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The fluctuations of China’s energy intensity: Biased technical change

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Abstract: The fluctuations of China's energy intensity have attracted the attention of many scholars, but fewer studies consider the data quality of official input-output tables. This paper conducts a decomposition model by using the Divisia method based on the input-output tables. Because of the problems with input-output tables and price deflators, we first produce constant prices to deflate the input-output tables. And then we consider different levels of biased technical change for different sectors in the adjusting the input-output table. Finally, we use RAS technique to adjust input-output matrix. Then the decomposition model is employed to empirically analyze the change of China’s energy intensity. We compare the decomposition results with and without biased technical change and do sensitive analysis on the level of biased technical change. The conclusions are that during 2002-2007, except crude oil and refined oil, the energy intensity increased and the changes were mostly attributed to the structural change, while the changes in the production technology actually decreased the energy intensity. Furthermore, compared to the decomposition without biased technical change, the degree of the influence from structural change on the changes in energy intensity depends on the level of biased technical change.

Keywords: Biased Technical Change; Divisia Decomposition; Input-Output Analysis; Energy Intensity; China; RAS Technique

1. Introduction

The fluctuations of China's energy intensity have attracted the attention of many scholars. Most of the studies focus on the national trend of energy intensity, energy consumption, etc. For example, Wei and Liao *et al*. [1] examined the impact of economic structure on the energy macro-efficiency, and applied Divisia and input-output analysis to analyze the way the industrial structure, final use structure and national income distribution structure affected China's energy macro-efficiency. Liu and Jiang [2] employed the structural decomposition method to study the increasing trend of China's energy consumption in recent years. Similar studies like energy intensity changes (Wang and He [3]), emerging energy expenditure relationship (Kahrl and Roland-Holst [4]).

Some other studies consider the changes in energy intensity or energy consumption at a specific sector or enterprises. Cao *et al*. [5] used a structural decomposition method to reveal the changes in the total embodied energy requirement for the agricultural sector. Fisher-Vanden *et al*. [6] used a panel data for industrial enterprises to find the decline in energy consumption and energy intensity. Similar studies such as residential carbon emission (Fan *et al*. [7]).

Besides the national studies and sectoral studies, the rest pay attention to the changes in energy intensity at regional level. Li and Leung [8] applied a panel cointegration and error-correction model to investigate the relationship between coal consumption and real GDP of 23 provinces in China. Liao *et al*. [9] used the structural decomposition analysis method to analyze the changes in energy intensity in Beijing. Similar studies like regional CO2 emissions in Beijing (Wang *et al*. [10]).

This paper decomposes the changes in China's energy intensity between 2002 and 2007 using a Divisia decomposition method and input-output tables. Compared to most of the other similar researches, the main improvement is that this paper considers the biased technical change between different years which draws on the work of Garbaccio *et al*. [11]. The reason why we introduce the biased technical change is that the corresponding data have some problems. Therefore we come up with an adjustment framework of input-output tables to obtain a consistent data set. Different from Garbaccio *et al*. [11], we use input-output tables with more detailed sectors to get more accurate results. Furthermore, we present a definition of the biased technical change and apply different levels of biased technical change for different sectors instead of a fixed level in Garbaccio *et al*. [11].

Our main conclusion is that most of the increase in the energy intensity between 2002 and 2007 were caused by structural change, while changes in the production technology offset the level of increase. Section 2 describes the structure of energy intensity decomposition model. Section 3 discusses the problems of corresponding data and the framework of adjustment. Section 4 presents the decomposition results for changes in China's energy intensity during the period of 2002-2007; the last section offers the conclusions and future work.

2. Decomposition Model for Energy Intensity

Divisia method (As far as we know, Boyd [12] introduced the Divisia index method to the decomposition in energy) and two approximate methods (which include arithmetic pattern [13] and logarithmic pattern [14, 15]) used in discrete state have been widespread used in the studies related to price index, energy, resources, environment, pollution, etc. The two approximate methods both have residual and meet the properties of monotonicity, commensurability, expansibility, linear homogeneity and transitivity [16].

Our Divisia model is based on the work of Garbaccio *et al*. [11] and also uses the input-output tables. Input-output analysis is widely used in the social, energy and environmental aspects, such as energy use and air pollutants emissions (Cellura *et al.* [17]), socio-economic impacts of sugarcane-derived bioethanol production (Herreras *et al*. [18]), greenhouse gas (Cansino *et al*. [19], Limmeechokchai and Suksuntornsiri [20]), energy and GHG emission intensity (Chung *et al*. [21]), Socio-technological impact (Chung *et al*. [22]).

In the general input-output model, the sum of intermediate use and final use equal the gross output and using the matrix pattern, i.e.

