

Determinants of Energy Intensity in Industrializing Countries
A Comparison of China and India

By

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Master of Science
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Submitted to the Department of Urban Studies and Planning
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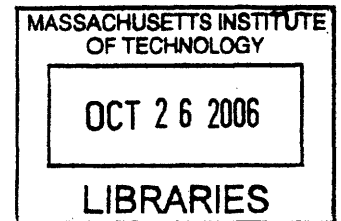
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ABSTRACT

The amount of final energy per unit of economic output (usually in terms of gross domestic product, or GDP), known as energy intensity, is often used to measure the effectiveness of energy use and the consumption patterns of different economies.

China and India are both developing countries with large population and rapid economic growth. China has decreased its energy intensity by 67% from 1978 to 2003; while India only decreased its energy intensity by 5% over the same period. By applying shift-share analysis on each country's industry sector, I decompose their changes of industrial energy intensity into two factors: structural change and efficiency change; then, I explore the determining factors of energy intensity in China and India, and analyze why they are different.

The result shows that, in China, the driving force of energy-intensity change is the improvement of energy efficiency, which decreases the energy intensity. Meanwhile, structural-mix changes played a low, but positive, role in decreasing the energy intensity. In India, energy efficiency also plays a positive role. However, the industrial structure has become more energy-intensive because of the increasing share of energy-intensive sub-sectors, which offsets the impact of energy efficiency on energy intensity; thus, the overall energy intensity only decreased slightly in India over time.

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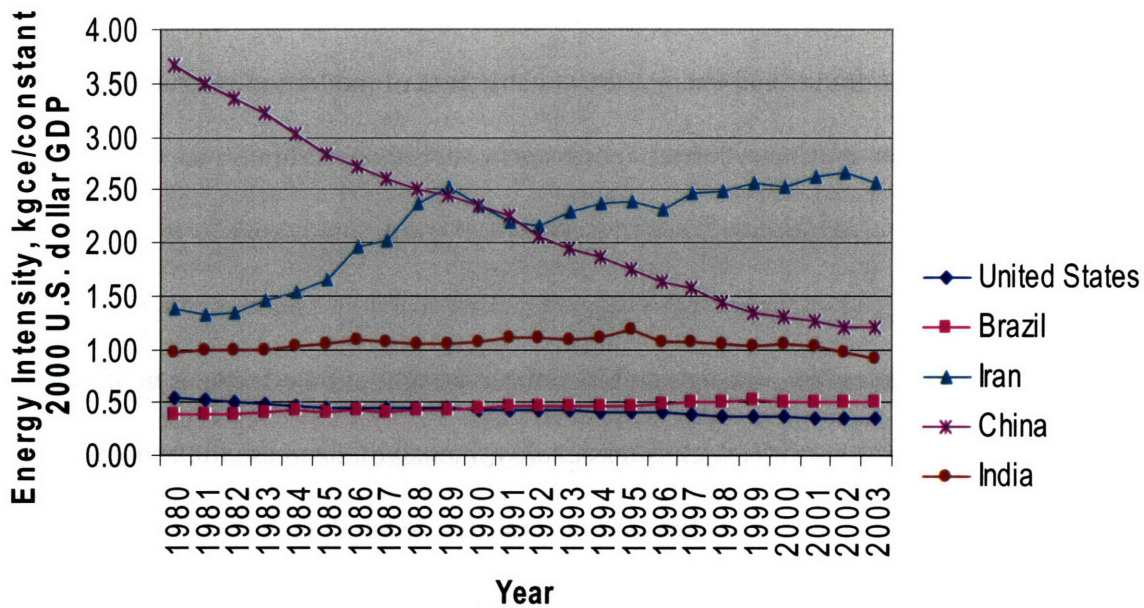
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Chapter 1

Introduction

Energy intensity measures the overall energy use relative to economic output, usually Gross Domestic Product (GDP), which measures output purchased by final users. It indicates the effectiveness of energy use and the consumption patterns of different economies, and provides a rough basis for projecting energy consumption. Structure and level of demand for energy services, together with the performance of end-use technologies, largely determine the magnitude of final energy demand. The degree of interdependence between economic activity and energy use is neither static nor uniform across regions. Therefore, energy intensity differs among different countries and changes over time.

Figure 1 presents the energy-intensity levels in different countries from 1980 to 2003 (EIA, 2005). Between 1978 and 2003, the energy intensity of the United States fell by 37%; in China, the energy intensity dropped by 67%; while in India, another Asian developing country, the energy intensity fluctuated slightly over time, and overall it only declined by 5%.



Energy intensity= Energy consumption (Kgce) per unit of GDP (Constant 2000 U.S. dollars using Market Exchange Rates)

Kgce= Kilogram of coal equivalent

Source: Energy Information Administration (EIA), *International Energy Annual 2003*.

Figure 1 Energy Intensity in Selected Countries, 1980-2003

Energy is universally recognized as one of the most significant inputs for economic growth and human development. China and India both have a remarkable economic and population growth. China has a population of 1.3 billion with an area of 9.6 million square kilometers (km²) in 2004, while India has a population of 1.1 billion with an area of 3.2 million km² in 2004 (CIA, 2005). Both China and India's GDP growth has been twice the global rate in the past 20 years. China has grown at an annual average of 9.7% since the economic reforms were initiated in 1978; India's GDP has expanded at 5.8% a year since the economy was opened up in 1991 (Ahya, et al. 2004).

Rapid growth of the economy and population usually requires a growing consumption of energy, and typically energy consumption grows faster than GDP in developing countries. This is, as Lin (1992, p.195) indicated, the result of several major changes associated with development: industrialization, increases in the capital-to-labor ratio, substitution of

commercial energy for traditional energy, the construction of modern infrastructure, and urbanization, all of which usually lead to increases in energy consumption and energy/GDP ratio.

