Chapter 12
An Empirical Analysis on Guangdong Industrial Energy Intensity Based on Panel Data

Xin-dong Hao

Abstract Energy is of vital importance to the modern industrial economy. Based on the panel data of 36 industrial sectors in Guangdong, this paper analyzes the relationship between energy intensity and industrial added value by means of gray relational analysis. The results show that the energy intensities of industrial sectors are quite inconsistent with their industrial added values. Guangdong should attach great importance to the development of "win–win" industrial sectors which increasing industrial output while reducing energy intensity.

Keywords Energy intensity · Grey relational analysis · Industrial added value · Panel data

12.1 Introduction

China is facing severe challenges from energy supply and environment protection due to its heavy dependence on energy. Up to now, Guangdong has made great progress in industrialization, and its industrial output value has ranked first in China for many years, and even some of its manufactured goods play a prominent role on world scene. Industrialization needs large amounts of energy, Guangdong's total energy consumption was 152.367 million tones of standard coal in 2011, and Guangdong try to reduce its per unit energy consumption by 18 % in the 12th 5-Year Plan (2011–2015).

Over the years, Guangdong's industrial growth rely heavily on high input and high energy consumption, its industrial energy consumption accounts for about 70 % of the total consumption. At present, Guangdong is facing serious challenges

X. Hao (✉)
School of Economics and Management, Wuhan University, Wuhan, China
e-mail: haoxindong123@126.com

E. Qi et al. (eds.), *The 19th International Conference on Industrial Engineering and Engineering Management*, DOI: 10.1007/978-3-642-38391-5_12,

of resources and environmental, and the energy problem is hindering Guangdong's economic growth and industrialization. The energy intensities of industrial sectors play a dominant role in total energy consumption; many studies have focused on this problem. A brief literature review as follows.

Sinton and Levine (1994) studied China's industrial energy intensity of 1980–1990 and found that the reasons for the decline of overall industrial energy intensity were primarily the improvement of energy efficiency. Garbaccio et al. (1999) tried to construct an index system on energy intensity and they pointed to that technological changes being one of main reasons for the decline of energy intensity. Karen et al. (2004) analyzed the panel data of 1997–1999 on large and medium-sized industrial enterprises in China, and found that the decline of energy intensity mainly due to the reduction of coal consumption in industrial sector, technology development, industrial restructuring.

Lun and Ouyang (2005) analyzed the relationship of Guangdong's economic and energy consumption, and they argued that there was a significant positive correlation between them. He and Zhang (2005) insisted that the increasing of China GDP energy intensity was mainly due to the fast increase of energy consumption in industry, particularly in heavy and chemical industrial sectors. Fisher-Vanden et al. (2006) studied China's energy intensity based on sample data which coming from a large number of industrial enterprises and they found that the change of production structure was one of the major factors for the decline of energy intensity. Hu and Wang (2006) conducted a comprehensive analysis on the factors of affecting China regional energy efficiency, and they insisted that the main influencing factors include energy structure, industrial structure, technology and so on.

Shi and Dong (2007) insisted that the differences of energy efficiency in China were due to the factors such as economic development level, industrial structure, energy consumption structure, maketization degree. Yu (2007) thought that the decrease of Guangdong's energy intensity was mainly due to the increase of energy utility efficiency in the second industry. The rising of energy utility efficiency in the key sectors of industry had led to the fall of the whole energy intensity. Ma and David (2008) analyzed the data of energy intensity between 1980 and 2003 in China and they pointed out that the technological progress was extremely important for knock-down industrial energy intensity. Zha et al. (2009) nalyzed the energy consumption of 36 China industrial sub-sectors from 1993 to 2003. The results showed that the industrial structure played a important role in China's energy intensity.

Zhu (2010) studied the general characteristics of energy consumption based on the data of Guangdong, and he designed an energy demand path of low-carbon development for Guangdong. Cai (2010) insisted that the energy problems had seriously affected the development of Guangdong's industry and he suggested that the reduce of energy intensity would be a direct ways of accelerating the development of Guangdong industrialization. Fu and Zhang (2011) analyzed the data of 36 Guangdong industrial sectors from 2001 to 2010, the results showed that the structural effect and technical effect had a positive role on the reduction of energy consumption while the scale effect had a negative role. The development of steel, nonferrous metal, building materials, chemical and other high energy consumption industrial sectors was the main reason for the rapid rise of total energy consumption. Zheng (2011) analyzed the general characteristics of energy consumption and energy efficiency based on the data of industrial sectors in Guangdong, and the result showed that there were many differences in different industrial sectors.

In this paper, we go through the main study results of previous literature so as to explore the relationship between industrial energy intensity and industrial added value in Guangdong basing on gray relational analysis. By this way, we try to find out which Guangdong industrial sectors should be the priority development ones by the perspective of energy intensity and industrial added value. Our goal is to identify the key industrial sectors of "win–win" which increasing industrial output while reducing energy intensity.