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

where A is the input-output matrix, X is the vector of gross output and Y is the vector of final use.

According to the input-output table and expenditure approach of GDP, the final use can be divided in:

$$Y = CON + GOV + INV + STO + EX - IM \tag{2}$$

where CON, GOV, INV, STO, EX, IM is the vector of household consumption expenditure, government consumption expenditure, gross fixed capital formation, change in inventories, exports and imports, respectively.

We rewrite the final use and its components as follows:

$$Y = \gamma Q = CON + GOV + INV + STO + EX - IM \\ = \left(\gamma^{con} + \gamma^{gov} + \gamma^{inv} + \gamma^{sto} + \gamma^{ex} - \gamma^{im}\right) Q \tag{3}$$

where Q is the sum of final use (i.e. GDP); and γ^{con}, γ^{gov}, γ^{inv}, γ^{sto}, γ^{ex}, γ^{im} is the share vector of household consumption expenditure, government consumption expenditure, gross fixed capital formation, changes in inventories, exports and imports, respectively.

We rewrite the final use in Eq. (3) as the gross domestic demand (i.e. final use of domestically produced goods) minus imports:

$$Y = Y^{d} - IM = \left(\gamma^{d} - \gamma^{im}\right) Q \tag{4}$$

In general, Eq. (1) has the following solution:

$$X = (I - A)^{-1} Y = LY = L\gamma Q \tag{5}$$

And the domestic energy use (EU) in a country equals domestic production plus imports minus exports:

$$EU = e(X + IM - EX) = e(L\gamma Q + IM - EX) \tag{6}$$

where e is a vector with n sectors. The elements, which correspond to the energy sectors, are ones, and the rest are zeros. The purpose of this vector is to select the energy sector.

According to the definition of the energy intensity, we get the energy intensity (EI) by energy type as:

$$EI = \frac{EU}{Q} = \frac{e(L\gamma Q + IM - EX)}{Q} = eL\gamma + e\gamma^{im} - e\gamma^{ex} = eL\gamma^{d} - eL\gamma^{u} + e\gamma^{im} - e\gamma^{ex} \tag{7}$$

Differentiating the Eq. (7) with respect to time and we get:

$$\dot{EI}_{it} = \sum_j e_i \dot{L}_{ijt} \gamma_{jt} + \sum_j e_i L_{ijt} \dot{\gamma}^{d}_{jt} - \sum_j e_i L_{ijt} \dot{\gamma}^{im}_{jt} + e_i \dot{\gamma}^{im}_{jt} - e_i \dot{\gamma}^{ex}_{jt} \tag{8}$$

where i, j is the *i*th and *j*th sector, t stands for the time.

Then both sides of Eq. (8) are divided by EI_{it}:

$$\frac{\dot{EI}_{it}}{EI_{it}} = \sum_j \frac{e_i L_{ijt} \gamma_{jt}}{EI_{it}} \times \frac{\dot{L}_{ijt}}{L_{ijt}} + \sum_j \frac{e_i L_{ijt} \gamma^{d}_{jt}}{EI_{it}} \times \frac{\dot{\gamma}^{d}_{jt}}{\gamma^{d}_{jt}} - \sum_j \frac{e_i L_{ijt} \gamma^{im}_{jt}}{EI_{it}} \times \frac{\dot{\gamma}^{im}_{jt}}{\gamma^{im}_{jt}} \\ + \sum_j \frac{e_i \gamma^{im}_{jt}}{EI_{it}} \times \frac{\dot{\gamma}^{im}_{jt}}{\gamma^{im}_{jt}} - \sum_j \frac{e_i \gamma^{ex}_{jt}}{EI_{it}} \times \frac{\dot{\gamma}^{ex}_{jt}}{\gamma^{ex}_{jt}} \tag{9}$$

And then curvilinear integrating the both sides of the Eq. (9), we get:

$$\int_\Gamma \frac{\dot{EI}_{it}}{EI_{it}} = \int_\Gamma \sum_j \frac{e_i L_{ijt} \gamma_{jt}}{EI_{it}} \times \frac{\dot{L}_{ijt}}{L_{ijt}} + \int_\Gamma \sum_j \frac{e_i L_{ijt} \gamma_{jt}^d}{EI_{it}} \times \frac{\dot{\gamma}_{jt}^d}{\gamma_{jt}^d} - \int_\Gamma \sum_j \frac{e_i L_{ijt} \gamma_{jt}^{im}}{EI_{it}} \times \frac{\dot{\gamma}_{jt}^{im}}{\gamma_{jt}^{im}}$$
$$+ \int_\Gamma \sum_j \frac{e_i \gamma_{jt}^{im}}{EI_{it}} \times \frac{\dot{\gamma}_{jt}^{im}}{\gamma_{jt}^{im}} - \int_\Gamma \sum_j \frac{e_i \gamma_{jt}^{ex}}{EI_{it}} \times \frac{\dot{\gamma}_{jt}^{ex}}{\gamma_{jt}^{ex}} \tag{10}$$

