An Analysis the Determinants of China's Energy Intensity change for 1987-2005

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Abstract： In China, between 1997 and 2005, energy intensity changed as U shape. There has been considerable debate about the major factors responsible for the dramatic decline of China's energy intensity in the 1980s and 1990s. However, no detailed analysis has been done to explain the U shape change in energy intensity in 1987-2005, i.e. after declining for more than twenty years the energy intensity increased during 2002-2005. In this paper, we use the structural decomposition method to develop the energy intensity decomposition model and to decompose energy intensity into five determinants: energy consumption coefficient, Leontief inverse coefficient, final demand structure, final demand level and final energy consumption coefficient. We then use the RAS method to decompose energy consumption coefficient and Leontief inverse coefficient into changes both in structure and efficiency. Empirical study is carried out on the constant price energy-input-output tables from 1987 to 2005. One main conclusion, that should be highlighted, is that between 1987 and 2002, input structure accounts for most of the decline in energy intensity. However, the total demand of production per unit final demand and final demand structure explain the energy intensity increase between 2002 and 2005.

Keywords: energy intensity; structural decomposition method; input-output technology; RAS method

1. Introduction

With the upsurge of world crude oil price, as well as the acceleration of exhaustion in fossil energy, many countries pay more attention to promoting energy utilization levels, to enhancing energy supplying capability, and to improving energy utilization efficiency. At present, energy intensity (energy consumption per unit GDP) is widely used as an index of measuring comprehensive energy utilization efficiency. It can be used to reflect the energy utilization level in production and consumption of a country or region over a certain period. In "The Outline of the Eleventh Five-Year Plan for National Economic and Social Development of China", a target which aims at 20% energy intensity reduce by the end of 2010 is set forth restrictively. This target, on the other hand is also an important index to judge the performance of provincial leaders as a part of the Evaluation System.

Structural decomposition analysis (SDA) is an important tool to quantify the determining factors of economic structural change over time. The main idea is to decompose the change of a certain index in an economic system into changes of related factors in order to measure the contribution of all factors. The SDA has broad application worldwide and has been demonstrated to obtain reliable results. However, some results turn out to offer paradoxical conclusions, in particular for the same problem but using different samples and objects. Energy (Lin & Polenske, 1995; Dietzenbacher and Stage, 2006), economic growth (Dietzenbacher & Los, 2000; Liu and Saal, 2001), technology progress (Albala-Bertrand, 1999; Roy et al., 2002), price regime (Fujikam & Milana, 2002), international trade (Hitomi et al., 2000; Peters and Hertwich, 2006), labor (Paul de Boer, 2008), and scrap pollution (Haan, 2001; Kagawa and Inamura, 2001, 2004) are all examples.

In order to reduce energy intensity and improve energy utilization level we need to analyze the determining factors of energy intensity and gross consumption. In 1995, Lin & Polenske (1995) investigated determining factors for the gross energy consumption in China, based on input-output technology and structural decomposition analysis. They found that the decrease in Chinese energy consumption in 1981-1987 is due to production technology change, rather than a change in final demand. Garbaccio & Ho (1999) analyze the reason of decline in energy intensity in 1987-1992. They end by concluding that the change of technology among sectors is the main reason. There are many comparable conclusions to the role that technological progress plays, such as: Vanden & Jefferson who studied the decline of energy intensity in 1997-1999s by adopting the Divisia method;

Ding et al. (2007) researched the energy intensity during 1994-2005 by the factor substitution method; Zhou and Li (2006) tried to explain energy intensity during 1980-2003 by the Adaptive Weighted Divisia index method; Huang (1993) analyzed the energy intensity of Chinese secondary industry in 1980-1998s, and decomposed it into structural change effect and improved effect of energy intensity while the latter contributes more in the findings; Zhang (2003) calculated the energy use of industrial sectors during 1990-1997, and disentangles it into scale effect, real intensity effect and structural effect, concluding that the real intensity (namely the technology effect) is the dominant factor; Chunbo Ma & David I. Stern (2006) decomposed energy intensity during 1980-2003 by Logarithmic Mean Divisia Index finding that technology progress is a main (negative) reason since 2000. In addition, there are also many studies on energy consumption and energy intensity in other countries. Kagawa (2001) analyzed the energy consumption in Japan during 1985-1990 by using a hybrid input-output table. He concluded that the final demand of non-energy sectors resulted in the increase of energy consumption. Muigiopadhyay (1999) finding that final demand structure and technology are both important factors to promote energy consumption in India in 1973-1992. Alcantara & Duarte (1999) deemed that the difference between internal energy intensity and final demand lead to distinct energy intensity within OECD countries. Piyush Tiwari (2000) analyzed the change of energy intensity between different sectors in India in 1983-1990. The results indicated that sectors like coal tar products, textiles, etc. had worsened during the time.

