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Sources of China's Energy Usage Changes in 1990's

(Draft)

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1. Introduction

It is interesting to think of the Chinese energy issue in the long run. Due to the obvious reasons, for example, China is the largest developing country, and undergoing the industrialization, the future of Chinese energy consumption may dramatically change the way of we are thinking about the world energy issue today.

In fact, Many observers (See, Jorgenson, et.al, 1996) have indicated that because of Chinese fast economic growth in the recent two decades , the world has perceived the influence of Chinese rising energy consumption: China has transformed from the net oil exporter to net oil importer, and Chinese Co2 emission is the second largest in the world, and so on.

The two principle forces underpinning the long run Chinese energy consumption are its economy structure and its technical level in the future. Among them, the technical level lies in the heart in our postulation for the future energy consumption.

We can not know what the future will be now, but can only form our expectation for the future based on the past. In our cases, two methodologies are often used. One is based on the other 'similar' country's experience, say Japan economy in 1970's can be regarded as the approximation of Chinese economy in 1990's. World Bank (1994) basically used this methodology to study Chinese energy consumption and related green house gas emission up to 2020. But Chinese special characteristics [1]often make such simple approximation failed[2]. Lin and Polenske(1995) indicated that even many researchers had founded that in most developing countries the energy output ratio was rising in the late 1970'd and 1980's, Chinese energy output ratio declined sharply at the same time.

Then some researchers used the second methodology: using Chinese own historical data to form the future's expectation. We will follow this way, but we should bear in mind the defect of this methodology: Chinese historical statistics may be not consistent and reliable because of changes of ways to make statistics or manmade manipulation and so on.

There are three methods to extract energy consumption trend using historical data. One is to use econometric method to estimate the production function of each sector in the economy and get the technical change in the energy usage. But in China, it is always difficult to obtain such detailed time series with the sufficient time length to make the meaningful statistical inference. So it is rarely used.

[1] China has large amount of population, it is developing country, it is transiting from the planned economy to the market economy.

[2] World bank's work obviously know China and Japan has different energy usage pattern, so it used other method to get Chinese energy usage coefficient.

The second way uses the input-output analysis. And the third way is to use the decadent of input-output model –CGE model. Both models used the data set in the two different years to get the changes in their exogenous variables which including technical change. The difference is just the degree of complexity. In CGE model, we uses the social accounting matrix as the basic data se, but the input output analysis only use the input output table; the CGE model allows the flexible substitution among inputs, while the input output analysis assume fixed input coefficients. This difference implies that the input mix changes due to relative price changes may be falsely attributed to the technical shift in the input-output framework. In CGE model, we can also embody the policy instruments, say import tariff, import quotation etc., but in the input output model, it is not so easy to add the policy instruments[3].

It is apparent that CGE model has greater potency to get more accurate information in technical change than the input output analysis. But there is no free lunch here, it is well known that CGE model is very data intensive. In Dixion and (1998), to get all of the information about exogenous variables changes in two different years, they had to collect and compile the consistent data about the sector output volumes and prices, import, export volumes and prices, policy instruments changes, etc in these two years. But in the input output analysis, we only need two (or more) input output tables in different years. At the same time, by carefully interpreting its results, we can also get some useful message of technical change from the input output analysis. So in this paper, we used the input-output model to analyze the sources of changes in Chinese energy consumption in 1990's.

There are two papers are very close to ours in spirit. Lin and Polenske(1995) introduced a method to decompose the sources of changes in energy usage, and used it to explain the reasons that Chinese energy output ratio fell in 1980's. They used the input-output table in 1981 and 1987. And they found the major changes in energy usage were resulted from the technical changes, the changes in final demand had relatively small effects on the saving of energy usage. Garbaccio, et.al(1999) used the similar methods, but used different input output tables in 1987 and 1992. To make to two tables comparable, they made considerable adjustment based on some assumptions. And they also reached the same conclusion that the technical change is the most important factor in energy saving.

[3] As before, it is also possible that input output model inclines to spuriously to attribute the effects of policy changes to technical shift in the input output analysis. Here we don't want to disparage the simplicity of input output framework, but to warn the reader that the meaning of technical change in input output analysis has broader senses than we usually use.