However, as industrialization proceeds and incomes rise, saturation effects, as well as an expansion of the service sector (which is less energy intensive), decrease the energy intensity after it reaches a peak. In developing countries, technological leapfrogging (i.e., bypassing some of steps followed in industrialized countries in the past and jumping directly to modern technologies) to the use of highly efficient appliances, machinery, process, vehicles and transportation systems, and other energy technologies, offers considerable potential for energy efficiency improvements (WEA, 2000). China follows this route as its energy intensity has been falling rapidly since 1975 while India also decreased its energy intensity but only modestly.

Most energy-intensity analysts attribute the change of energy intensity to the effects of sectoral shift and technology change. To explore the underlying determinants of the different trends of energy intensity in China and India, I conduct a comparative analysis to examine if such effects are different in these two countries. I focus more on the industrial sector, because both countries are in the process of industrialization, and industry sectors generate a large proportion of GDP--51.1% in China and 26.4% in India in 2001 (ADB, 2002), while consuming the largest proportion of primary energy. For example, in 2001, the industry sector in China accounted for 45.2% of total commercial energy consumption; in India, it accounted for 36.5% (WRI, 2005).

Hypothesis

Energy intensity in a given economy is determined by two major factors: industrial structure and energy efficiency (Lin 1992). I believe that such factors functioning differently in determining the energy intensity in India and China. My hypothesis is that in China, the industrial structure has a positive impact on reducing the energy intensity, reinforcing the impact of energy efficiency on energy intensity; thus, the energy intensity in China has declined in recent years. In India, these two factors both change fairly slightly hence contribute trivially to the change of energy intensity; or, these factors played opposite roles and offset each other of the impact on energy intensity.

Industrial structure indicates the effect of structural changes on energy use. In my research, I examine two levels of industrial structure: sectoral structure and sub-sectoral structure. Sectoral structure means the composition of sectors in the national economy: agriculture, industry, commerce, etc. By sub-sectoral structure, I refer to the detailed structure within the industry, especially the manufacturing industries: food, chemicals, metallurgy, textiles, etc. Generally, industry is more energy intensive than commerce (Kambara 1992), while, by definition, heavy industry is more energy intensive than light industry. For example, in China, the energy intensity of iron and steel (heavy industry) is 2.48 kgce/dollar in 2001, while the energy intensity of textile (light industry) is 0.3 kgce/dollar. Therefore, different economic structures and industrial structures cause different energy intensities.

Efficiency change measures the change in energy efficiency in a specific sector or sub-sector over time. For a specific sector, a negative (positive) efficiency change indicates that the energy efficiency in this sector has improved (declined) over time. In China, because the energy intensity declined dramatically overtime, I expect to find that both the industrial mix and efficiency improvement played positive role in reducing the energy intensity. In India, the overall energy intensity only changed slightly; therefore, I expect to find a lower contribution of both factors, or, these factors played opposite roles and offset each other of the impact on energy intensity.

Literature review

Scholars have been interested in explaining why aggregate energy intensity of an economy has changed over time, and they have developed different methods to decompose or attribute it to underlying causes. Such analyses mainly differ in the methodology used and the empirical findings.

(1) Methodology

Many analysts of energy intensity use the method of structural decomposition analysis (SDA), which decomposes the energy intensity into different components, such as output effect, intensity effect, and structure effect (Sun 1998; Lin 1994; Zhang 2003). Using this method, analysts assume that the aggregate industrial energy consumption is the sum of consumption in m different sectors (e.g. food, textiles, metal products, etc.). The aggregate energy intensity is the summation of the sectoral production share multiplied by its energy intensity (sectoral energy consumption divided by its industrial output).

The variation of the aggregate energy intensity from time 0 to time t is expressed as the

summation of structural change and sectoral intensity. Different decomposition methods differ mainly in the means of calculating structural change and sectoral intensity.

The most often used decomposition methods are Laspeyres and arithmetic mean divisia index (AMD). Generally speaking, analysts use the Laspeyres index decomposition method to compare each of the components of energy usage patterns with a fixed base year, while holding the other components constant. Arithmetic means divisia index (AMD) method uses integral index number to capture the year-to-year change rate (Ang and Zhang, 2000).

The Shift-Share analysis is a Laspeyres-based decomposition method. Lin (1992) used this method to examine the change of China's energy intensity for the period of 1980-1988, using 1980 as a fixed base year. He divided energy use into three components: constant share, industrial mix, and efficiency change. He found that the improvements in energy efficiency rather than changes in industrial structure were the dominant forces behind China's energy intensity reduction during 1980-1998. I explain the framework of this method in Chapter 2.

Econometric analysis is an AMD-based decomposition method. Analysts use time-series methods to apply either a rolling base year or an annually changing weighting scheme (Greening et al. 1997). This type of method captures how energy consumption has evolved over time. One example of this method is the adaptive weighting divisia (AWD),

which allows for changing weights or parameter values through time in response to changing energy inputs and outputs (Liu et al. 1992; Ang and Lee 1994).

Generally, energy-intensity analysts rely on the method of decomposition, because only by decomposing can they capture the factors that determine energy usage, particularly the technological aspects, or the mix of energy-using activities.