Along with economic development, some positive effects may decrease and transform to negative effects. The remainder of the paper is structured as follows: Section 2 presents the model, Section 3 presents empirical results, and finally Section 4 concludes.

2 Model of energy intensity

This paper mainly focuses on answering two main questions: 1) Does the decline of energy intensity depend only on industrial energy consumption coefficient, namely energy consumption per unit of output, or on final demand structure coefficient; 2) Which is the most important reason of the energy intensity increase between 2002 and 2005.

2.1 Hybrid model

We compiled a hybrid (physical-monetary) energy input-output table, as shown in table 1:

Table 1 the basic framework of physical-monetary energy input-output table

		Intermediate demands	Final demands					Gross Output
		1,2,…,n	Consumption	Capital Formation	Export (+)	Import (-)	Others	
Intermediate Input	1 2 … n subtotal	X_{ij} (E_{ij})	Y_{fc} (E_{fc}) f_c	Y_s (E_s) f_s	Y_x (E_x) f_x	Y_i (E_i) f_i	Y_ε (E_ε) f_ε	X_i
Primary Input	Depreciation Compensation Net Taxes							
	Subtotal	V_j						
Total Input		X_j						

2.1.1 Basic input-output model

From the row of monetary terms, we have

$$AX + Y = X \tag{2-1}$$

Where, X denotes the column vector of gross output,

Y denotes the column vector of final demands,

A denotes the input coefficient matrix of the monetary table. So

$$X = (I - A)^{-1}Y \tag{2-2}$$

$L = (I - A)^{-1}$ denotes the total requirement coefficient matrix, usually called Leontief inverse matrix.

Equation (2-2) can be rewritten as

$$X = LBF \tag{2-3}$$

Where: B denotes final demand structural coefficient matrix, whose element b_{ij} represents the share of product j in each final demand; and F denotes the column vector of all final demands.

2.1.2 Energy consumption model

From the row of physical terms, we have

$$e'_{ij} = E_{ij} / X_j$$

$$e'X + E_y = EI \tag{2-4}$$

$$E_y = E_{fc} + E_s + E_x - E_i + E_\varepsilon \tag{2-5}$$

Where: e' denotes the energy consumption coefficient matrix, representing different energy consumption per unit of output, and the element e'_{ij} represents the consumption of energy *i* per unit of output of product *j;* $eX = E_{in}$ indicates the direct energy input matrix in intermediate production field; EI is the column vector of gross energy output; E_y is the energy consumption matrix for final demands; E_{fc} is the direct life energy consumption matrix; E_s is the column vector of energy inventory; E_x gives the column vector of energy export; E_i represents the column vector of energy import; E_ε represents the column vector of others; and TE is the column vector of total energy consumption. So

$$TE = E_{in} + E_{fc}$$

$$TE = e'X + E_{fc} \tag{2-6}$$

Life energy consumption can be defined as

$$E_{fc} = hcF \tag{2-7}$$

If an economic system has n sectors, of which the number of energy sectors is k, the number of non-energy sectors is $(n-k)$. Denoting h as final energy consumption coefficient matrix gives:

$$h=\begin{bmatrix} e_{1fc} & e_{1s} & e_{1x} & e_{1i} & e_{1\varepsilon} \\ e_{2fc} & e_{2s} & e_{2x} & e_{2i} & e_{2\varepsilon} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ e_{kfc} & e_{ks} & e_{kx} & e_{ki} & e_{k\varepsilon} \end{bmatrix} \begin{bmatrix} f_c^{-1} & & & & \\ & f_s^{-1} & & & \\ & & f_x^{-1} & & \\ & & & f_i^{-1} & \\ & & & & f_\varepsilon^{-1} \end{bmatrix} \tag{2-8}$$

Where $e_{ifc}, e_{is}, e_{ix}, e_{ii}, e_{i\varepsilon}$ represents different kinds of energy consumption in final demands (consumption, change of inventory, export, import, others, respectively), $f_c, f_s, f_x, f_i, f_\varepsilon$ stand for determinants of total final demands, c means diagonal matrix consisting of ones and zeros, in which the diagonal elements corresponding to consumption are one, others are zero.

2.1.3 Modeling energy intensity

With μ being the sum of a row vectors in rank k, whose elements consist of one, the expression of gross energy consumption is

$$TE=\mu(e'LBF+hcF) \tag{2-9}$$

The expression of GDP based on input-output model is then

$$GDP=V=vX=vLBF=\lambda F \tag{2-10}$$

Where, V represents gross value added, v is the value added coefficient. With λ being the sum of a row vectors in rank 5, whose elements consist of one, the energy intensity I can be defined as

$$I=TE/GDP=\frac{\mu(e'LBF+hcF)}{\lambda F} \tag{2-11}$$

Consequently, the change of energy intensity can be decomposed into the change of five components: energy input coefficient e', total requirement coefficient L, final demands structure B, final demands F, and finally energy consumption coefficient h.

