Industrialization, Structure Change and Electricity Consumption----the Case of China

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Abstract:- In the paper factor decomposition method is used for the study of China's industrial electricity consumption from 1990 to 2003. The output effect, structural effect and intensity effect of industrial electricity growth is reported, demonstrating the reason of rapid industrial electricity growth is in the rapid growth of industrial output. Then according to the three-stage classification of industrialization process three kinds of industries are classified and the industrial structure transition from 1990 to 2003 is analyzed. Finally the effect of industrialization to electricity demand is analyzed. The paper concludes that the deepening of industrialization will lessen electricity intensity overall, while the structural effect of three kind of industries is related with the order of industrialization process, with the first two being negative and the third being positive.
Key words*: Industrial electricity demand; Index decomposition; Industrialization; Output effect; Structure effect; Intensity effect*

1 Introduction

After Asian Crisis of 1997, because of the slowness of economic growth in China, the shortage of electricity supply has gradually ceased and electricity surplus comes. The developing policy of electric sector has then adjusted to slacken the electricity construction pace. Since 2000, however, the electricity demand walks out of valley and increases rapidly for four years, and situation of serious electricity shortage reemerges. In 2004, the provinces restricting the power have increased to 24 and the total gap of electric power amounted to 31 GW.

The situation of continuous electric shortage has solicited a great many of discussions on the relationship between electric power and economic growth. The coherent point is that the recently continuous power shortage is caused by the rapid growth of industry, especially the energy connotation industries. However, no literature has ever systematically investigated the factorial decomposition of industrial electricity consumption, to investigate the influence of industry output, structure change and electricity intensity on electricity demand. There are at least two reasons for choosing the industrial sector for our study. First, in China, industry is the dominant electricity-consuming sector. Because the industrial sector is critical for the past and future electricity consumption, a deeper understanding of how electricity consumption evolves in the sector is very important in formulating future policy. Second, the data at fine level of disaggregation are available for the sector. This makes it possible to calculate how much of the increase in the total industrial electricity use is due to structural shifts within the subsectors and how much to change in real electricity intensity.

Herein, the paper is to adopt factor decomposition technique to decompose the China's industrial electricity consumption growth from 1990 to 2003.

2 Decomposition Method

Let E_o and E_t be total energy consumption in the industrial sector in year o and t year t. The change in total industrial electricity consumption between the two years, $\Delta E_{tot} = E_t - E_o$ is decomposed as follows:

$$\Delta E_{tot} = \Delta E_{out} + \Delta E_{str} + \Delta E_{\text{int}} + \ell \qquad (1)$$

The first term ΔE_{out} on the right-hand side represents a change in energy consumption due to a change in aggregate production (output effect). The second term ΔE_{str} represents a change in energy consumption due to changes in composition of aggregate production (structural effect). If less energy-intensive industrial subsectors grow faster than do more energy-intensive industrial ones, such a structural change will put the downward pressure on energy demand, thus resulting in lower growth rate of energy consumption than would otherwise have been the case. The third term ΔE_{int} shows a change in energy consumption due to changes in subsectoral energy intensities (intensity effect). Real energy intensity may decline as a result of the adoption of more efficient production technologies and energy management techniques, changes in product mix within and between subsectors, changes in product value as well as changes in the quality and mix of material and fuel inputs. This is the reason why we refer this effect to the intensity effect rather than the technological effect, because it contains more than purely technological changes. The last term is a residual.

In decomposing the change in overall energy consumption, the Laspeyres method has been used extensively. Proposed by Park (1992), the method calculates changes in energy consumption with respect to a constant base year and has the following components:

$$\Delta E_{out} = \sum_i Q_t\, s_{i,o} I_{i,o} - E_o = \left(Q_t - Q_o\right) \sum_i s_{i,o} I_{i,o} \qquad (2)$$

$$\Delta E_{str} = \sum_i Q_o\, s_{i,t} I_{i,t} - E_o = Q_o \sum_i \left(s_{i,t} - s_{i,o}\right) I_{i,o} \qquad (3)$$

$$\Delta E_{\text{int}} = \sum_i Q_o\, s_{i,o} I_{i,t} - E_o = Q_o \sum_i \left(I_{i,t} - I_{i,o}\right) s_{i,o} \qquad (4)$$

where Q_o and Q_t are aggregate production in the industrial sector in year *o* and year *t*, $s_{i,o}$ and $s_{i,t}$ are the *i*th industrial subsector's share of aggregate production in year *o* and year *t*, $I_{i,o}$ and $I_{i,t}$ are energy intensity in each industrial subsector year *o* and year *t*.