(2) Empirical findings on determinations of energy intensity

Many analysts used different methodologies to explore the determination of energy intensity in different countries. Cornillie et al. studied the decrease of energy intensity in central and East Europe transition countries during 1992- 1998 by decomposing energy data with the use of econometric analysis. They used panel data to identify the main factors driving the improvements in energy intensity. Their finding was that energy prices and progress in enterprise restructuring were the two most important drivers for more efficient energy use. Howrath et al. (1993) used the Laspeyres method to examine the trends in the structure and intensity of final energy demand in five Organisation for Economic Co-operation and Development (OECD) countries between 1973 and 1988. They concluded that the changes in the structure of a nation's economy would lead to substantial changes in its energy/GDP ratio, which was unrelated to the changes in the technical efficiency of energy utilization. Ang (1994) used the time-series data of industrial energy intensity for Singapore and Taiwan. The results showed that changes in sectoral electricity intensities (efficiency change) was the major reason causing the changes of overall energy intensity in Singapore from 1974-1984; and structural change

was the major contributor of energy intensity change during 1985-1990. In the case of Taiwan, the efficiency change was the predominant factor through 1971-1991.

(3) Analysis of China's declining energy intensity

China's dramatic decline in energy intensity during 1980-2000 has triggered many studies. The results of these studies varied in terms of major contribution to the declining energy intensity in three respects:

- Efficiency improvement

Most of the analysts, including Sinton and Levine (1994), Lin and Polenske (1994), Garbaccio et al. (1999), and Zhang (2003), argued that the improvement in energy efficiency was the primary factor explaining the decline of China's energy intensity.

They used the decomposition methodology based on a fixed base year, which measured the difference between would-be (if the energy intensity is equal to the base year) and actual energy intensity of a specific year. The results indicated a large contribution of efficiency improvement.

- Structural shift

In contrast to the above studies, Kambara (1992) argued that a structural shift from more energy-intensive industrial sub-sectors to less energy-intensive ones was the major cause of the energy-intensity decline in China. Such different results were mainly due to the methodology he used. Kambara did not use the decomposition model; instead, he compared the regional energy consumption and economic activity in China. He found

that, because of the different economic structure, East and South China, which have more energy-efficient sectors than other parts of the country, generated a larger proportion of GDP, while their energy consumption was much lower than that in the West and North China, which have more energy-intensive sectors.

- Multifactor determination

Other scholars, Sinton and Fridley (2000) and Fisher-Vanden, et al. (2004) for instance, provided a multifactor explanation. They stressed the importance of some other factors, such as environmental and energy-efficiency policies, research and development expenditures, and ownership reform in enterprise sectors.

Compared with the studies on China's energy intensity, there is much less research conducted on India's energy intensity. This is partially because the energy intensity in India did not show a significant change during the same period (1980-2003).

Mukhopadhyay et al. (2005) used input-output tables (1983, 1989, 1993, and 1998) to measure direct and indirect energy intensity. They found that energy intensity in different sectors had decreased but still could be reduced further by changing technologies and improving energy efficiency in economic activities.

Although China and India are both regarded as large energy consumption countries and both have rapid economic growth, very few scholars have probed into why there are different trends of energy intensity in these two nations. By comparing the underlying determinants of their different energy- intensity trends, I provide some policy

implications in terms of energy conservation and structural improvements to both China and India.

Chapter 2

Methodology and Data

The methodologies I use are mainly based on previous literature.

Comparative Analysis

Focacci (2005) used comparative analysis to examine the environmental and energy policies in Brazil, China, and India, focusing on different macroeconomic indicators. Focacci's major finding was that a gradual increase in the importance of service sectors and the corresponding reduction in manufacturing industry explained the reduction in energy intensity. I will use a comparative analysis of energy and economic indicators to show the different performances of the indicators in China and India. The indicators include (1) energy intensity over time; (2) sources of final energy consumption; (3) composition of GDP in terms of economic structure; (4) energy consumption in each sector over time; (5) composition of GDP in terms of sub-sectors of industry; and (6) energy consumption in each sub-sector during time. I will also compare the extent of contribution of energy-efficiency improvement and structural shift to energy intensity in both countries.

Shift-Share Analysis

Based on the analysis by Lin (1992), I will examine energy intensity changes in industrial sector in China and India.

- Shift-share technique

The shift-share technique analyzes the changes in energy use over time. Using this technique, analysts divide energy use into three components: constant share, industrial mix, and efficiency change. Algebraically, the three components are defined as follows (Lin, 1992):

$$E_t = e_o * O_t + \sum_i [(e_{i,o} - e_o) * O_{i,t}] + \sum_i [(e_{i,t} - e_{i,o}) * O_{i,t}] \quad (1)$$

(Constant share) (Industrial mix) (Efficiency change)

Where

E_t = actual energy consumption in the industrial sector in year t;

O_t = total industrial output in year t;

$O_{i,t}$ = output of industrial i in year t;

e_o = overall industrial energy intensity at base year;

$e_{i,o}$ = energy intensity for industry i at base year; and

$e_{i,t}$ = energy intensity for industry i, year t,

Constant share indicates the energy consumption that would have occurred if the energy intensity had remained at the same level as the base year.

By dividing both sides of Equation (1) by O_t , I obtain the following equation, which describes the impact of industrial structure and energy efficiency on energy intensity:

$$e_t = e_o + \sum_i [(e_{i,o} - e_o) * O_{i,t}] / O_t + \sum_i [(e_{i,t} - e_{i,o}) * O_{i,t}] / O_t \quad (2)$$

(Constant share) (Industrial mix) (Efficiency change)

Where e_t is E_t / O_t , which is the energy intensity for the industrial sector as a whole in a given year. The industrial mix and efficiency change measure the effects of structural shift and efficiency improvement, respectively.

Using Equation (2), I obtain data to show the contributions of structural shift and efficiency improvement to the change of energy intensity in China and India over time. Comparing the contribution of these components, I can examine which factors are the main determinants of energy intensity in both countries and how large such impacts are; moreover, I can examine which country will have the most potential improvement in these components.