Where Γ is the integration path, which stands for curve segments ($eL\gamma^d$, $eL\gamma^{im}$, $e\gamma^{im}$ and $e\gamma^{ex}$) in the time interval (0, T). According to the Hulten [23], when the curve is linearly homogeneous, the curve integral is path independent. Referring to the definition of energy intensity, the energy intensity is linearly homogeneous, so the Eq. (11) can be written as:

$$\int_\Gamma d \ln EI_{it} = \int_\Gamma \sum_j \frac{e_i L_{ijt} \gamma_{jt}}{EI_{it}} d \ln L_{ijt} + \int_\Gamma \sum_j \frac{e_i L_{ijt} \gamma_{jt}^d}{EI_{it}} d \ln \gamma_{jt}^d - \int_\Gamma \sum_j \frac{e_i L_{ijt} \gamma_{jt}^{im}}{EI_{it}} d \ln \gamma_{jt}^{im}$$
$$+ \int_\Gamma \sum_j \frac{e_i \gamma_{jt}^{im}}{EI_{it}} d \ln \gamma_{jt}^{im} - \int_\Gamma \sum_j \frac{e_i \gamma_{jt}^{ex}}{EI_{it}} d \ln \gamma_{jt}^{ex} \tag{11}$$

Eq. (11) is the index decomposition in the continuous form, but the data in reality usually are discrete. Therefore, we apply the mean value theorem of integral to obtain the index decomposition in discrete form. We use the Törnqvist [13] index method in this paper, and we get:

$$\ln\left(\frac{EI_{iT}}{EI_{i0}}\right) = \sum_j \frac{1}{2}\left(\omega_{ij0} + \omega_{ijT}\right) \ln \frac{L_{ijT}}{L_{ij0}} + \sum_j \frac{1}{2}\left(\omega_{ij0}^d + \omega_{ijT}^d\right) \ln \frac{\gamma_{jT}^d}{\gamma_{j0}^d}$$
$$- \sum_j \frac{1}{2}\left(\omega_{ij0}^{im} + \omega_{ijT}^{im}\right) \ln \frac{\gamma_{jT}^{im}}{\gamma_{j0}^{im}} + \frac{1}{2}\left(\alpha_{i0}^{im} + \alpha_{iT}^{im}\right) \ln \frac{\gamma_{jT}^{im}}{\gamma_{j0}^{im}} \tag{12}$$
$$- \frac{1}{2}\left(\alpha_{i0}^{ex} + \alpha_{iT}^{ex}\right) \ln \frac{\gamma_{jT}^{ex}}{\gamma_{j0}^{ex}} + R$$

Where $\omega_{ijT} = \frac{e_i L_{ijT} \gamma_{jT}}{EI_{iT}}$, $\omega_{ijT}^d = \frac{e_i L_{ijT} \gamma_{jT}^d}{EI_{iT}}$, $\omega_{ijT}^{im} = \frac{e_i L_{ijT} \gamma_{jT}^{im}}{EI_{iT}}$, $\alpha_{iT}^{im} = \frac{e_i \gamma_{jT}^{im}}{EI_{iT}}$, $\alpha_{iT}^{ex} = \frac{e_i \gamma_{jT}^{ex}}{EI_{iT}}$ and R is the approximation residual.

As shown in Eq. (12), we decomposition the changes in energy intensity into production technology changes (L), final use structural changes for domestic goods (γ^d), imports structural changes (γ^{im}), exports structural changes (γ^{ex}).

3. Adjustments on China's Official Data

As one of the main purposes of this paper is to determine the causes for the changes in energy intensity, the ideal data source is the input-output table. However, due to the problems with China's official data discussed in Garbaccio *et al*. [11], using the original input-output tables will get biased results.

We only consider the changes of energy input rates, and the changes of energy input rates also can be decomposed into biased technical change and others. This paper tries to adjust the input-output data, as shown in Fig.1.

3.1 Data Pre-processing

Before we adjust the gross output of the input-output tables, we should do some data pre-processing. First, we combine the input-output tables of 2002 and 2007 into 46 sectors, due to the difference of the sectors numbers and data availability of price deflators. Second, we rearrange the "Error" column in the input-output tables and share it to other columns according to the relative proportions. Third, we adjust the electricity sector, because the use of electricity by power enterprises was included in the electricity row in 2007, but not included in 2002.

3.2 Produce Constant Prices

The next step for adjustments is producing constant prices and making the monetary values consistent with physical productions of energy sectors, as presented in Table 1. We use the physical production to determine the real gross output of the energy sectors, similar to Garbaccio *et al*. [11].