The Laspeyres method is more easily interpreted. But the disadvantage of the method is that there is a residual, which is not equal to zero and generally increases as *t* increases (Howarth et al., 1991). This leaves part of the observed change in industrial energy consumption unexplained. For this reason, we propose a different decomposition method. By keeping the definition of the first term unchanged but redefining the last two terms, this proposed method is as easily interpreted as the Laspeyres method, but gives no residual.

In what follows, we start describing the proposed method by defining ΔE_{str} represent a difference between what energy consumption would have been if each subsectoral output at year t had been produced at the energy intensity of year o and that if the aggregate production at year t had been composed in the same way at year t as at year o and had been produced at the energy intensity of year o. Define ΔE_{int} to represent a difference between the observed energy consumption and what energy consumption would have been if each subsectoral output at year t had been produced at the energy intensity of year o. Thus, we have

$$\Delta E_{str} = \sum_i Q_t\, s_{i,t} I_{i,o} - Q_t s_{i,o} I_{i,o} = Q_t \sum_i \left(s_{i,t} - s_{i,o}\right) I_{i,o} \qquad (5)$$

$$\Delta E_{\text{int}} = \sum_i Q_t\, s_{i,t} I_{i,t} - Q_t s_{i,t} I_{i,o} = Q_t \sum_i \left(I_{i,t} - I_{i,o}\right) s_{i,t} \qquad (6)$$

The proposed decomposition method gives no residual on the right-hand side. This can be illustrated as follows. Summing over the three terms, we have

$$\Delta E_{out} + \Delta E_{str} + \Delta E_{\text{int}} = (Q_t - Q_o) \sum_i s_{i,o} I_{i,o} + Q_t \sum_i (s_{i,t} - s_{i,o}) I_{i,o} + Q_t \sum_i s_{i,t} (I_{i,t} - I_{i,o})$$

$$
\begin{aligned}
&= Q_t \sum_i s_{i,o} I_{i,o} - Q_o \sum_i s_{i,o} I_{i,o} \\
&+ Q_t \sum_i s_{i,t} I_{i,o} - Q_t \sum_i s_{i,o} I_{i,o} \\
&+ Q_t \sum_i s_{i,t} I_{i,t} - Q_t \sum_i s_{i,t} I_{i,o} \\
&= -Q_{ot} \sum_i s_{i,o} I_{i,o} + Q_t \sum_i s_{i,t} I_{i,t} = -E_o + E_t \\
&= \Delta E_{tot} \qquad (7)
\end{aligned}
$$

3 Data and Calculation Process

The choice for a level of sector disaggregation is mainly dictated by the purpose of analysis and data availability. Ideally, the fine level of subsectoral detail is desirable in order to accurately disentangle the structural effect from the intensity effect. Sinton and Levine (1994) show that as the level of subsectoral detail becomes finer, more intensity change becomes attributable to structural shift. Given that the effect of changes in product mix within and between subsectors is counted as the intensity effect, this should thus come as no surprise because a finer level of sector disaggregation is able to more accurately separate the effect from the intensity effect. But, in practice, the desire for a finer level of sector disaggregation is often restrained by data availability. This is certainly the case in China where the data for industrial value added and the energy use are at roughly the 2-digit industry classification level.

Unlike Huang (1993) and Sinton and Levine (1994) where gross output value is used as the output indicator, following Zhang (2004), value added is used as the output indicator for this present study in order to avoid double accounting the value of intermediate goods. The data for value added in the industrial sector are disaggregated into 40 subsectors for the period 1991–1992 and into 39 subsectors in 2003, the latest year in which detailed end-use electricity consumption data in a consistent manner are available. The data for end-use electricity consumption are disaggregated into 26 subsectors for the period 1990–2003. For each subsector, because the electricity consumption data are not compatible with such an industrial subsector classification, reconciling the differences between the two data sets obliges us to disaggregate the industrial sector into 22 subsectors.

In this study, we use 1990 as the base year. Price indices from 1991 to 2003 are disaggregated into 14 subsectors and are derived from the Chinese State Statistical Bureau (2004). Because price indices are less disaggregated than the value added data, in converting 29-subsector value added at current prices into that in 1990 constant prices, the same price index is thus used for those subsectors that are further disaggregated from the same higher-level subsector.