2.2 Analysis of factor independence

The key assumption of SDA is independence of determining factors, in other words, these components cannot be influenced each other, nor be changing simultaneously.

In the model, the relationship between physical and monetary terms is not exactly corresponding because price is determined by both supply and demand. Hence the relationship between physical consumption coefficient e' and L, and monetary consumption structure h and B are all approximately independent. F is defined as the monetary diagonal matrix which assumed to be independent between coefficient matrix and structure matrix.

2.3 RAS Method

Change in the direct consumption coefficient can come from two sources: real consumption coefficient decreasing via production management improvement meaning that, given the same input structure (*ceteris paribus*) per unit output consumption will contract. On the other hand, input structure changing but with the constant product efficiency, which could be viewed as due to the replacement effect between old raw materials and new ones. The RAS method is usually used to analyze the change in direct consumption coefficient. It is assumed that the direct consumption coefficient is affected by two factors: input structure and real efficiency. The change in input structure refers to substitution, for example steel substituted for plastic, copper for aluminum etc. A real efficiency increase means an improvement in technology and management. At the same time, the RAS method assumes that the structural effect and the efficiency effect are inter-sector consistent. It is conclusions that the proportions of consumption and the extent of progress in all sectors are also the same.

Therefore, in this paper, the energy consumption coefficient e' , and technology coefficient L can continue to be decomposed into changes both in structure and efficiency. The change in energy consumption coefficient reflects the direct consumption, which is decomposed into input structure and real energy consumption coefficient. The technology progress gives the total demand of production per unit final demand. So the structure effect of technology means the total demand structure of production, which implies the proportion change of total demand in production due to final demand change.

Therefore the energy consumption coefficient e_1' and technology coefficient L_1 can be expressed as,

$$\begin{aligned} e_1' &= R_{e1} e_0' S_{e1} \\ L_1 &= R_{l1} L_0 S_{l1} \end{aligned} \qquad (2\text{-}12)$$

Where, R_e and R_l are the effects of input structure and the proportion of total demand in production respectively. S_e and S_l are the effects of real energy efficient and real technology progress respectively.

2.4 The decomposition model of SDA

It is suggested in the literature that when using the SDA two-polar decomposition method could be adopted as sound proxy. That is to decompose from the base year and from the report year respectively, and then obtain the estimation by averaging the two polar results. Let two-polar be denoted as 0 and 1 time, respectively.

Taking 1 time into account, the decomposition equation of one polar SDA of energy intensity is

$$\frac{I_1}{I_0} = \frac{\mu(e_1' L_1 B_1 + h_1 c)F_1}{\mu(e_0' L_0 B_0 + h_0 c)F_0} \times \frac{V_0}{V_1} \tag{2-13}$$

$$\frac{I_{11}}{I_{10}} = \frac{\mu(e_1' L_1 B_1 + h_1 c)F_1}{\mu(e_0' L_1 B_1 + h_1 c)F_1} \times \frac{\mu(e_0' L_1 B_1 + h_1 c)F_1}{\mu(e_0' L_0 B_1 + h_1 c)F_1} \times \frac{\mu(e_0' L_0 B_1 + h_1 c)F_1}{\mu(e_0' L_0 B_0 + h_1 c)F_1}$$

$$\times \frac{\mu(e_0' L_0 B_0 + h_1 c)F_1}{\mu(e_0' L_0 B_0 + h_0 c)F_1} \times \frac{\mu(e_0' L_0 B_0 + h_0 c)F_1}{\mu(e_0' L_0 B_0 + h_0 c)F_0} \times \frac{\lambda F_0}{\lambda F_1} \tag{2-14}$$

Taking 0 time into account, the decomposition equation of another polar SDA of energy intensity is

$$\frac{I_{01}}{I_{00}} = \frac{\mu(e_1' L_0 B_0 + h_0 c)F_0}{\mu(e_0' L_0 B_0 + h_0 c)F_0} \times \frac{\mu(e_1' L_1 B_0 + h_0 c)F_0}{\mu(e_1' L_0 B_0 + h_0 c)F_0} \times \frac{\mu(e_1' L_1 B_1 + h_0 c)F_0}{\mu(e_1' L_1 B_0 + h_0 c)F_0}$$

$$\times \frac{\mu(e_1' L_1 B_1 + h_1 c)F_0}{\mu(e_1' L_1 B_1 + h_0 c)F_0} \times \frac{\mu(e_1' L_1 B_1 + h_1 c)F_1}{\mu(e_1' L_1 B_1 + h_1 c)F_0} \times \frac{\lambda F_0}{\lambda F_1} \tag{2-15}$$