- Strengths and weaknesses of the technique

The energy shift-share technique is a useful method to decompose the energy intensity changes over time into effects of industrial shift and efficiency shift. Therefore, we can analyze the contribution of each factor to the overall change of energy intensity, and hence examine how governments can affect these changes. Analysts also use shift-share analysis to forecast long-term energy demand and conservation possibilities. Energy intensity is usually used to project future energy consumption assuming that the ratio of energy consumption to output is relatively stable overtime. By decomposing the energy intensity into industrial mix and efficiency, analysts can use the technique to adjust the values of energy intensity in future years according to projected or planned industrial structure and efficiency levels. This should be more accurate than the projection based only on the energy consumption/output ratio.

However, the shift-share analysis has its limitations. First, it is a descriptive method, which only shows how much of the change in energy intensity is caused by industrial mix change or efficiency change. However, it cannot explain why these two factors change. Second, the results of shift-share analysis are not invariant to industrial disaggregation. For any given year, the industrial mix and efficiency shift might change if the classification of industries is changed. As Lin (1992) pointed out, an infinite disaggregation would reduce the efficiency shift to zero and contribute all changes in energy consumption and energy intensity to industrial mix. On the other extreme, aggregating all industries into one will attribute all the changes to efficiency differences. Finally, the choice of base year may also bias the results. Because the impacts of industrial mix and efficiency change are calculated through the difference of actual energy intensity and base year intensity, the result might be biased if the base year is not “normal” in the study period.

Data sources and limitations

The major data sources in my research are the national statistical data. Data of China mainly come from *China Statistical Yearbook* and *China Energy Statistical Yearbook*; data of India mainly come from *India Industrial Annual Survey*, obtained from www.indiastat.com. These official data are fairly reliable; however, there are also limitations. First, there are variations among different official statistical books and international statistics (e.g., EIA and other data). Second, the classifications of some key indicators are different in two countries. In my research, in order to make the comparison, I adjust the data into the same classification in some cases, which might cause errors in

the analysis. Third, because not all the data of these two countries can be adjusted to the same classification, the comparison is not absolutely sufficient. For example, the energy intensity in China is measured by primary energy consumption divided by total value of industrial output; while for India, the energy intensity is measured by fuels consumption divided by total value of industrial output. Therefore, the data and analysis I present here should be regarded as general patterns instead of exact estimates of each indicator.

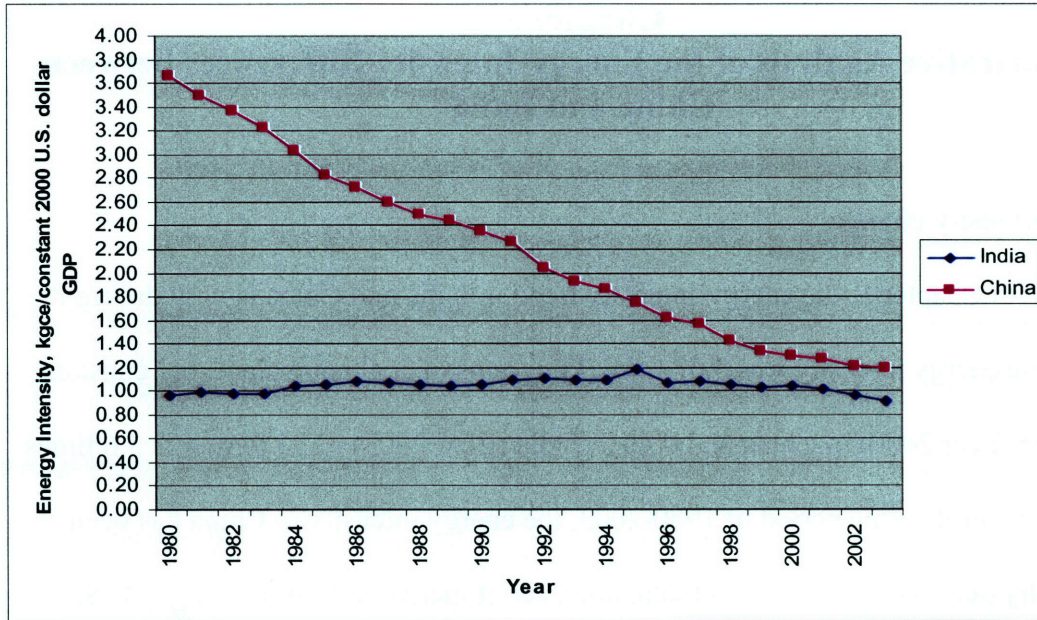
Chapter 3

Comparative Analysis of the Energy-Intensity Differences between China and India

Energy-intensity change

As I stated in Chapter 1, the energy-intensity trend in India and China is very different. In 1982, the energy intensity was 3.67 kgce (kilograms of coal equivalent) per constant U.S. dollar (Year 2000) in China and 0.96 in India (EIA, 2003). The former is 3.6 times the latter. Over the time period of 1980-2003, the energy intensity in China has been dramatically decreased by 67%. In India, however, it increased from 0.96 kgce/U.S. dollar in 1980 to 1.04 in 1984, and since then kept increasing until it reached the highest point at 1.18 in 1995. After 1995, the energy intensity in India began to decrease and returned to below 1.0. The overall drop from 1980 to 2003 is only 5%, a very minor change compared to China's change of 67% (Figure 2).

Energy intensity is a measurement of the effectiveness of energy use and the consumption patterns of different economies. According to the World Energy Assessment (WEA), economies with a large share of services in GDP and a large share of electricity in the final energy mix usually have lower final energy intensities than do economies based on materials and smokestack-based industries and fuelled by coal and oil (WEA, 2000). Therefore, to compare the determinants of energy intensity in China and India, I first compare their economic structures and energy consumption patterns.