4 Analysis results

4.1 Aggregate output, structural and intensity effect

Table 1 gives out the aggregate effect of total industrial electricity consumption in China from 1990 to 2003. We can see that if the industrial output structure keep as 1990, the total electricity consumption would be 1785 TWH, however the actual number is 894 TWH, decreasing about 50 per cent. Among the reduction, 62.4 per cent can be attributed to the decrease in electricity intensity, while the influence of structural shift also contribute to 37.6 per cent, which implies that, with the rapid increase of industrial electricity consumption, because of the remarkable success of national energy saving policy, the increase of electricity consumption is controlled effectively.

Tab 1 the aggregate effect of industrial electricity consumption (TWH)

Output	Structural	Intensity	Net increase
1785	-335	-556	894

To reveal the dynamics of electricity consumption among the period, we make the year-by-year analysis of factor decomposition. The results indicate that the output effect behave characteristics of distinct fluctuation. Year 1990 to 1995 is a fluctuation cycle while 1995 to 1998 is another one. From 1998 then on, the output effect keep positively increasing, however according to the character of last two cycles, the positive fluctuation would not keep on. Concerning the structural effect, only periods 91-92, 94-95, 97-99 is positive and all the others are negative, which implies that the output structure of industry comes towards less energy intensity.

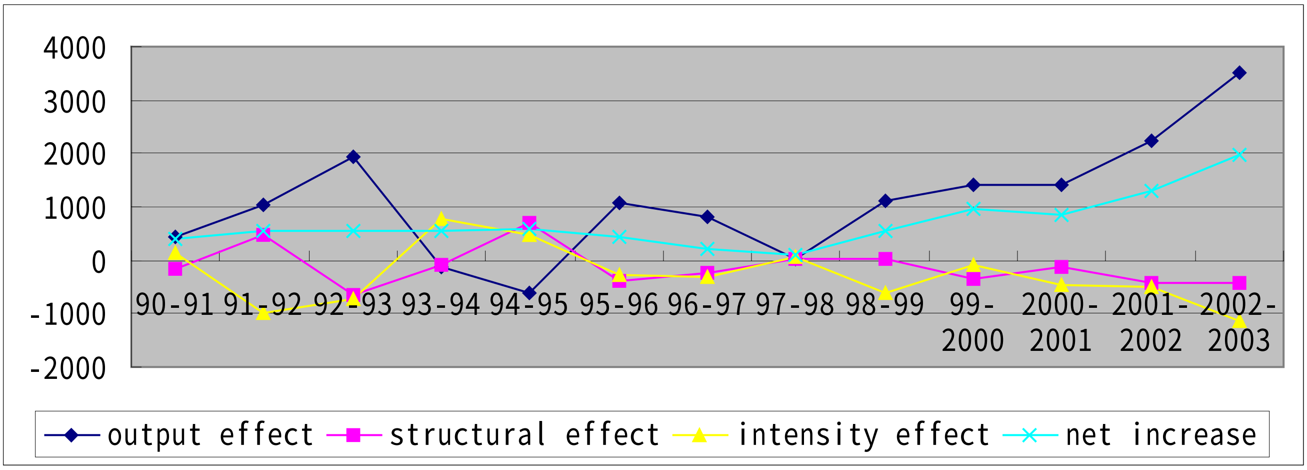

Fig 1 The dynamics of industrial electricity consumption (in 10^8 KWH)