So $\frac{I_1}{I_0} = (1.1) \times (1.2) \times (1.3) \times (1.4) \times (1.5)$

$$(1.1) = \sqrt{\frac{\mu(e_1' L_1 B_1 + h_1 c)F_1}{\mu(e_0' L_1 B_1 + h_1 c)F_1} \times \frac{\mu(e_1' L_0 B_0 + h_0 c)F_0}{\mu(e_0' L_0 B_0 + h_0 c)F_0}}$$

Where, (1.1) is the change of energy consumption coefficient.

$$(1.2) = \sqrt{\frac{\mu(e_0' L_1 B_1 + h_1 c)F_1}{\mu(e_0' L_0 B_1 + h_1 c)F_1} \times \frac{\mu(e_1' L_1 B_0 + h_0 c)F_0}{\mu(e_1' L_0 B_0 + h_0 c)F_0}}$$

Where, (1.2) is the change of total requirement coefficient.

$$(1.3) = \sqrt{\frac{\mu(e_0' L_0 B_1 + h_1 c)F_1}{\mu(e_0' L_0 B_0 + h_1 c)F_1} \times \frac{\mu(e_1' L_1 B_1 + h_0 c)F_0}{\mu(e_1' L_1 B_0 + h_0 c)F_0}}$$

Where, (1.3) is the structural change of final demands.

$$(1.4) = \sqrt{\frac{\mu(e_0' L_0 B_0 + h_0 c)F_1}{\mu(e_0' L_0 B_0 + h_0 c)F_0} \times \frac{\lambda F_0}{\lambda F_1} \times \frac{\mu(e_1' L_1 B_1 + h_1 c)F_1}{\mu(e_1' L_1 B_1 + h_1 c)F_0} \times \frac{\lambda F_0}{\lambda F_1}}$$

Where, (1.4) is the change of final demands.

$$(1.5) = \sqrt{\frac{\mu(e_0' L_0 B_0 + h_1 c)F_1}{\mu(e_0' L_0 B_0 + h_0 c)F_1} \times \frac{\mu(e_1' L_1 B_1 + h_1 c)F_0}{\mu(e_1' L_1 B_1 + h_0 c)F_0}}$$

Where, (1.5) is the change of final energy consumption coefficient.

3 Empirical results

3.1 Data

Based on the model developed above, five determining factors' data are needed. The data come from two kinds of tables: one is the constant price input-output time-series tables of the 1985-2005s, compiled by National Bureau of Statistics of China based on 2000 prices; the other is physical-monetary energy input-output table, constructed by the Chinese Academy of Sciences, based on physical data in the Chinese energy statistical yearbooks. There are eight categories of final demands in our serial tables: 1) rural household consumption; 2) urban household consumption; 3) government consumption; 4) fixed capital formation; 5) changes in inventory; 6) export; 7) import; 8) others. In order to be compatible with energy data, the serial tables are aggregated into 44 sectors, in which the former nine sectors belong to energy sectors. The primary sectors are: coal, crude oil, natural gas and watered electricity (including nuclear electricity); and the secondary energy sectors contain: firepower electricity, finished oil (including fuel oil, gasoline, kerosene, diesel oil), coke, steam, gas and others. Furthermore, the gross energy consumption refers to the summation of intermediate energy input, final energy consumption and energy loss in the primary sector.

Figure 1 shows the trend in energy intensity in China in 1991-2005s. Before 2002, energy intensity in China had been controlled efficiently. However, in 2002-2005s, energy intensity shows a reverse trend. Therefore, the change in energy intensity has been divided into four time periods: 1987-1992, 1992-1997, 1997-2002, and 2002-2005. The main focus here lies on explaining the reason behind the rise in energy intensity in 2002-2005s.