Energy intensity = Energy consumption per unit of GDP (constant 2000 U.S. dollar using Market Exchange Rate)

Kgce = Kilogram of coal equivalent

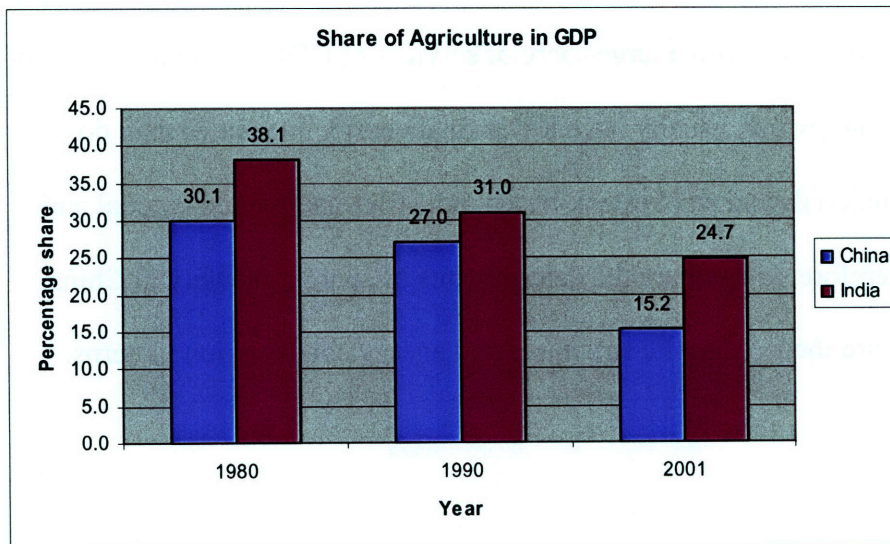
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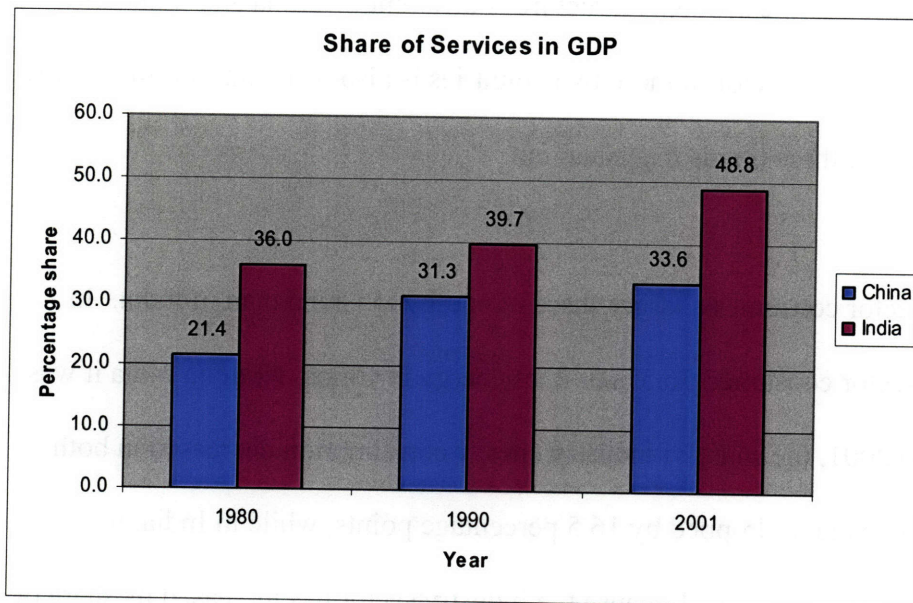
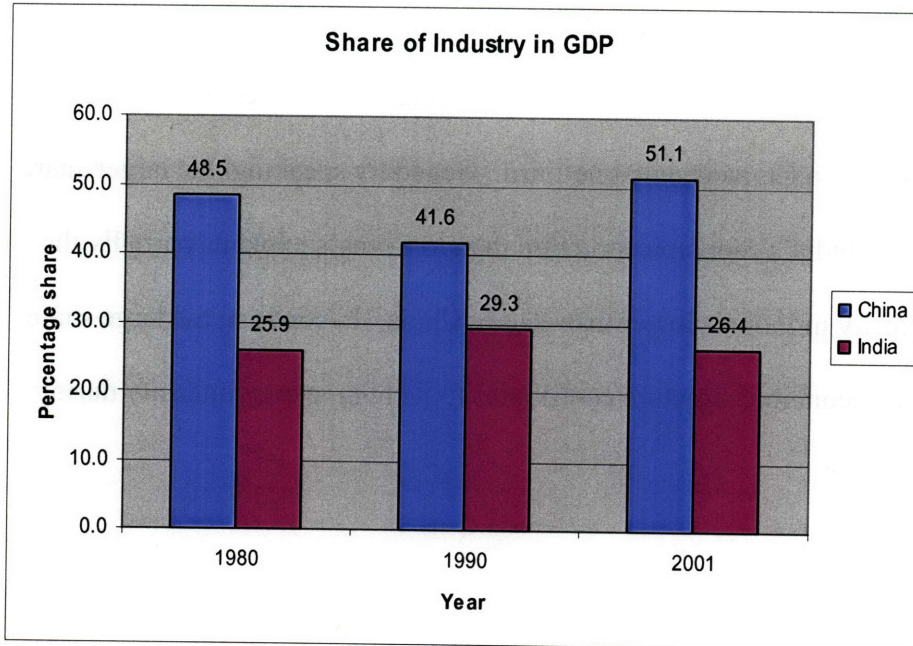
Figure 2 Energy Intensity of China and India, 1980-2003

Economic structure

Although both China and India are industrializing countries and the industry sector

represents a large part of their GDP, the composition of GDP still differs in two countries.