As for other non-energy sectors, we don't have real production data, so we use the official data to obtain the price deflators. For the sectors of the industry, we apply "Producer Price Indices for Manufactured Goods by Sector" from National Bureau of Statistics; the rest, we use nominal and real GDP to calculate the price deflators. Therefore, we get the price deflators of 46 sectors (as is shown in Table A.1 in Appendix) to adjust the input-output table of 2007 into constant prices in 2002. We adjust the table to balance the final use and GDP in the end.

3.3 Adjust Gross Output

As discussed in Garbaccio *et al*. [11], one of the main problems of China's official data is gross output, and we adjust gross output next. We assume the adjusted energy input rate as:

$$\frac{e'_{jT}}{x'_{jT}} = c'_j = \left(1\text{-}\alpha_j\right)\frac{u_{j0}}{x_{j0}} + \alpha_j \frac{u_{jT}}{x_{jT}}, \ j = 1, 2, \cdots, n \tag{14}$$

where u'_{jT}, x'_{jT}, c'_j is the adjusted total energy input, gross output, energy input rate for sector j at time T, respectively; u_{j0}, x_{j0}, u_{jT}, x_{jT} is the original total energy input, gross output for sector j at time 0 and time T, respectively; α_j, $j = 1, 2, \cdots, n$ means the level of biased technical changes in sector j. When $\alpha_j = 0$, there is no biased technical change in sector j and the changes in energy input rate comes from other reasons; when $\alpha_j = 1$, the case means all of the energy input rates changes coming from the biased technical changes and it is no need to adjust the input-output table.

How to determine the level of the biased technical change (α_j) is a crucial problem in this paper. Garbaccio *et al*. [11] used a fixed value for every sector and only consider the difference in the growth rate of adjusted gross output and physical production for coal and crude oil to get the value α_j. Different from Garbaccio *et al*. [11], we provide different values for different sectors and considering all of the sectors.

As we focus on the biased technical change related to energy input, the ideal α_j should reflect the difference in the technical change owing to energy input and the average technical change. Then we use the change rate of total factor productivity (TFP) to stand for the average technical change and the change rate of energy efficiency (TE) to stand for the technical change coming from the energy input. Therefore α_j will be defined as:

$$\alpha_j = \frac{TFP_j - TE_j}{TFP_j}, \ j = 1, 2, \cdots, n \tag{15}$$

where TFP_j means total factor productivity of sector j and TE_j means the growth of the energy efficiency of sector j. The TFP data of industrial sectors come from Chen [24] and TE data of industrial sectors come from Wang [25, 26].

Furthermore, in order to determine the adjusted gross output, we should assume the final use, value-added and intermediate input (except energy inputs) keep the same for the input-output table of 2007, which means:

$$x'_{jT} = m_{jT} + u'_{jT} + v_{jT}, \ j = 1, 2, \cdots, n \tag{16}$$

$$\sum_j a'_{ijT} x'_{jT} + y_{jT} = x'_{iT}, \ i = 1, 2, \cdots, n \tag{17}$$

where $m_{jT} = \sum_i a_{ijT}$ (i not in energy sectors) means the sum of intermediate input except energy input of the sector j for the time T; a_{ijT} is the element in the input-output matrix (A_T).

According to the Eq. (14) and (16), we get the adjusted gross output as:

$$x'_{jT} = \frac{v_{jT} + m_{jT}}{1 - c'_j}, \ j = 1, 2, \cdots, n \tag{18}$$

3.4 Adjust Input-output Matrix

Given the gross output and intermediate input, there are many methods to determine the input-output matrix. On the basis of Garbaccio *et al*. [11], we put forward a model to adjust input-output matrix. And the framework of this model is:

$$\min \sum_{i=1}^{n} \sum_{j=1}^{n} \left(a'_{ij} - a_{ij} \right)^2$$
$$s.t. \begin{cases} \sum_j a'_{ij} x'_j + y_{jT} = x'_i, \ i = 1, 2, \cdots, n \\ \sum_j a'_{ij} = \mathrm{c}'_i, \ i = 1, 2, \cdots, n, \ j \text{ in energy sectors} \\ 0 \le a'_{ij} \le 1 \end{cases} \tag{19}$$

As this model is a nonlinear programming model, there is no general solution. For example, *fmincon* function in Matlab can calculate some nonlinear programming model, but this function needs an initial point and the solution often is associated with the initial point. Therefore, we readjust the model (constraint 1 is adjusted as: $a'_{i1}x_1 + a'_{i2}x_2 + \cdots + a'_{in}x_n = x_i\text{-}y_i$, $i = 1, 2, \cdots, n$; constraint 2 is adjusted as: $a'_{i1}x_1 + a'_{i2}x_2 + \cdots + a'_{ij}x_j = \mathrm{c}_i x_i = e_i$, $i = 1, 2, \cdots, n$, $1, 2, \cdots, j$ is energy sectors), and then employ the RAS("RAS also known as a "biproportional" matrix balancing technique "(Miller and Blair chapter 7.4, [27]) and is a widely used technique to update input-output tables) to do the iterative solution.