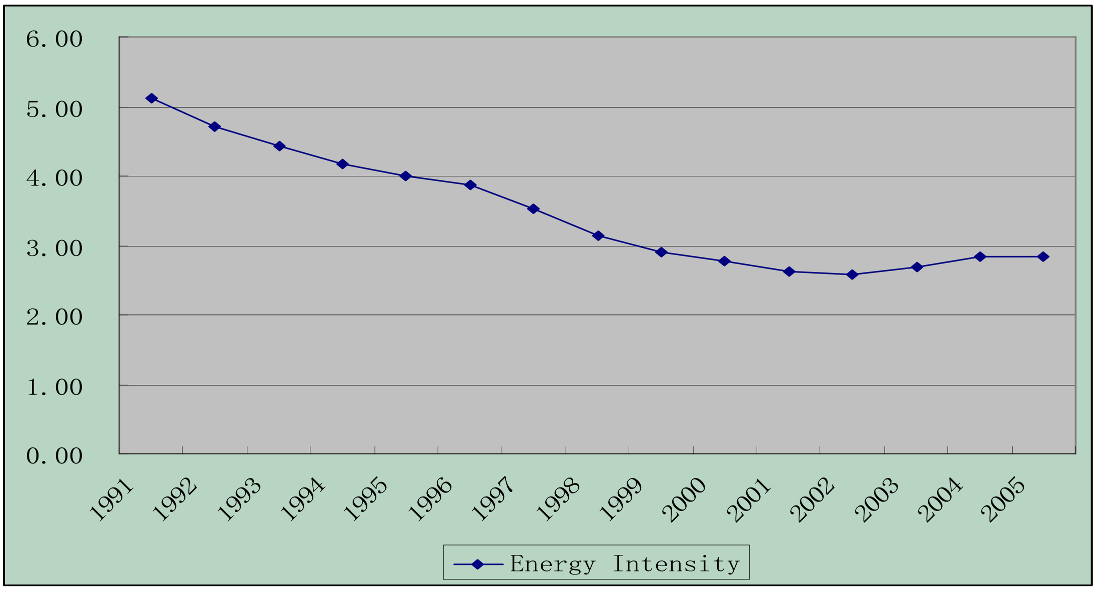

Figure 1 the trend in energy intensity in China in 1991-2005 (1990 price）

3.2 Result and analysis

3.2.1 Overall analysis

Based on the model and energy input-output serial table, table 2-4 show the results

Table 2 the determinants of energy intensity

Determinants	1987-1992	1992-1997	1997-2002	2002-2005
Energy consumption coefficient	0.936	0.643	0.735	0.909
Technology coefficient	0.904	1.133	1.071	1.130
Final demands structure	1.044	1.139	1.073	1.029
Final demands	0.976	1.005	0.906	0.998
Final energy consumption coefficient	0.957	0.945	0.969	1.010
Change of energy intensity	0.825	0.787	0.742	1.065

Table 3 the contribution ratios of determinants of energy intensity

Determinants	1987-1992	1992-1997	1997-2002	2002-2005
Energy consumption coefficient	-24%	-52%	-50%	-35%
Technology coefficient	-36%	19%	13%	50%
Final demands structure	16%	20%	14%	11%

Final demands	-9%	1%	-18%	-1%
Final energy consumption coefficient	-16%	-8%	-6%	4%

Table 4 the determinants of energy consumption and technology coefficient

Determinants	1987-1992	1992-1997	1997-2002	2002-2005
Input structure	0.655	0.576	0.729	0.903
Real energy consumption coefficient	1.429	1.116	1.009	1.006
Energy consumption coefficient	0.936	0.643	0.735	0.909
Proportion of total demand in production	0.915	1.081	1.046	1.133
Real technology coefficient	0.987	1.048	1.025	0.998
Technology coefficient	0.904	1.133	1.071	1.130

Table 2 and 4 present the impact of determining factors of energy intensity. The value that is larger than 1 indicates positive effect on the increase of energy intensity; while the opposite represents the negative effect on the increase of energy intensity. The value closer to 1 indicates the weaker effect of determining factors is on energy intensity. Table 3 shows the contribution ratio of each component.

Ⅰ.Energy intensity

1997-2005 energy intensity changes in U-shape. Before 2002, energy intensity had continued to decline about 20%, mainly caused by the combined effect of the input structure (30% contribution) and final energy consumption coefficient (10% contribution) . However, the real energy consumption gave rise to energy intensity. Since 2002, the energy intensity increased by 6%, mainly due to the 13% increase in total demand structure of production and 3% in final demand structure.

Ⅱ.Energy consumption coefficient

Consumption coefficient is an extremely important factor to positively pull-down the energy intensity. There are numerous literatures pointing out that the main factor helps to reduce energy intensity in 1990s is energy consumption coefficient. Despite those studies, this paper argues that input structure is the main reason pulling down energy intensity by using RAS method. Table 4 shows that the input structure falls more than 30%, while the real energy efficiency is not improved. Real energy efficiency, nevertheless, lifts up energy intensity though the trend is increasingly weak.

Ⅲ.Technology

Technical factor or Leontief inverse has gradually increased impact on energy intensity change. It is found that the total demand structure in production (increased by 13.3%) to be the main factor in explaining the energy intensity rise in 2002-2005. Over the past few years, the most obvious change was seen in "Tenth Five-Year Economic Planning", when China's infrastructure developed rapidly followed by significant increase for iron and steel, building materials, chemical industry and other related products. Most of them are intensive-energy-consuming industries, which may lead to energy intensity goes up. Whereas the real technical factor has not changed much with the value approximately one, indicating minor technological progress taken place to lower energy intensity. With respect to this perspective, in contrast with the argument "negative technological progress lead to higher energy intensity" holding by some other research, our result shows little role played by the real technology factor to energy intensity change.