Note: Data are based on GDP at current factor cost.

Source: Asian Development Bank (ADB), Asian Development Outlook 2002.

Figure 3 Composition of GDP in China and India

On the other hand, from Figure 3, it is obvious that the industry sector accounts for much more GDP in China than in India – taking 2001 for example, in China, the percentage of GDP created by industry sector is more than 50%, while that in India is only about 25%.

On the other hand, the share of the service and agriculture sectors in GDP in India is larger than those in China: in 2001, almost one-half of India's GDP is created by the service sector, while that in China is only one-third. Generally speaking, the larger share of the service sector in India's economic structure than in China's explains partially the fact that energy intensity in India is lower than that in China. In contrast, the large share of industry in China's economic structure contributes to its high energy intensity during time.

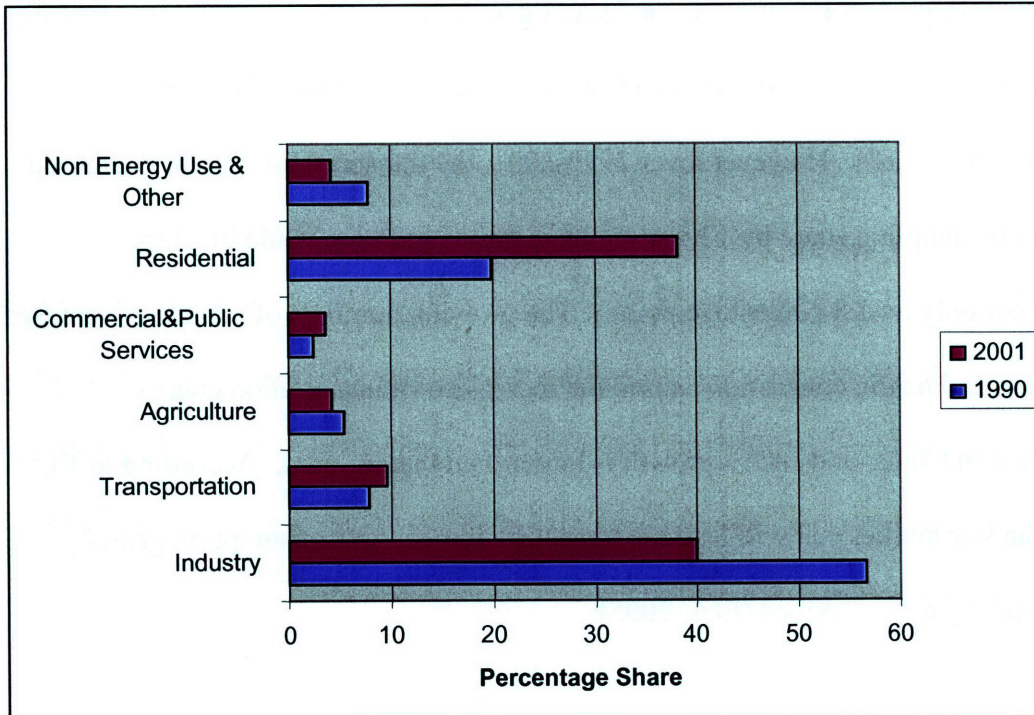
Energy-consumption pattern

Because the composition of the economy structure is different in China and India, the energy consumption of each sector in these two countries is also different. From Figures 4 and Figure 5, there are three trends that stand out.

First, the industry sector consumes a larger share of energy in China than in India. In 1990, the industry sector consumed 56.5% of total energy in China, while in India it was 44%. From 1990 to 2001, the share of industry energy consumption decreased in both China and India. In China, it dropped by 16.5 percentage points, while in India, it dropped by 17.8 percentage points. Because the industry sector has increased its share of GDP in China from 1990 to 2001, while it has decreased in India (Figure 3), the reduction of energy consumption share indicates a better improvement of energy efficiency in China than in India.

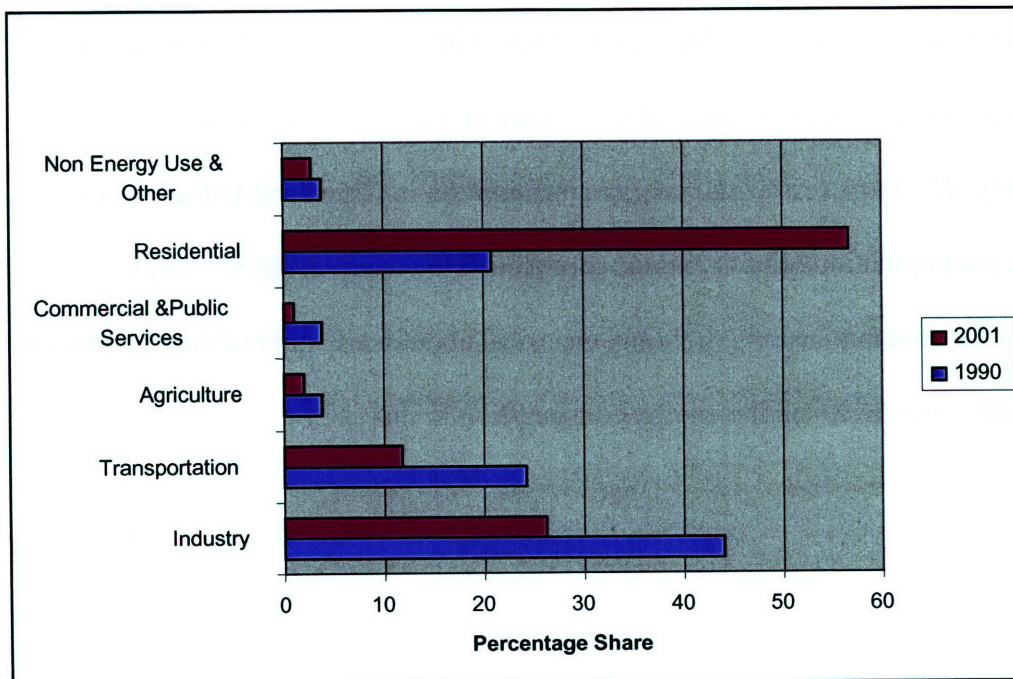
Second, the transportation sector consumes a larger share of energy in India than in China. The transportation sector consumed 24.1% of total energy in 1990 in India, while in China it was only 7.8%. However, over 1990-2001, the transportation sector decreased its energy consumption share by 12.4 percentage points in India; while in China, it increased but only by 1.8 percentage points. The growing numbers of vehicles, increased urbanization and traffic congestion caused the increase of transportation energy consumption in China, and such a growth is larger than that in India. According to EIA, China is the key market that will lead the transportation energy consumption growth in the Asian emerging economies (EIA, 2005).