The result of the RAS procedure is the adjusted input-output matrix. Because the RAS method is an iterative solution, gross output should be recalculated as:

$$X' = \left(I - A' \right)^{-1} Y \tag{21}$$

where X', A' is adjusted gross output and input-output matrix, respectively. And using the adjusted gross output and input-output matrix, we can calculate adjusted input-output table.

All the above adjusted input-output tables at each step can be found and download online (SupplementaryData.xls).

4. Decomposition Results

After finishing the adjustments on China's official data, we use the decomposition model to analyze the changes in China's energy intensity between 2002 and 2007. We consider three cases: S1 (No biased technical change), S2 (Biased technical change) and S3 (Original table) and the results are shown in Table 2.

As we can find the results in Table 2, except for S1, energy intensity of coal and electricity increased, but energy intensity of crude oil and refined oil decreased. The reasons for almost opposite results between S1 and S2 may be that there are major changes in coal and refined oil consumption from 2002 to 2007. Therefore we mainly consider the results of S2, which is about biased technical change and others as a reference.

As for coal, the energy intensity increased a little, and the major cause is the changes in final demand structure. Nevertheless, the changes in final demand structure were partially offset by the changes in production technology and import structure. And the changes in import quantity and export quantity all account small changes in energy intensity. Similar to coal, the energy intensity of electricity increased from 2002 to 2007. The difference between coal and electricity is the changes in production technology increased the energy intensity of electricity.

As for crude oil, the results were different from the ones of coal. There was a significant drop in the energy intensity of crude oil. And the changes in production technology accounted the most for changes in energy intensity. Changes in export quantity also contributed to the decline, but the changes in final demand structure, import structure and import quantity actually increased the energy intensity of crude oil. The results of refined oil are similar to those of crude oil. However, changes in the import structure decreased the energy intensity of refined oil.

5. Sensitive Analysis on α

The important coefficient in the adjustment is α and we put up a definition of α. However, given the data of TFP and TE is incredible, in this section we do a sensitive analysis on α to test the impacts from the level of α on the results.

Fig. 2 shows the results for alternative assumption about α. We adjust α for all the industrial sectors (except energy sectors) to change by -10% (S2.1), -5% (S2.2), 5% (S2.3) and 10%

(S2.4), respectively. As we don't adjust the energy sectors, the changes in energy intensity for various energy types remain the same, but the changes in the components are changed. The changes in import and export quantity also remain the same, because the adjustments of α don't affect the imports and exports for energy sectors. For coal, with the increase of adjustment rate, the changes in production technology increase, but the changes in final demand structure and import structure decrease. For crude oil, with the increase of adjustment rate, the changes in final demand structure increase, but the changes in production technology and import structure decrease. And the tendency for refined oil is different from that for crude oil, the changes in production technology and final demand structure both decrease when the adjustment of α increases, but the changes in the import structure stay the same. As for electricity, the changes in production technology and import structure increases and the changes in the final demand structure decrease following the adjustment of α increases.

A common feature of all of the decomposition results is that the changes in the final demand structure and import quantity work to increase the energy intensity, but the changes in the import structure and export quantity work to decrease the energy intensity.

6. Conclusions and Further Work

In this paper, we analyze the changes in the energy intensity of 2002-2007 using the Divisia decomposition method and adjusted input-output tables. Our major findings are that: i) structural change accounted for most of the increase in the energy intensity, while the changes in the import structure and export quantity worked to decrease the energy intensity; ii) production technology change actually decreased the energy intensity except for electricity. The conclusions are robust to various levels of biased technical change (α) which is used to correct the unreliable input-output data.

Compared to Garbaccio *et al*. [11] which also consider biased technical change, we put forward a definition to determine the different levels of the biased technical change (α) for various sectors rather than use one adjustment factor (α) for all sectors. Furthermore, Garbaccio *et al*. [11] made adjustment of gross output and direct input coefficient first and produced constant price later. Here we produce constant price first as the biased technical change was based on the constant prices. And we also use input-output tables with more detailed sectors and can get more accurate results than Garbaccio *et al*. [11].

Distinct from other decomposition studies, we carefully address the problems of official data and put up with an adjustment method. However, our method has some limitations to be overcome in the future: i) when we consider the influence of biased technical change, how to quantify the level of the biased technical change (α) to make the adjusted input-output tables consistent with the reality; ii) Because of the data availability of the physical production, we use the "Producer Price Indices for Manufactured Goods" to take the place of production. Therefore the adjustment of price deflators needs further research.