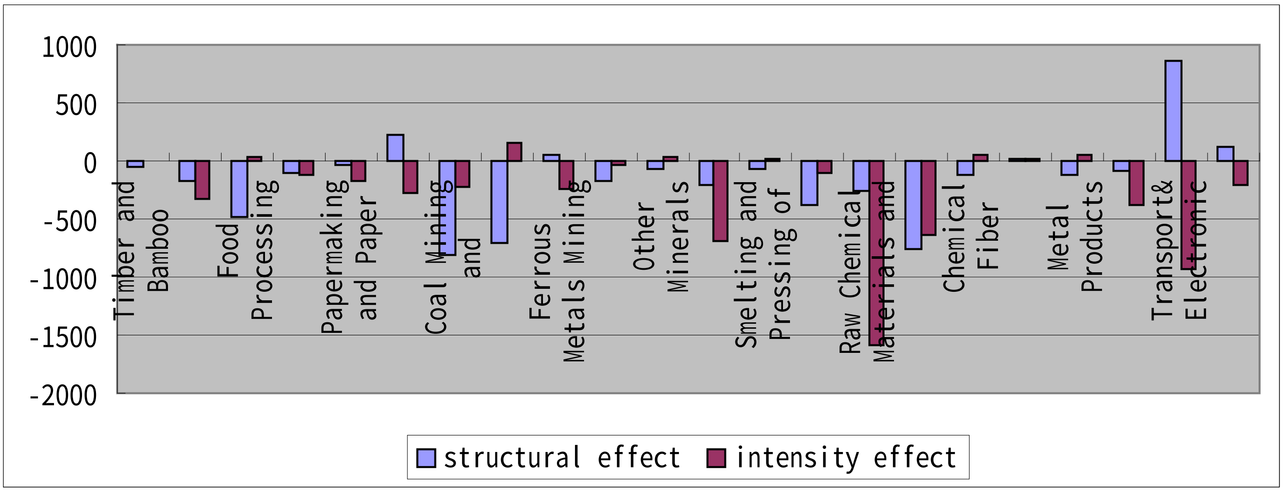

Fig 2 the subsector analysis of industry electricity consumption

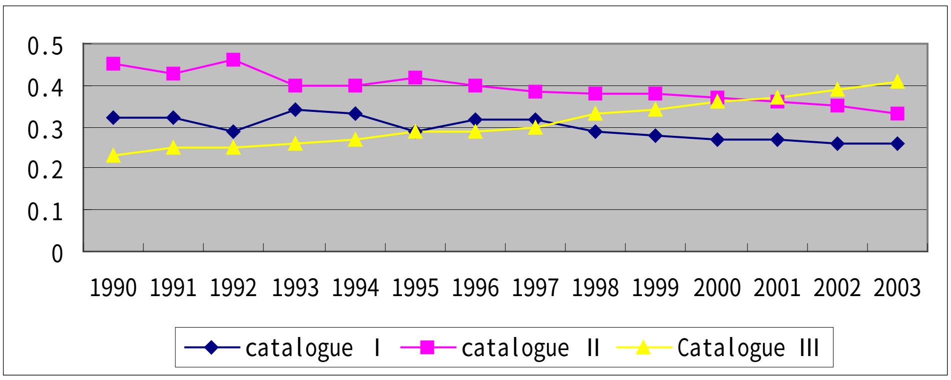

Fig 3 the share of three catalogue industry in industry output

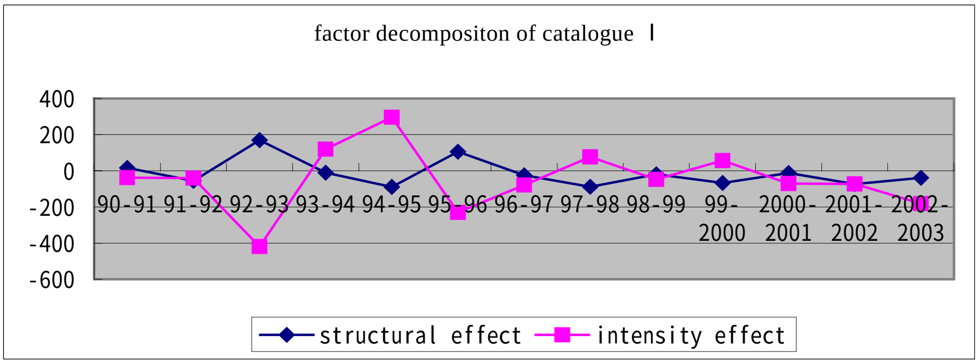

Fig 4 Factor decomposition analysis of catalogue Ⅰ

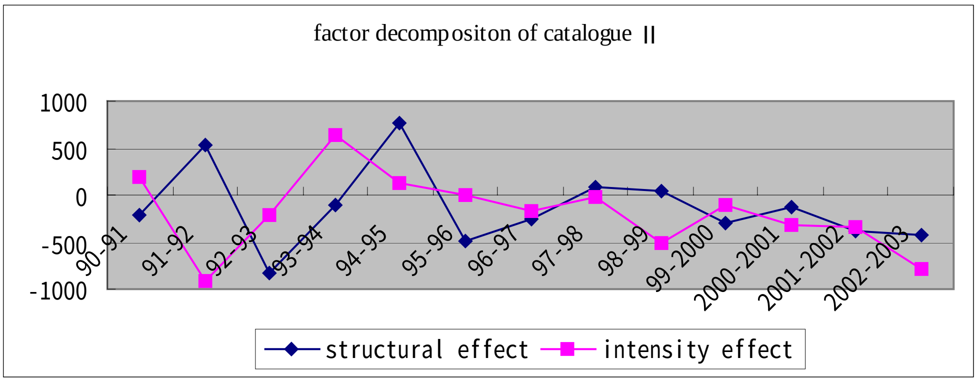

Fig 5 Factor decomposition analysis of catalogue Ⅱ

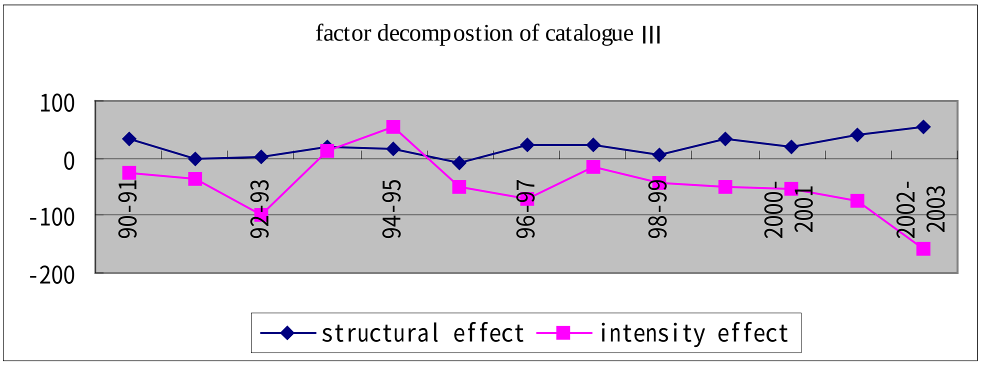

Fig 6 Factor decomposition analysis of catalogue Ⅲ

4.2 Subsector analysis

Fig 2 gives the factor analysis of twenty-two subsectors. It is obvious that the sectors of smelting and pressing of ferrous metals, chemical, power, transportation & electronics behave distinct effect in energy saving.

According to the classification of industrialization into three stages, we calculate the share of industry output into three catalogues, among which the catalogue Ⅰ refers to sectors associates closely with the daily life of ordinary people, such as food, textile and clothing, catalogue Ⅱ mainly refers to heavy industry, such as petroleum, chemical, fiber, plastic, ferrous metal, nonferrous metal, metal product, et al . Catalogue Ⅲ refers to medical and pharmaceutical products, transport& electronic equipment, et al, which mainly is high value-added industry. It is seen that the share of catalogue Ⅰ gradually decrease from 32 per cent to 26 per cent, catalogue Ⅱ from 45 per cent to 33 per cent, while Catalogue Ⅲ increasing from 23 per cent steadily to 41 per cent which implies that China has entered into the development stage of anaphase from metaphase.