In this paper, we used the same method illustrated by Lin and Polenske(1995). The difference is that we used the 1990 and 1995's fixed prices input output table newly released by State Statistical Bureau of China. So our analysis extended Lin and Polenske's analysis. It also has more sectors than Lin and Polenske(1995), which includes 30 sectors while Lin and Polenske(1995) has 18 sectors. The more dis-aggregated is the data, the better results can we get.

It was correctly indicated by Garbaccio, et.al(1999) that the 1990 and 1995's input output tables were derived from RAS method according to 1987 and 1992's tables, which were compiled from the survey data. There are two reasons we used these two tables: First, when it compiled the fixed prices input-output table, the SSB adjusted some strange items existed in the input-output tables at present prices; Second, may be more important, is that we compiled the energy balance account of 1990 and 1995 according to many sources. In China's energy statistics, it is more accurate in the physical unit than the value because there are many subsidies or tax exemptions in the usage of energy among different sectors. With such data, we can verify the quality of fixed prices input output table.

Our major conclusions are that the energy technical changes mainly contributed to the saving of energy usage in 1990's, and the growth of GDP increased the energy usage the most. The distribution of GDP and the composition of final demand components only moderately reduced the energy usage

The following sections are organized as follows: section 2 will describe our data set; section 3 will briefly illustrate our method to decompose the sources of changes of energy consumption; Section 4 is our results and the final section is the conclusion and future research.

2.Data

In 1998, the SSB of China published a book which includes a series of fixed prices input output data, from 1981 to 1995[4]. This work was the results of cooperative research between the SSB and the HongKong Chinese University.

Because from 1981 to 1995, the SSB changed its way to compile the input output table in several times, they have to aggregate the sectors of the original input output table to avoid the discrepancies in the definition[5]in different years. The consistent sector's price indexes were also compiled to deflate the original input-output tables that were valued at prices of

[4] There are totally six input-output tables in the book.
[5] In the complete input output table, there are more than 100 sectors.

that year.[6]

Even the longest input output series (from 1981 to 1995) only has 18 sectors, there are another series of input output tables including 30 sectors from 1987. We will use the tables with such classification in 1990 and 1995. The names of sectors are listed below in Table 2.1.

The energy sectors in the input-output table are Coal, Oil & Gas, Electricity, Petroleum and Coke industry. The first two industries are primary energy and the last three are secondary energy.[7]

In the input-output table, the final demand includes six parts: Consumption, Investment, Government expenditure, export, import and others.

Table 2.1 Names of sectors of the fixed prices input-output table

1	Agriculture	16	Metal Manufacturing
2	Coal	17	Metal product
3	Oil & Gas	18	Machinery
4	Metal Mining	19	Transport Equipment
5	Non-metal Mining	20	Electric
6	Food	21	Electronic
7	Textile	22	Meters
8	Clothes	23	Maintain
9	Furniture	24	Other industries
10	Paper	25	Construction
11	Electricity	26	Transport
12	Petroleum	27	Restraunt
13	Coke	28	Other social services
14	Chemical	29	Finance
15	Building material	30	Public administration

We compiled the energy balance account in 1990 and 1995 by combining the data from

[6] More details can be found in Li and Xue et.al(1998).

[7] It is not an exact expression because the electricity industry includes the electricity generated by the hydro power, or wind, which can be regarded as the primary energy. In Lin and Polenske(1995) or Garbaccio,et.al (1999), they splited the electricity industry into thermal and an artificial hydro electricity sector two parts.

different sources.[8] The energy balance account has five related accounts, and the most useful account here is the energy usage account, which has the form as Table 2.2:

Table 2.2 Form of energy usage account

	Coal	Oil	Gas	Electricity	Coke	Petro	Dissel	Heat
Agriculture								
⋮								
Public administration								
Consumption								

It is apparent that energy usage account has more energy sectors than the input-output table. Each item of this table means the physical usage of one kind of energy by sector. Its each column approximately corresponds to the row of energy usage in input-output table. In theory, each energy has only one price in the perfect market economy, then the usage share of energy from these two sources must be the same. But in China, we used different way to collect the value data and physical data and the different sectors may face different prices even for the same kind of energy due to subsidies[9]. So we can compare the usage shares of energy from these two different ways, and check whether such distortions are significant in our analysis

We found that the differences between the shares from two sources are reasonable even there exist some discrepancies.