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Figures

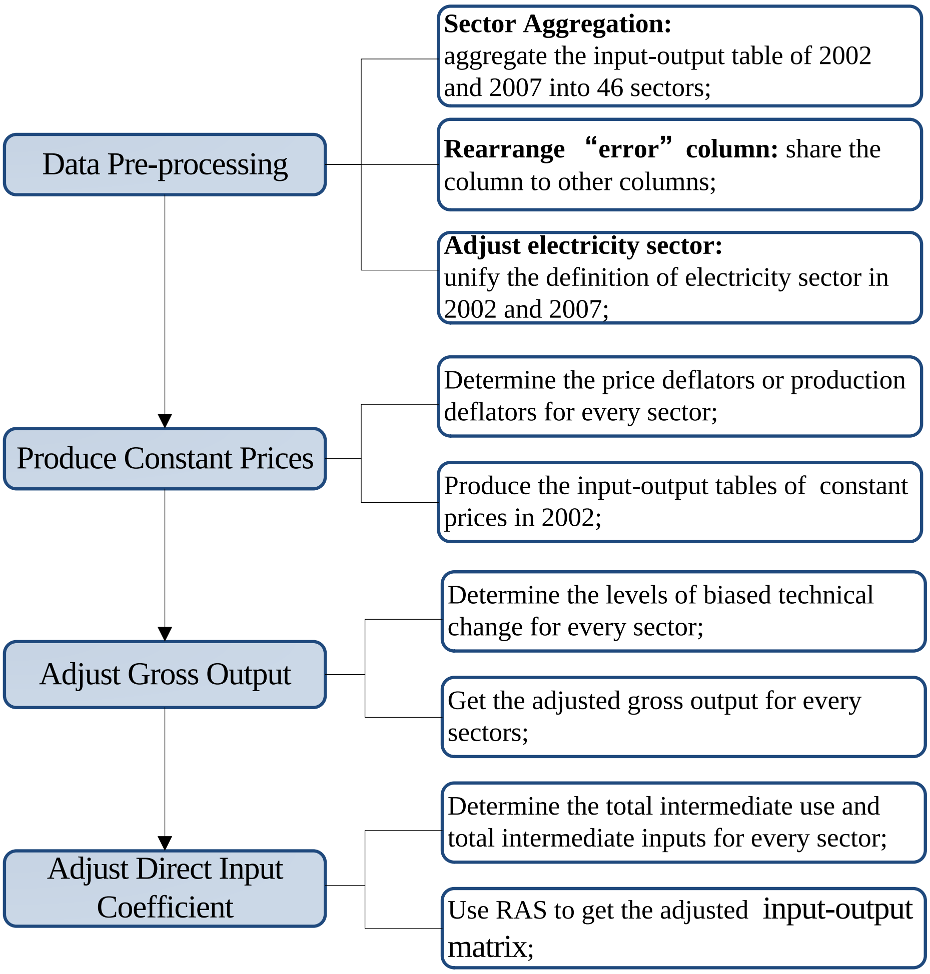

Figure 1. Flow Chart of Adjustments on China's Official Data

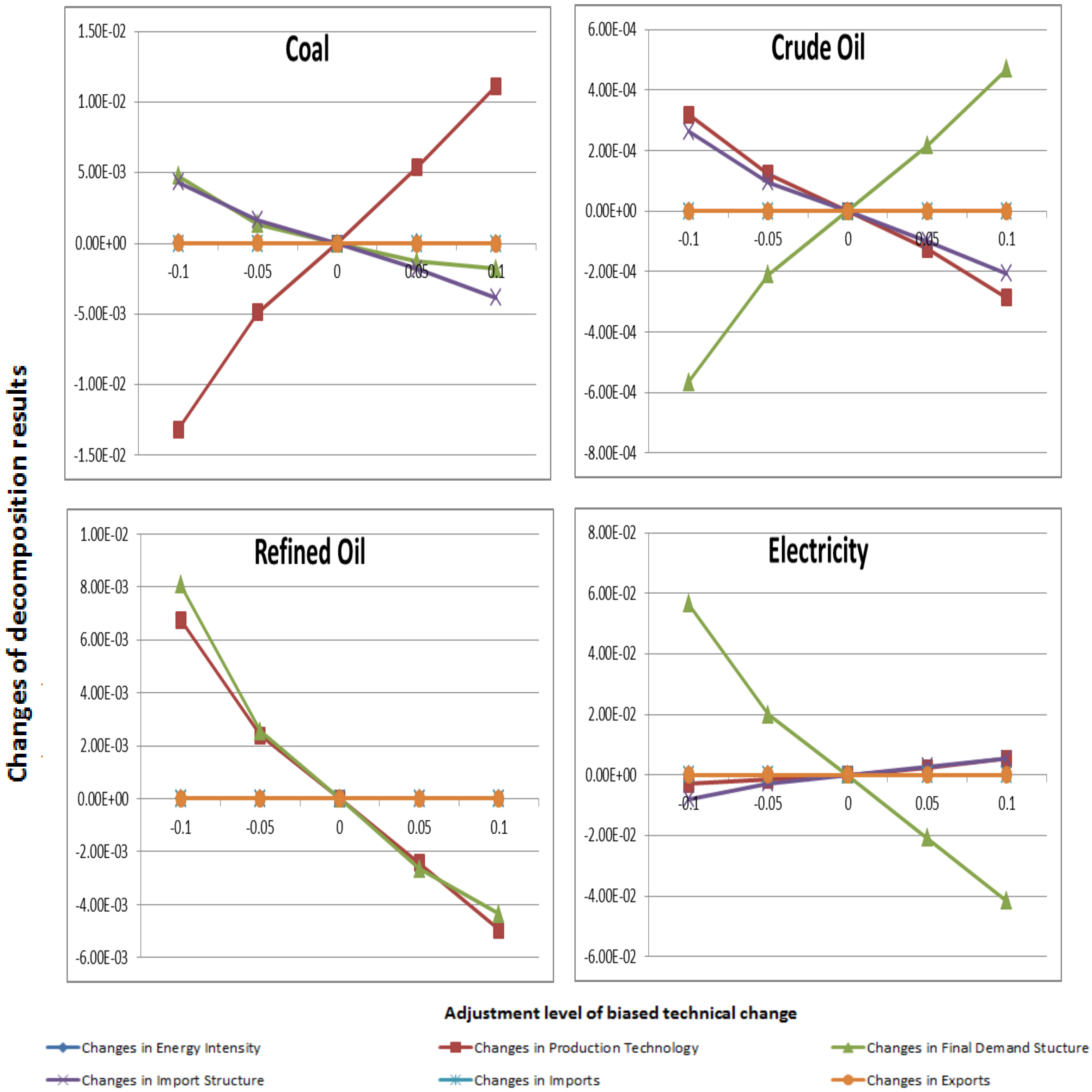

Figure 2. Results of Sensitive Analysis on α

Tables

Table 1. Physical Production for Energy Sectors (2002-2007).

Year	Coal (million tons)	Oil (million tons)	Natural Gas (billion m^3)	Electricity (billion kwh)	Refined Petroleum (million tons)	Oil & Gas Index	GDP (trillion yuan, constant prices in 2002)
2002	1550	167	33	1654	157	1.00	120
2003	1835	170	35	1911	174	1.02	132
2004	2123	176	41	2203	195	1.06	146
2005	2350	181	49	2500	207	1.09	162
2006	2529	185	59	2866	219	1.12	183
2007	2692	186	69	3282	233	1.13	209
Growth	74%	12%	112%	98%	48%	13%	73%

Source: NBS [28] and authors' calculations.

Table 2. Decomposition of various energy intensity changes in China from 2002–2007

Cases	Energy type	Changes in various components						