12.2 Methodology of Gray Relational Analysis (GRA)

The gray system theory was first proposed in 1982, and it is a system containing both insufficient and sufficient information, called "black" and "white," respectively, is a gray system. A system can be called as a black box if its mathematical equations or internal characteristics that describe its dynamics are completely unknown. On the other hand, a system can be named as a white system if the description of the system is completely known. Similarly, a system that has both known and unknown information is defined as a gray system. The gray system theory deals with a system containing insufficient information, the gray relational analysis can capture the relationship between the main factor and other factors in a system regardless whether this system has adequate information. The gray relational analysis can effectively avoid subjective bias and have better performance than some traditional methods when the study involves economic, environmental and technical indices problems.

In real life, each system can be considered as a gray system because there are always some uncertainties in them. Even a simple price system always contains some gray characteristics because of the various kinds of social and economic factors. These factors are generally random and make it difficult to obtain an accurate model. There are many situations in which the difficulty of incomplete or insufficient information is faced, by gray relational method; we can calculate the gray relational coefficient and the gray relational grade of a gray system, and to find out the system's internal relationships.

A GRA model is a kind of impact measurement model of two series which named reference series and compare series. During the processes of system development, the change trends of two series should be consistent, a higher grade of synchronized change can be considered to have a greater ranking; otherwise, the grade of relation would be smaller. Thus, the analysis method, which takes the ranking of the relation into account, is established upon the degree of similarity or difference of the developmental trends of two series to measure the degree of relation.

12.3 Empirical Analysis

Taking energy intensity (Tons of standard coal/yuan) as reference series, and taking industrial added value as compare series. The energy intensity come from the energy consumption per unit industrial added value, the data involving 36 industrial sectors of Guangdong from 2004 to 2010. The compare series are the industrial added values of above-mentioned 36 industrial sectors. All the data come from Guangdong Statistical Yearbooks (GSY, 2005–2011). By the methodology of GRA, we summary the gray relational degrees (descending order) in Table 12.1, we take also Guangdong energy intensity data(ascending order) into Table 12.1, so as to find out the "win–win" industrial sectors.

The 36 industrial sectors as follows: tobacco manufacturing industry (X_1), oil and gas mining industry (X_2), transportation equipment manufacturing industry (X_3), recycling and disposal of waste industry (X_4), instrumentation and culture, office equipment manufacturing industry (X_5), electrical machinery and equipment manufacturing industry (X_6), pharmaceuticals manufacturing industry (X_7), universal equipment industry (X_8), special equipment manufacturing industry (X_9), garments, shoes and caps manufacturing industry (X_{10}), beverage manufacturing industry

Table 12.1 The sorts of energy intensity and grey relational degree (2004–2010)

Sectors	Energy intensity	Sort	Degree	Sort	Sectors	Energy intensity	Sort	Degree	Sort
X_1	0.061	1	0.893	6	X_{19}	0.858	19	0.896	3
X_2	0.127	2	0.910	2	X_{20}	0.923	20	0.850	18
X_3	0.283	3	0.830	29	X_{21}	0.982	21	0.849	19
X_4	0.379	4	0.727	34	X_{22}	1.063	22	0.878	9
X_5	0.445	5	0.841	25	X_{23}	1.258	23	0.894	5
X_6	0.454	6	0.840	27	X_{24}	1.370	24	0.842	24
X_7	0.623	7	0.895	4	X_{25}	1.386	25	0.833	28
X_8	0.664	8	0.845	22	X_{26}	1.403	26	0.827	30
X_9	0.667	9	0.843	23	X_{27}	1.529	27	0.823	31
X_{10}	0.678	10	0.854	16	X_{28}	1.658	28	0.864	12
X_{11}	0.681	11	0.917	1	X_{29}	1.780	29	0.820	32
X_{12}	0.687	12	0.856	13	X_{30}	1.946	30	0.889	8
X_{13}	0.724	13	0.876	10	X_{31}	2.106	31	0.841	26
X_{14}	0.769	14	0.850	17	X_{32}	2.448	32	0.855	15
X_{15}	0.771	15	0.713	35	X_{33}	3.308	33	0.685	36
X_{16}	0.776	16	0.856	14	X_{34}	4.306	34	0.846	20
X_{17}	0.776	17	0.890	7	X_{35}	5.797	35	0.845	21
X_{18}	0.847	18	0.867	11	X_{36}	6.013	36	0.813	33

