well as economic, so $\beta 1=\beta 2=\beta 3=1/3$.

Table 5
Comprehensive Score and Ranking of 3e Systems

City	F_A	F_B	F_C	F
Zhengzhou	-0.720417	0.135123	2.587735	0.667480
Luohe	0.620982	0.847545	-0.24518	0.407782
Xuchang	0.559158	0.486897	0.037006	0.361020
Zhoukou	0.737666	0.840636	-0.73067	0.282544
Kaifeng	0.501675	0.612100	-0.46573	0.216015
Zhumadian	0.457952	0.560475	-0.59668	0.140582
Nanyang	-0.081459	0.514955	-0.09295	0.113515
Puyang	0.454822	0.146910	-0.42192	0.059937
Xinyang	0.405308	0.300204	-0.57207	0.044481
Hebi	0.247381	0.067981	-0.35233	-0.012323
Xinxiang	-0.109934	-0.078814	-0.03392	-0.074223
Luoyang	-0.820691	-0.201227	0.741315	-0.093534
Jiyuan	0.433659	-1.224713	0.446015	-0.115013
Shangqiu	0.286725	-0.032850	-0.69534	-0.147155
Sanmenxia	-0.157633	-0.440062	-0.1104	-0.236032
Jiaozuo	-0.480836	-0.733878	0.397328	-0.272462
Pingdingshan	-0.858053	-0.722229	-0.01753	-0.532604
Anyang	-1.476296	-1.079039	0.12532	-0.810005

Table 5 shows that 3E integrate scores of Zhengzhou, Luohe, Xuchang, Zhoukou, Kaifeng, Zhumadian, Nanyang, Puyang and Xinyang are all positive, but there are big variances among three subsystems' scores. Environment subsystem's comprehensive point of Zhengzhou ranks third from bottom, while the economic subsystem is far more than other 17 cities and ranks first. That is because Zhengzhou, the capital of Henan province and the center city of "Zhongyuan economic area", has ranked the 20th large and medium-sized city in China; its economic aggregate is top 20 in China and the total output value achieve to 491.27 billion yuan in 2011; the annual ordinary budget revenues of local finance reach to 50.23 billion yuan, and rank 17th in the large and medium cities; the total volume of retail sales amounts to 198.71 billion yuan ranking 19th. Therefore rapid development in economy is following with energy consumption and environmental pollution. Due to inferior economic development level of industry, the economic subsystem scores of Luohe, Zhoukou, Kaifeng, Zhumadian, Nanyang, Puyang and Xinyang are low relatively and negative. Of the 18 cities, Xuchang is the only one whose three subsystems and 3E comprehensive points are all positive. That is to say, its three subsystems coordinate relatively.

3E integrate scores of Hebi, Xinxiang, Luoyang, Jiyuan, Shangqiu, Sanmenxia, Jiaozuo, Pingdingshan and Anyang are all negative, but their three subsystems' scores are uneven. Because of prosperous industry development, the economic subsystem points of Luoyang, Jiyuan, Jiaozuo and Anyang are all positive. On the contrary, their environment and energy subsystems mark lower, which is closely related to local resources endowment and economic development.

CONCLUSION AND SUGGESTION

Energy, economy and environment compose a whole. The requirement of scientific development is making energy, economy and environment harmonious, so as to realize the sustained, stable and coordinated development of the three subsystems. Although the economy of Henan province is developing, the energy scarcity and environmental pollution have became one of the major problems which restrict the development of economic. To realize the sustainable development of central plains economic region, we should balance development among environment, energy and economic, and strive to build a friendly environment, energy saving and economic efficiency society.

First, the score of energy subsystem in 18 cities is generally low, therefore, improving energy efficiency and developing new energy as well as renewable energy are extremely urgent. The important foundation for growth in 18cities of Henan province is improving efficiency in use of energy and resources, so 18 cities should stick to raise the efficiency of energy use, optimize energy structure, build environment friendly and energy saving area, research and popularize energy-saving technical progress in reducing emissions, develop recycling economy and promote the development of tertiary industry with low energy consumption; actively developing new energy and renewable energy can change the energy structure of each city along with decrease the purchase of extra power. For this reason, wind energy, solar energy, geothermal energy other renewable energy should be developed to reduce environmental pollution and realize the sustainable development of economy.

Second, each region should actively carry out environmental protection policies. Environment enforce policies should be formulated to promote effective utilization of energy, and standards should be constituted of industrial pollution emissions as well as energy consumption. In order to encourage some industrial enterprises transform into eco-friendly enterprises, government should perfect environmental standard system certification and establish some preferential policies. Besides, government also should perfect market mechanism of environmental conservation and improve the system of emission trade, and increase the charge degree of pollution discharge.

Third, the quality of economic growth should be paid attention in the process of protect environment and save energy. Economic growth should be grasped appropriately, for example, the economic of Zhengzhou develop rapidly, but it is not harmonious with the environment and energy. With focusing on the quality of economic development as the guidance and coordinating economic structure the target, the government should adjust the distribution of industry structure rationally and follow economic cycle development rules. At the same time, the former economic development model, which is at the cost of energy consumption and environmental disruption, should be changed into the new one that adapts to eco-carrying capacity. Only by doing these are there certain space for the long-term sustainable development of central plains economic zone.

REFERENCES

Gu, G. F., & Wang, S. L. (2009). The study on grey relation analysis of energy consumption, environmental pollution and economic development: Based on Jilin province. *Ecological Economy*, (9), 54-56.

Hanley, N. D., McGregor, P. G., Swales, J. K., & Turner, K. R. (2006). The impact of a stimulus to energy efficiency on the economy and the environment: A regional computable general equilibrium analysis. *Renewable Energy*, *31*(2), 161-171.

Lü, L. H., & Luo, H. (2009). Coordination degree analysis of the energy-environment-economy compound system in China. *Journal of Beijing Forestry University (Social Sciences Edition)*, *8*(2), 80-83.

Ma, L. P. (2011). *Statistics application*. Beijing: Capital University of Economics and Business Press.

Ren, B., & Li, S. Y. (2007). Grey Incidence analysis of energy consumption, environmental pollution and economic development of China. *Statistics & Information Forum*, *22*(1), 46-49.

Wang, S. J., Liu, J., & Ren, L. J., et al. (2009). The development and practices of strategic environmental assessment in Shandong province. *China Environmental Impact Assessment Review*, *29*(6), 408-420.

Wang, Y. J., & Zong, Y. G. (2010). An empirical study on the relationship among energy, environment and economy in Shaanxi province. *Henan Science*, *28*(7), 880-884.

Zhao, F. (2009). Empirical study on the coordinated development of China's energy -economy-environment (3E). *Economist*, (12), 35-41.

Zhao, T., & Li, X. Y. (2008). On the coordinating evaluation model for energy-economy-environment system. *Journal of Beijing Institute of Technology (Social Sciences Edition)*, *10*(2).

Zhou, R. M., Liu, L. J., & Wang, G. Z. (2011). Research on the countermeasures of promoting energy-economic-environment system to coordinating development in Hebei province. *Hebei Academic Journal*, *31*(1), 231-234.