		Energy intensity	Production technology	Final demand structure	Import structure	Import quantity	Export quantity	Residual
S1 (No biased technical change)	Coal	-0.008	-0.917	1.700	-0.602	0.014	-0.076	-0.126
	Crude Oil	-0.462	-0.467	0.059	0.088	0.310	-0.034	-0.417
	Refined Oil	0.181	-2.670	1.613	-0.042	0.084	-0.054	1.248
	Electricity	0.181	0.659	3.034	-0.855	0.057	-0.001	-2.713
S2 (Biased technical change)	Coal	0.001	-0.853	1.707	-0.619	0.014	-0.076	-0.171
	Crude Oil	-0.424	-0.468	0.066	0.084	0.304	-0.034	-0.376
	Refined Oil	-0.156	-2.667	1.593	-0.042	0.098	-0.063	0.924
	Electricity	0.135	0.750	2.882	-0.819	0.059	-0.001	-2.735
S3 (Original table)	Coal	0.001	-0.884	1.717	-0.597	0.014	-0.076	-0.173
	Crude Oil	-0.424	-0.465	0.061	0.086	0.304	-0.034	-0.376
	Refined Oil	-0.156	-2.607	1.591	-0.042	0.098	-0.063	0.867
	Electricity	0.135	0.812	3.153	-0.868	0.059	-0.001	-3.021

Appendix

Table A.1. Price Deflator by Sector (2002-2007).