(X_{11}), leather, furs, feathers manufacturing industry (X_{12}), food manufacturing industry (X_{13}), handicrafts and other Manufacturing industry (X_{14}), nonferrous metals mining and extraction industry (X_{15}), furniture manufacturing (X_{16}), printing and copying industry (X_{17}), metal products industry (X_{18}), ferrous metals mining and extraction industry (X_{19}), cultural, educational, sporting articles manufacturing industry(X_{20}), chemical raw materials and chemical products manufacturing(X_{21}), agro-food processing industry (X_{22}), nonmetal mineral mining and extraction industry (X_{23}), plastic products industry (X_{24}), nonferrous metals smelting and rolling processing industry (X_{25}), wood, bamboo, timber processing industry (X_{26}), water processing and supplying industry (X_{27}), rubber products industry (X_{28}), chemical fiber industry (X_{29}), textiles industry (X_{30}), electric power, hot power producing and supplying industry (X_{31}), papermaking and paper products industry (X_{32}), gas producing and supplying industry (X_{33}), oil processing, coking and nuclear fuel processing industry (X_{34}), nonmetal mineral products industry (X_{35}), ferrous metals smelting and rolling processing industry (X_{36}).

The Table 12.1 shows that the top fifteen industrial sectors from the perspective of gray relational degree are: beverage manufacturing, oil and gas mining, ferrous mining, medicine manufacturing, non-metallic Mining, printing recording media replication, tobacco manufacturing, textiles, agro-food processing, food manufacturing, fabricated metal products, rubber, leather, fur, feathers and their products, furniture, paper and paper products industries. Obviously, the top fifteen sectors from the perspective of energy intensity are different.

12.4 Conclusion

Energy intensity is the comprehensive reflection of a country or region's economic structure, mode of growth, level of science and technology, management capacity, consumption patterns and so on. This study examines Guangdong's industrial energy consumption during 2004–2010 by the gray analysis method and it gives us a new way of thinking (named "win–win") for breaking through Guangdong's energy bottlenecks.

The gray relational analysis shows that there are complex relationships between Guangdong's industrial energy intensity and industrial added value, i.e. the industrial added value of the sectors can be high while their energy intensities are low.

Comparing the rankings of energy intensity and gray relational degree, we find out the "win–win" industries, i.e. increasing industrial output while lowering energy intensity industries, include tobacco manufacturing industry, oil and gas extraction industry, pharmaceutical manufacturing industry, beverage manufacturing industry, leather, fur, feather products industry, food manufacturing industry, they all should be given priority to development. We should also pay attention to the industrial sectors of transportation equipment manufacturing industry, recycling and disposal of waste industry, electrical machinery and equipment manufacturing, non-ferrous metal mining industry because their gray relational degree are low but their ranks of energy intensity are high. Although such industries cannot play an important role in create industrial added value, but they consume less energy.

References

Cai MR (2010) The research of energy and industrial development in Guangdong province. In: Proceedings of information management, innovation management and industrial engineering, ICIII'10, Hong Kong, VA, pp 333–336

Fisher-Vanden K, Jefferson GH, Jingkui M (2006) Technology development and energy productivity in China. Energy Econ 28(5):690–705

Fu JY, Zhang HL (2011) An empirical analysis of influential factor of Guangdong's energy consumption in the industrial sector. http://www.paper.edu.cn/index.php/default/releasepaper/content/201204-424

Garbaccio RF, Ho MS, Jorgenson DW (1999) Why has the energy output ratio fallen in China? Energy J 20(3):63–91

He JK, Zhang XL (2005) Analysis on the impact of the structural changes in the manufacturing industry on the rising of intensity of GDP resources and its trend (in Chinese). Environ Prot 12:37–41

Hu JL, Wang SC (2006) Total-factor energy efficiency of regions in China. Energy Policy 17(5):3206–3217

Karen FV, Gary HJ, Liu HM, Tao Q (2004) What is driving China's decline in energy intensity? Resour Energy Econ 26(1):77–97

Lun X, Ouyang YG (2005) A study on energy constraint based on Guangdong sustainable development (in Chinese). Coal Econ Res 28(2):30–32

Ma CB, David IS (2008) China's changing energy intensity trend: a decomposition analysis. Energy Econ 30(3):1037–1053

Shi D, Dong L (2007) A study on energy efficiency and energy saving potential and its influencing factors in China (in Chinese). Nat Gas Technol 1(2):5–8

Sinton JE, Levine MD (1994) Changing energy intensity in chinese industry; the relative importance of structural shift and intensity change. Energy Policy 22(5):239–255

Yu PG (2007) A factor analysis of the energy intensity in China (in Chinese). Acad Res 2:74–79

Zha Dl Zhou DQ, Ning D (2009) The contribution degree of sub-sectors to structure effect and intensity effects on industry energy intensity in China from 1993 to 2003. Renew Sustain Energy Rev 13(4):895–902

Zheng LZ (2011) Study on the energy efficiency of industrial sector in Guangdong province. http://210.44.1.99/kns50/detail.aspx?dbname=CMFD2011&filename=1011191476

Zhu SX (2010) An analysis of fictitious conditions in Guangdong low coaban growth (in Chinese). China Opening Herald 148(1):57–61