3.Model

Since Lin and Polenske(1995) detailed presented the method to decompose the changes of energy usage, here we just briefly discussed it .

In the input-output model, We have the following expression:

$$X = (I - A)^{-1} Y = CY \qquad (3.1)$$

where X is the vector of sectoral output, Y is final demand, I is identity matrix, A is the matrix of direct input coefficient. C is the matrix of all input coefficient, obviously it represented the production technologies used in the economy.

By the Taylor extension, we can get:

[8] The sources includes The Energy Year Book of China(1991,1996), Statistic Yearbook of China(1991,1996) , and additional data provided by SSB.

[9] For example, the plan price of energy may be much lower than the market prices.

$$\Delta X = C\Delta Y + Y\Delta C + \frac{1}{2}\Delta C'\Delta Yi + \xi \qquad (3.2)$$

where Δ means change of variable, and *i* is 1's vector,

Following Lin and Polenske(1995), we will use the first order approximation. Let e is diagonal matrix whose diagonal element is 1 if it is energy sector or 0 if it is not energy sector.[10]Then we have:

$$\Delta E = eX = eC\Delta Y + eY\Delta C \qquad (3.3)$$

where ΔE means the change of energy consumption.

Equation (3.3) showed that the changes of energy usage have two sources: changes of final demand and changes of techniques. Final demand changes is the first part equation (3.3), which said if we keep the technology level constant, the changes of final demand will result in how much changes in the usage of energy. The technical changes is the second part of equation (3.3), which said if we keep the final demand constant, the changes of techniques will result in how much changes in the usage of energy.

We can further decompose the final demand change and technical change. First we will discuss the decomposition of final demand.

The final demand can be separated into three parts: level, distribution and pattern. The level is the total expenditure of final demand, or GDP. The distribution means how the GDP distribute among the final demand sectors we mentioned in section 2. The pattern means the composition of commodity bundle in each kind of final demand. We can write them as the following equation:

$$Y = MDL \qquad (3.4)$$

where L is a 6×6 diagonal matrix whose diagonal elements are all the value of GDP, which embodies the level, D is also a 6×6 diagonal matrix whose diagonal elements respectively correspond to the expenditure share of every kind of final demand, which embodies the distribution of aggregate final demand, M is the matrix which shows the composition of consumption bundles of each kind of final demand.

It is easy to understand the meanings of the above decomposition: not only the change of GDP changes the energy usage, the change of the distribution of GDP, and the change of the consumption mix are also matter. If one country import lots of energy intensive goods, and produce the non-energy intensive goods or services, it may have low energy usage and high GDP.

Now we decompose the technical changes as the technical changes of energy usage or technical changes of non-energy usage. It is clearly that any technical improvement in usage of energy in any sector may reduce the usage of energy, but it is so obvious that

[10] In our paper, e is a 30×30 matrix, and its 2ed,3rd , 11ed,12,13,diagonal elements are 1.

any technical improvement in usage of non-energy good can also reduce the usage of energy. But we should emphasize the inter dependence among sectors characterized by the input-output matrix. So we can rewrite the matrix C as:

$$C = CE + CN \qquad (3.5)$$

where CE is a matrix only the rows of energy sector has the same elements as C in corresponding rows, and numbers of the other rows are just zero, CN is matrix of C-CE. Eventually we can get the following equation by combining equations (3.3), (3.4) and (3.5):

$$\Delta E = eCMD\Delta L + eCM\Delta DL + eC\Delta MDL + \Delta CEY + \Delta CNY \qquad (3.6)$$

We will use the above equation to decompose the 1990 and 1995's input output tables.