Code	Sector	Price Deflators (Year 2002=1)				
		2003	2004	2005	2006	2007
A1	Agriculture, Forestry, Animal Husbandry and Fishery	1.03	1.19	1.18	1.21	1.39
A2	Mining and Washing of Coal	1.18	1.37	1.52	1.63	1.74
A3	Extraction of Petroleum and Natural Gas	1.02	1.06	1.09	1.12	1.13
A4	Mining and Processing of Ferrous Metal Ores	1.10	1.60	1.80	1.74	1.92
A5	Mining and Processing of Non-Ferrous Metal Ores	1.07	1.26	1.51	1.86	2.09
A6	Mining and Processing of Nonmetal and Other Ores	1.00	1.06	1.16	1.19	1.23
A7	Processing of Food from Agricultural Products	1.03	1.17	1.19	1.19	1.35
A8	Manufacture of Foods	1.00	1.03	1.04	1.05	1.08
A9	Manufacture of Beverages	0.99	1.00	1.00	1.01	1.02
A10	Manufacture of Tobacco	1.01	1.02	1.03	1.03	1.03
A11	Manufacture of Textile	1.02	1.06	1.07	1.09	1.10
A12	Manufacture of Textile Wearing Apparel, Footware, and Caps	1.00	1.01	1.00	1.01	1.02
A13	Manufacture of Leather, Fur, Feather and Related Products	1.00	1.01	1.03	1.04	1.07
A14	Processing of Timber, Manufacture of Wood, Bamboo, Rattan, Palm, and Straw Products	0.99	1.01	1.03	1.05	1.09
A15	Manufacture of Furniture	1.00	1.01	1.04	1.04	1.06
A16	Manufacture of Paper and Paper Products	0.99	1.00	1.01	1.02	1.03
A17	Printing, Reproduction of Recording Media	0.98	0.96	0.95	0.95	0.96
A18	Manufacture of Articles For Culture, Education and Sport Activity	1.00	1.02	1.04	1.06	1.07
A19	Processing of Petroleum, Coking, Processing of Nuclear Fuel	1.11	1.24	1.32	1.39	1.48
A20	Manufacture of Raw Chemical Materials and Chemical Products	1.03	1.14	1.24	1.24	1.29
A21	Manufacture of Medicines	0.99	0.97	0.98	0.97	0.99
A22	Manufacture of Chemical Fibers	1.04	1.13	1.18	1.20	1.24
A23	Manufacture of Rubber	1.00	1.01	1.05	1.10	1.14
A24	Manufacture of Plastics	1.00	1.06	1.12	1.13	1.16

A25	Manufacture of Non-metallic Mineral Products	1.00	1.03	1.04	1.05	1.06
A26	Smelting and Pressing of Ferrous Metals	1.10	1.31	1.37	1.32	1.42
A27	Smelting and Pressing of Non-ferrous Metals	1.05	1.25	1.40	1.71	1.95
A28	Manufacture of Metal Products	1.00	1.08	1.12	1.13	1.16
A29	Manufacture of General Purpose Machinery	1.00	1.03	1.05	1.05	1.06
A30	Manufacture of Special Purpose Machinery	1.00	1.01	1.03	1.04	1.06
A31	Manufacture of Transport Equipment	0.98	0.96	0.95	0.95	0.95
A32	Manufacture of Electrical Machinery and Equipment	0.98	1.01	1.05	1.12	1.17
A33	Manufacture of Communication Equipment, Computers and Other Electronic Equipment	0.94	0.89	0.85	0.82	0.80
A34	Manufacture of Measuring Instruments and Machinery for Cultural Activity and Office Work	0.97	0.96	0.95	0.94	0.93
A35	Manufacture of Artwork and Other Manufacturing	1.02	1.08	1.12	1.15	1.20
A36	Recycling and Disposal of Waste	1.11	1.30	1.37	1.42	1.48
A37	Production and Distribution of Electric Power and Heat Power	1.16	1.33	1.51	1.73	1.98
A38	Production and Distribution of Gas	1.03	1.06	1.11	1.19	1.25
A39	Production and Distribution of Water	1.05	1.10	1.14	1.21	1.27
A40	Construction	1.03	1.11	1.14	1.16	1.24
A41	Transport, Storage and Post	1.00	1.02	1.05	1.09	1.17
A42	Wholesale and Retail Trade	1.02	1.06	1.06	1.05	1.10
A43	Hotel and Restaurants	1.02	1.07	1.09	1.10	1.16
A44	Financial Intermediation	1.01	1.05	1.05	1.11	1.32
A45	Real Estate	1.05	1.15	1.22	1.29	1.38
A46	Others	1.04	1.08	1.14	1.20	1.30

Source: Table 1, NBS [29] and authors' calculations.

SupplementaryData.xls