Ⅳ. Final demand structure

The changes of final demand structure are apt to energy intensity rise. Table 3 shows that the contribution of final demand structure is gradually weak year after year, with ratio from 14% to 3%. However, it can easily be observed that the demand structure is one important factor to higher energy intensity in 2002-2005. This may due to the increasing proportion of energy-consuming products, which finds its way in the upgrading of consumption structure, the changing of investment and export structure.

Ⅴ. Other factors

The changes of final demand affected both the total energy consumption and GDP. In this sense, the effect of this factor is weakened in explaining energy intensity, still we can see clearly that the changes of final demand lowers energy intensity. It is also found that this factor has greater impact on GDP growth than on energy consumption change.

From 1987 to 2002, the final demand efficiency made energy intensity reduce by 5%, but the role has gradually diminished; but the factor led energy intensity to increase by 1% in 2002-2005. It should also be paid attention to improve final energy efficiency, given the small effect.

3.2.2 Energy intensity increase in 2002-2005: industry by industry analysis

The main causes to increase of energy intensity in 2002-2005 were structural factors, such as the total demand structure in production and final demand structure. In the following, Tables 5-9 listed the first ten industries that change most significantly for energy intensity for both factors in 2002-2005. And industry by industry analysis is made to energy intensity change accordingly.

Table 5 the change of total demand structure in production

Ferrous metal ore mining	1.502
Hydro and Nuclear Power production and supply	1.410
Nonmetallic mineral products	1.356
Gas production and supply	1.335
Instruments, meters, cultural and office machinery	1.272
Thermal power production and supply	1.268
Food manufacturing	1.234
Electric equipment and machinery	1.219
Transport, storage and post services	1.200
Non-ferrous metal ore mining	1.183

Table 6 the change of rural residential consumption structure

Transport equipment	2.169
Electric equipment and machinery	2.013
Tobacco products	1.882
Transport, storage and post services	1.388
Wearing apparel	1.388
Petroleum and nuclear processing	1.380
Wines and Beverage manufacturing	1.293
Other manufacturing products	1.285
Electronic and telecommunication equipment	1.223
Metal products	1.170

Table 7 the change of urban residential consumption structure

Electric equipment and machinery	1.561

Gas production and supply	1.495
Transport equipment	1.384
Other manufacturing products	1.345
Transport, storage and post services	1.284
Wearing apparel	1.246
Steam and Hot water production and supply	1.219
Tobacco products	1.200
Special industrial machinery	1.200
Other services	1.118

Table 8 the change of investment structure in fixed assets

Instruments, meters, cultural and office machinery	4.090
Metal products	1.919
Other services	1.800
Electric equipment and machinery	1.759
General industrial machinery	1.480
Other manufacturing products	1.420
Sawmills and furniture	1.275
Transport, storage and post services	1.261
Electronic and telecommunication equipment	1.210
Wholesale, retail trade services, accommodation and food serving services	1.103

Table 9 the change of export structure

Ferrous metal smelting and pressing	2.440
Non-ferrous metal ore mining	2.062
Electronic and telecommunication equipment	1.522
Wines and Beverage manufacturing	1.503
Instruments, meters, cultural and office machinery	1.326
Tobacco products	1.299

Transport equipment	1.293
Chemical fibers	1.241
Rubber products	1.177
Metal products	1.143

Ⅰ. Overall analysis

From Tables 5-7, we can see that the structure of household consumption and total demand structure of production in energy sectors have markedly increased, such as petroleum, gas and electricity. In mining industries: for the ferrous metal mineral mining sector total demand structure in production and investment structure have increased; while for the non-ferrous metals sector, the export structure and total demand structure in production are worsen notably. In manufacturing industries: for the non-metallic mineral products sector, total demand structure in production and investment structure are upgrading; and for food and beverage manufacturing sector, total demand structure in production and final demand structure are improved though to a different extent. The changes in total demand structure of production and final demand structure for some industries are significant. These industries include instruments, meters, office equipment, transport equipment, electrical equipment and machinery, electronic and telecommunications equipment, all of which belong to the equipment manufacturing industry. In service industries, the total demand structure in production and final demand structure of transport, wholesale, retail and other services showed a trend to increase energy intensity.