4 Results

Our major results are listed in Table4.1, 4.2 and 4.3.First, we will examine the Table 4.1. As shown in Table 4.1, the usage of energy was increasing from 1990 to 1995. The largest increase is coke and the smallest one is coal.

All the technical changes are negative, which means that there were significant technical improvements in energy usage in China from 1990 to 1995. If we loot at the rows of the decomposition of technical changes, we can see that all of the technical improvements of energy usage were due to the saving of energy in production, the non-energy usage techniques increased the consumption of energy. This doesn't means that there were no technical improvements in non-energy usage techniques, because the deepening and winding of production process in one production sector, for example the sector make or commodities than before, may increase the intermediate input.

We can also find that the final demand shift increased the usage of energy from 1990 to 1995. The change of final demand level is the major reason of increases of energy usage. The change of distribution and composition of final demand have relative small impacts on the changes of energy usage, and the signs of these impacts are different for different energies. For examples, the changes of distribution reduced the use of coal, oil and gas, electricity and petroleum, but increased the use of coke.

We can investigate the impacts of final demand shift from another perspective As indicated before, there are six parts in the final demand, so the changes of each part may have different impacts on energy usage. The last part of Table 4.1 showed such effects. The increases of household consumption, investment and export are three major factors in the increasing of energy usage, and the imports significantly reduced the energy usage.

Table 4.1 Decomposition of Energy Usage (Percentage Change w.r.t 1990)

	Coal	Oil&Gas	Electricity	Petroleum	Coke
Total change	5.78	14.09	36.55	12.65	37.24
Technical change	-30.42	-38.55	-42.24	-46.21	-48.64
Energy technical change	-40.16	-47.84	-55.91	-48.97	-59.29
Non-energy technical change	9.75	9.29	13.67	2.77	10.65
Final demand shift	36.19	52.63	78.78	58.86	85.88
Level	61.35	61.35	61.35	61.35	61.35
Distribution	4.73	6.84	0.18	4.26	-3.62
Composition	-29.9	-15.55	17.26	-6.75	28.15
Sources of Final demands shift					
Household Consumption	20	24.39	39	22.67	40.42
Government consumption	2.7	4.86	3.4	5.2	2.28
Investment	15	35.96	42	36.9	52.25
Export	23.4	12.87	28	22.4	42.93
Import	-23.6	-45.8	-32	-38.17	-33.68
Others	2.6	2.4	1.7	1.9	1.6

Table4.2 Changes of Energy Usage from Technical Changes of Sectors (Percentage Change w.r.t 1990)

	Coal	Oil&Gas	Electricity	Petroleum	Coke
Agriculture	0.61	0.96	-0.89	1.18	2.33
Coal	0.14	-0.15	-0.15	-0.17	-0.14
Oil & Gas	0.005	0.01	0.01	0	0.002
Metal Mining	0.034	0.12	0.1	0.12	-0.08
Non-metal Mining	-0.29	-0.6	-0.8	-0.62	-0.14
Food	0.49	-2.29	0.66	-3.09	1.55
Textile	-0.03	-0.21	-0.47	-0.35	0.12
Clothes	-1.14	-1.76	-3	-2.37	-0.19
Furniture	-0.94	-1.08	-1.5	-1.1	-0.73
Paper	-1.67	-1.14	-2.27	-1.21	-1.3
Electricity	-0.22	0.04	0.14	-0.5	-0.1
Petroleum	-0.02	0.31	-0.06	-0.03	-0.0081
Coke	-0.54	0.1	0.01	-0.47	-0.56
Chemical	-1.25	-0.93	-2.5	-1.12	-0.03
Building material	-0.95	-1.37	-0.3	-1.68	-0.95
Metal Manufacturing	0.49	0.1	0.58	0.59	4.2
Metal product	-1.02	-0.99	-1.6	-1.23	-3.4
Machinery	-4.9	-5.7	-6.54	-6.83	-12.3
Transport Equipment	-2.46	-3.13	-3.53	-3.68	-5.04
Electric	-2.41	-2.72	-3.3	-3.16	-5.39
Electronic	-4.22	-4.5	-6.55	-4.82	-5.9
Meters	0.1	0.09	0.14	0.11	0.18
Maintenance	0	0	0	0	0
Other industries	-0.016	-0.01	-0.02	-0.02	-0.03
Construction	-9.32	-15.2	-11.9	-18.02	-23.2
Transport	-0.4	-0.7	-0.2	0.27	-0.18
Restaurant	-0.08	0.96	-0.4	1.25	0.65
Other social services	-0.86	0.87	-0.002	0.87	0.98
Finance	0.3	0.45	0.52	0.47	0.29
Public administration	0.18	-0.17	1.6	-0.62	0.41