Third, the share of the residential energy consumption in both countries is close in 1990, both being around 20%; however, in 2001, it increased to 38.2% in China, and a much larger increase happened in India, reaching 56.6%. High energy consumption in the residential sector is typical in developing countries; while in developed countries, the residential sector energy consumption always counts for only 15% to 20% of the total (WEA, 2000). The large residential energy consumption in China and India is mainly due to the rapid population growth and urbanization. However, different energy technologies for cooking, heating, lighting, electrical appliances, and building insulation will have different impacts on the energy consumption in this sector.



Percentage Share = percent of total final energy consumption
 Source: World Resource Institute, 2005.

Figure 4 Sector Share of Energy Consumption in China



Percentage Share = percent of total final energy consumption
 Source: World Resource Institute, 2005.

Figure 5 Sector Share of Energy Consumption in India

Figure 6 and 7 show the energy consumption by major sources in each country. Figure 8 and 9 show the share of primary energy consumption by major sources in each country. Here the major primary energy sources in both China and India include coal, petroleum and natural gas; nuclear and renewable are not included, given their small share in the total primary energy consumption. Comparing the energy-consumption patterns in the two countries, I find five major characteristics.

(1) For each energy source, China consumes much more than India does. From Figure 6 and 7, in 1980, China consumed 5.6 times as much coal, 9.9 times as much natural gas, and 1.4 times as much petroleum as in India. In 2003, China consumed 4.3 times as much coal, 1.5 times as much natural gas, and 2.2 times as much petroleum as in India.

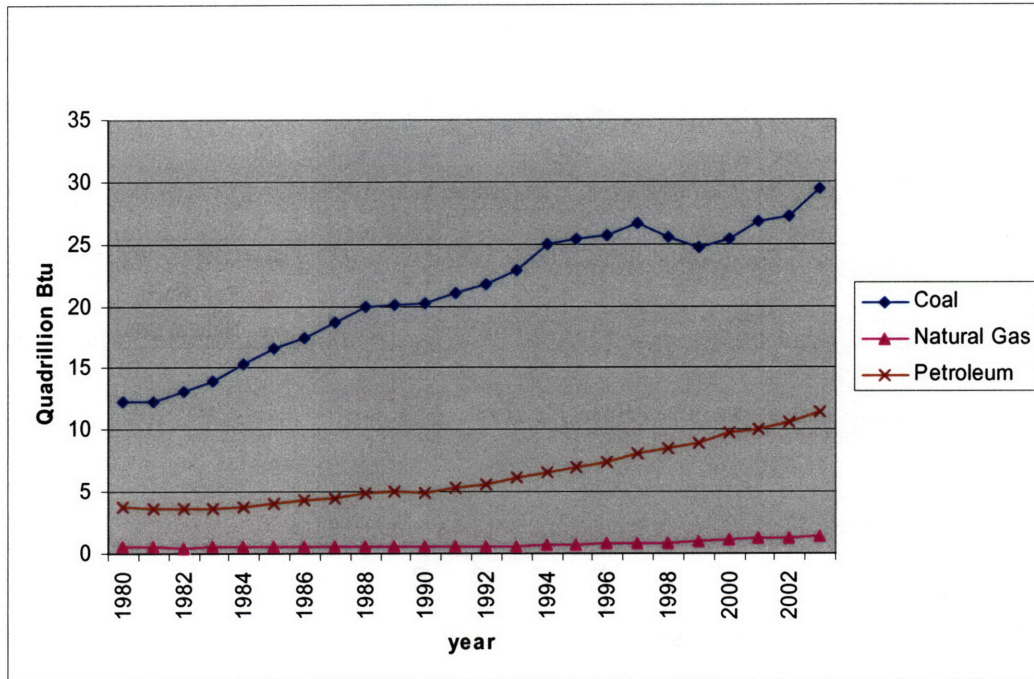
(2) The consumption of coal and petroleum in India is increasing more rapidly than that in China. From 1980 to 2003, coal consumption in China increased by 140%, while in India it increased by 229%; petroleum consumption increased by 199% in China and by 251% in India. This indicates a more rapid increase of primary energy consumption in India over time. It is possible that India will catch up China in terms of energy consumption in the near future, given its rapid growth of population and GDP.