Ⅱ. Ferrous metal industry

Tables 5 and 9 show that, among others, the ferrous metal mineral mining industry, and the ferrous metal smelting and pressing industry experience the most significant changes in total demand structure and export structure. Iron ore, steel and other ferrous related products are very important for economic development, as raw materials are involved in almost all industries, such as real estate, machinery, appliances and automobiles of downstream users. China's Tenth Five-Year period is marked as a period of rapid extensive economic growth, which caused some problems. Taking the mineral mining industry as an example, domestic production soared from 220 million tons of iron ore in 2000 to 370 million tons in 2005, which was an increase of 150 million tons in five years. Half of this increase was dependant on advanced mining and general level mineral processing equipment, and half of this on outdated equipment, which not only had a low recovery rate, but also came with heavy consumption and pollution. This was mainly due to China's economic policies on non-public enterprises in 2002-2005, when policy support was launched to encourage production aimed at financial income increases. Small-scale companies with low level production skills obtained unprecedented development, which were in intensive energy consuming industries. In some areas, different administrative levels, such as province, city and county, all developed iron and steel production leading to hundreds of dozens of steel mills in one region. At the same time as construction and expansion of large and medium-sized iron and steel plants, a large number of competitive-lacking small-scale steel mills were established. In this overheated investment and exploitation atmosphere, the national steel production capacity rose from 150 million tons in 2000 to 470 million tons in 2005, which was a growth of more than two-fold in five years.

Ⅲ. Machinery and equipment manufacturing

Instruments, meters, office equipment, transport equipment, electrical equipment and machinery, electronic and telecommunications equipment all belong to equipment manufacturing. From these tables, we can see that machinery and equipment manufacturing is the most import industry to affect energy intensity during 2002-2005. Furthermore, it is clearly demonstrated in the changes of consumption and investment structure. Machinery and equipment manufacturing have some merits, such as high technology intensity, a large export deficit, extensive covering, and sizeable investment. In the "Tenth Five-Year" period, one of the key points of China's economic planning is to revitalize the equipment manufacturing industry. This focuses on the development of large-scale power generation equipment, EHV substation equipment, large-scale coal-chemical equipment, large metallurgical equipment and so on. In 2005, the gross industrial output value of the machinery industry reached 4.1428 trillion yuan, a compared increase of 21.55%. The sales revenue rose to 4.0307 trillion yuan, an increase of 22.35%. The industrial value added was 1.0821 trillion yuan, an increase of 20.3%. The output of large and medium-sized tractors, power equipment grew by more than 30%, and total value of import and export reached 222.867 billion U.S. dollars, increasing by 16.73%.

Ⅳ. Transport, storage and post services

The most visible characteristic of government consumption structure is the increasing purchase of transport, storage and post services. In "Tenth Five-Year" period, China's export rebates amounted to 1.194447 trillion yuan, which was an increase of 2.8 times over the previous last five-year period. The annual average rebate has increased by 33 percent, which is much higher than the level of revenue growth during the same period. In addition, transport, storage and post services involve a wide range of industries, such as equipment manufacturing industries, transport equipment, steel, electricity and the oil industry. In 2005, with the development of the logistics industry, the investment growth in this industry increased significantly. The "Tenth Five-Year" period is the fastest growing period for China's highway infrastructure expansion. National road mileage reached 1.9 million kilometers, of which 500,000 kilometers was new. In the "Tenth Five-Year" period, China's railway infrastructure investment amounted to more than 600 billion yuan. And railway mileage increased by 24,700 kilometers, which is 1.52 times of the sum of the present rate of increase.

4 Conclusions

To sum up, since the 1980s, the energy intensity has increased because of the combined effect of many kinds of factors. So it is important to enhance energy-saving. The conclusions are as follows:

Ⅰ 1997-2005 energy intensity changed in U-shape. Before 2002, the input structure and final energy consumption coefficient were the main effect that promoted the reduction of energy intensity. However, the real energy consumption was leading to a rise in energy intensity. Since 2002, the energy intensity increased by 6% over that in 2005, mainly due to an increase in total demand structure in production and final demand structure.

Ⅱ The input structure has been the main reason for a reduction in energy intensity, but the real energy efficiency has not improved. However, real energy efficiency has led to energy intensity increasing, but the negative trend has been increasingly weak.

Ⅲ The total demand structure in production is the main cause of the energy intensity rise during 2002-2005. Over these few years, the most obvious effect was from the "Tenth Five-Year Economic Plan". The impact was China's infrastructure developing rapidly, which was followed by iron and steel, building materials, chemical industry and other related products increasing significantly. Almost all of them are intensive energy consuming industries, which have lead to increased energy intensity. However, real technological progress did not change much, and thus could do little to improve energy intensity.

Ⅳ The structural changes of consumption, investment and export demand have played an important role on energy intensity change. It is clear that the demand structure was an important factor affecting energy intensity during 2002-2005. The proportion of energy-consuming products increased, which took place with an upgrade in the consumption structure, and a change of investment and export structure.