Table4.3 Changes of Energy Usage from Final Demand Shift of Sectors

	Coal	Oil&Gas	Electricity	Petroleum	Coke
Agriculture	0.54	1.04	0.95	1.02	0.31
Coal	-15.7	-0.46	-0.83	-0.44	-0.34
Oil & Gas	-0.16	-19.08	-0.28	-0.27	-0.2
Metal Mining	-0.14	-0.18	-0.31	-0.18	-0.09
Non-metal Mining	1	1.31	2.11	1.3	0.5
Food	2.64	4.42	3.8	4.58	1.57
Textile	-0.96	-1.22	-1.56	-1.13	-0.52
Clothes	4.72	6.46	7.47	6.17	3.23
Furniture	1.36	1.49	1.89	1.5	1.03
Paper	2.17	2.07	3.16	1.93	1.76
Electricity	4.56	2.55	18	1.5	0.42
Petroleum	-0.1	-6.5	-0.18	-7.72	-0.11
Coke	3.75	1	0.53	0.73	48.5
Chemical	-0.5	-0.61	-0.8	-0.45	-0.24
Building material	3.75	3.05	4.06	3.07	2.78
Metal Manufacturing	-2.47	-1.65	-2.48	-1.55	-7.22
Metal product	0.81	0.76	1.07	0.72	1.78
Machinery	5.45	6.02	7.4	5.93	10.79
Transport Equipment	4	4.86	5.4	4.81	6.64
Electric	2.5	2.73	3.24	2.66	4.45
Electronic	5.3	6.02	7.73	5.71	7.05
Meters	-0.53	-0.55	-0.72	-0.53	-0.83
Maintenance	-1.09	-1.44	-1.56	-1.47	-1.55
Other industries	0.07	0.08	0.09	0.07	0.1
Construction	18.73	22.76	23.04	23.66	25.94
Transport	-0.91	-3.66	-0.95	-4.2	-0.65
Restaurant	-0.69	-1.03	-0.97	-1.08	-0.62
Other social services	0.82	1.06	1.15	-1.05	0.6
Finance	0.06	0.1	0.07	0.11	0.07
Public administration	1.48	3.17	1.68	3.53	1.35

In Table 4.2 and 4.3, we examined the technical changes and final demand shift by sectors. They showed that how much changes of energy usage were resulted from the final demand change or technical change of each sector.

For example, the first item of Table 4.2 is 0.61, which said that the final demand change of agriculture sector increased 0.6% coal usage, the first item of Table 4.3 said the technical change (includes energy technical changes and non-energy technical changes) of agricultural sector increased 0.54% coal usage.

From Table 4.2, we noticed the five sectors with the greatest technical increases in energy usage are Construction, Machinery, Electronics, Transport equipment and Electric sector. From Table 4.3, the five sectors with the greatest final demand increases in energy usage are Construction, Machinery, Electronics, Clothes and Electricity sector.

5.Conclusions

In this paper, We used 1990 and 1995's fixed prices input-output table to study the sources of China's energy usage in 1990's. The research confirmed that the energy technical changes mainly contributed to the saving of energy usage in 1990's, and the growth of GDP increased the energy usage the most. The distribution of GDP and the composition of final demand components only moderately reduced the energy usage

As to the further research, we will construct the input-output table consistent with energy balance account, which means more dis-aggregation of energy sectors in the current input-output table.

The input-output table for has just come. However, there has not been the one at constant price. We are looking forward to having the input output table at constant price and look into some interesting changes in Chinese energy usage at the end of 1990s.

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