It is widely accepted that China's industrialization process substantially starts from reform in city economics since 1990th .So it is of policy interest to analyze the trend industry structure shift from 90th. Figures 4 to 6 give out the year-by-year decomposition analysis for the three-industry catalogue. The structural effect of catalogue Ⅰ is mostly negative, except for 90-91, 92-93 and 95-96. The structural effect of catalogue Ⅱ is mostly negative, except for 90-91and 95-96, while that of Catalogue Ⅲ is rightly inverse. The intensity effect, on the other hand, is in line with the above analysis, catalogue Ⅰ in 93-95, 97-98, catalogue Ⅱ in 90-91, 93-95, Catalogue Ⅲ in 93-95 is positive during the peak period of fixed asset investment, in the other years is congruously negative.

Tab 2 the long trend of three catalogues of industry on industrial electricity consumption

Effect	Ⅰ	Ⅱ	Ⅲ
Structural	-	-	+
Intensity	-	-	-

5 Concluding Remarks

The conclusion of the paper is as follows:

The output structure and intensity effect of industry electricity growth in China during 1990 to 2003 is decomposed by factor decomposition technique, indicating that the energy saving, as well as structure shift plays important role in restraining electricity consumption growth.

According to the classification of three-stage industrialization, the influence of industrialization process on electricity consumption is analyzed. The conclusion is that the structural effect is synchronous with the industrialization process. All the long-term intensity effect of industry electricity demand is negatively, which is a powerful proof that the energy saving policy works in China.

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