China's Tenth Five-Year period was a period of rapid extensive economic growth, which caused some problems. During 2002-2005, China's extensive economic pattern succeeded in generating substantial growth in the national economy, while on the other hand, it also made industrial growth and urban construction a gloomy situation that became out-control, as well as reversing the rise in energy intensity. In other words, it is unwise that economic growth at the expense of increasing energy consumption and deteriorating environment.

Reference

[1]. Shigemi Kagawa and Hajme Inamura. A Structural Decomposition of Energy Consumption Based on a Hybrid Rectangular Input-Output Framework: Japan's Case. Economic systems research, 2001, 4(13):339-363.

[2]. Mark de Haan. A Structural Decomposition Analysis of Pollution in the Netherlands. Economic systems research, 2001, 2(13): 181-196.

[3]. Shigemi Kagawa and Hajme Inamura . A Simple Multi-Regional Input–Output Account for Waste Analysis. Economic systems research, 2004, 1(16): 3-22.

[4]. Henrik K.Jacobsen. Energy Demand, Structural Change and Trade: A Decomposition Analysis of the Danish Manufacturing Industry. Economic systems research, 2000, 3(12): 319-343.

[5]. Kiyoshi Fujikawa and Carlo Milana. Input-Output Decomposition Analysis of Sectoral Price Gaps between Japan and China. Economic systems research, 2002, 1(14): 59-79.

[6]. Kazumi Hitomi etc. The Role of Interregional Trade in Generating Change in the Regional Economies of Japan, 1980-1990. Economic systems research, 2000, 4(12): 515-537.

[7]. Erik Dietzenbacher and Bart Los. Structural Decomposition Analyses with Dependent Determinants. Economic systems research, 2000, 4(12): 497-514.

[8]. Aying Liu and David S.Saal. Structural Change in Apartheid-era South Africa: 1975-93. Economic systems research, 2001, 3(13): 235-257.

[9]. Rolando Alcala etc. Technical Change in the Private Consumption Converter. Economic systems research, 1999, 4(11): 389-400.

[10]. Erik Dietzenbacher and Bart Los. Labor Productivity in Western Europe 1975-1985: An Intercountry, Interindustry Analysis. Journal of Regional Science, 2000, 3(40): 425-452.

[11]. Erik Dietzenbacher and Jesper Stage. Mixing Oil and Water? Using Hybrid Input-Output Tables in a Structural Decomposition Analysis. Economic systems research, 2006, 1(18): 85-95.

[12]. Xiannuan Lin, Karen R. Polenske. Input-Output Anatomy of China's Energy Use Changer in the 1980s [J]. Economic Systems Research, 1995, 7(1):67-83.

[13]. Richard F. Garbaccio, Mun S. Ho. Why has the Energy-Output Ratio Fallen in China?. Energy Journal, 1999, 20(3): 63-91.

[14]. Karen Fisher-Vanden, Gary H. Jefferson. What is driving China's decline in energy intensity?

Resource and Energy Economics, 2004, 26: 77-97.

[15].]Huang J.P. Industry Energy Use and Structural Change: a Case Study of The People's Republic of China [J]. Energy Economics, 1993, (15):131~136.

[16].]Zhang, Z.X. Why did the Energy Intensity Fall in China's Industrial Sector in the 1990s? The Relative Importance of Structural Change and Intensity Change [J]. Energy Economics, 2003, (25):625~638.

[17].]ChunboMa, David I. Stern. China's Changing Energy Intensity Trend: a Decomposition Analysis [Z]. Working papers, Rensselaer Polytechnic Institute, 2006.

[18]. Muigiopadhyay & Chakraborty. India's Energy Consumption Changes during. Economic Systems Research, 1999, 4(11):423-438.

[19]. Vicent Alcantaraa, Rosa Duarte.Comparison of energy intensities in European Union countries: Results of a structural decomposition analysis. Energy Policy, 2004, 32:177-189.

[20]. Piyush Tiwari. An analysis of sectoral energy intensity in India. Energy Policy, 2000, 28:771-778.

[21]. Zhou Yong, Li Lianshui. The change factors of energy intensity in china based on AWD. Charcoal economy research. 2006, (5):39-43.

[22]. Ding Lequn etc. The decomposition model and analysis of energy consumption per unit GDP. Energy research and information. 2007, (3):146-153.

[23]. Shi Bo, The analysis of dominant effect on energy intensity in china. Transaction of Shan Xi fiancé and economic university. 2007, (12):24-28.

[24]. Chen Xikang. Analysis of total integrated energy consumption. System sciences and mathematics. 1981, (1):69-76.

[25]. Li Jinghua. Input-output analysis of the third industry in china: 1987-2005.The application paper volume of input-output, The Chinese statistics publishing company. 2004:174-176.