(3) Coal is the dominant energy source in both China and India. It satisfied more than 70% of China's primary energy demand and about 60% of India's energy demand in 2003. However, the share of coal consumption in both countries has slightly declined

over time. China and India can both improve their overall energy intensity by improving the efficient use of coal, given the large share of coal consumption.

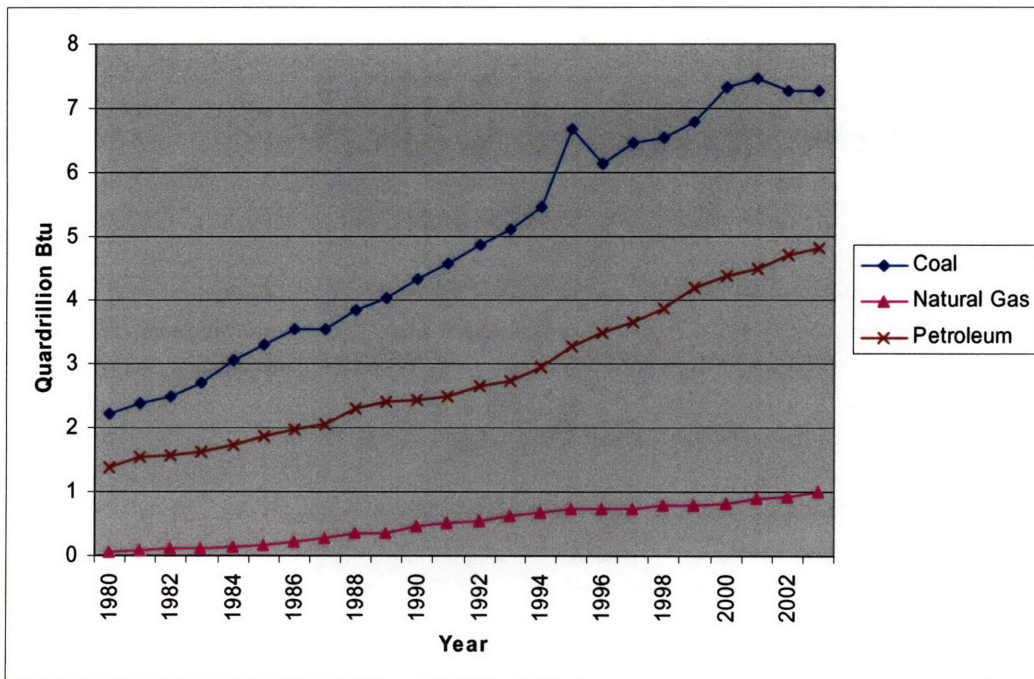
(4) Petroleum takes a larger share of energy consumption in India than that in China. It accounts for about 35% of India's total energy consumption, while in China it accounts for only about 20%. However, in China the petroleum share of total energy consumption increased from 21% in 1980 to 24% in 2003, while in India it decreased slightly from 34% to 32% over the same period. This is the consequence of the more rapid growth in China's transportation sector, which is the major consumer of petroleum.

(5) Natural gas is a minor fuel in the overall energy mix in both China and India, mainly because of the small reserve of this energy source. Natural gas only accounts for about 3% of energy consumption in China over time. In India, it accounted for less than 3% before 1986, but after that, it began to increase and accounted for about 7% during 1990s.



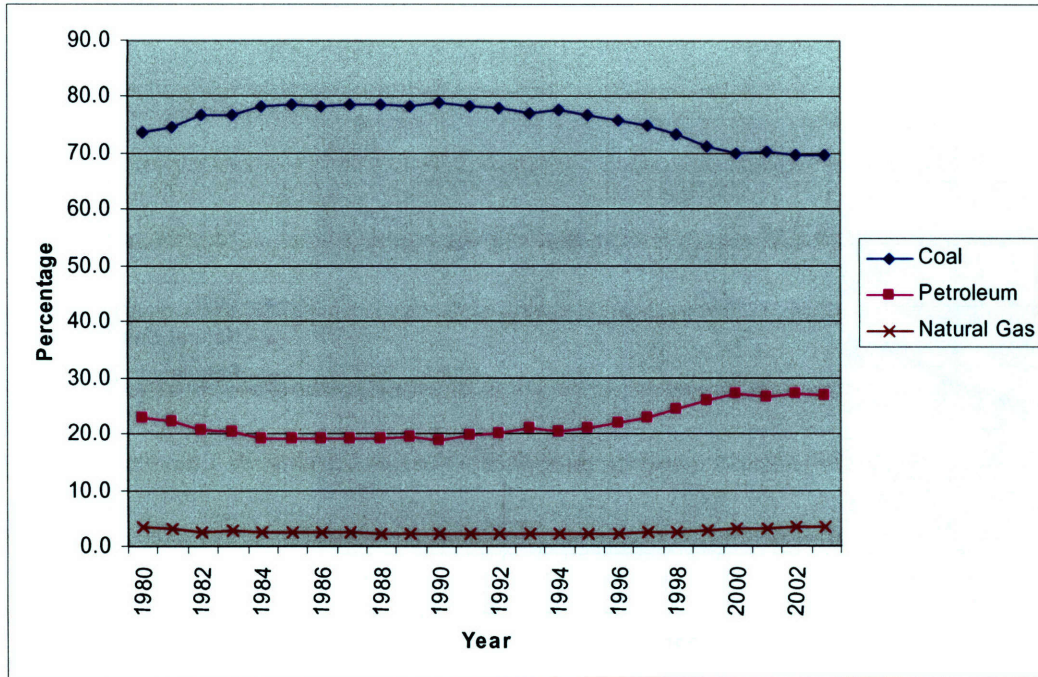
Source: Energy Information Administration, 2003.

Figure 6 Primary Energy Consumption by Source in China, 1980-2003



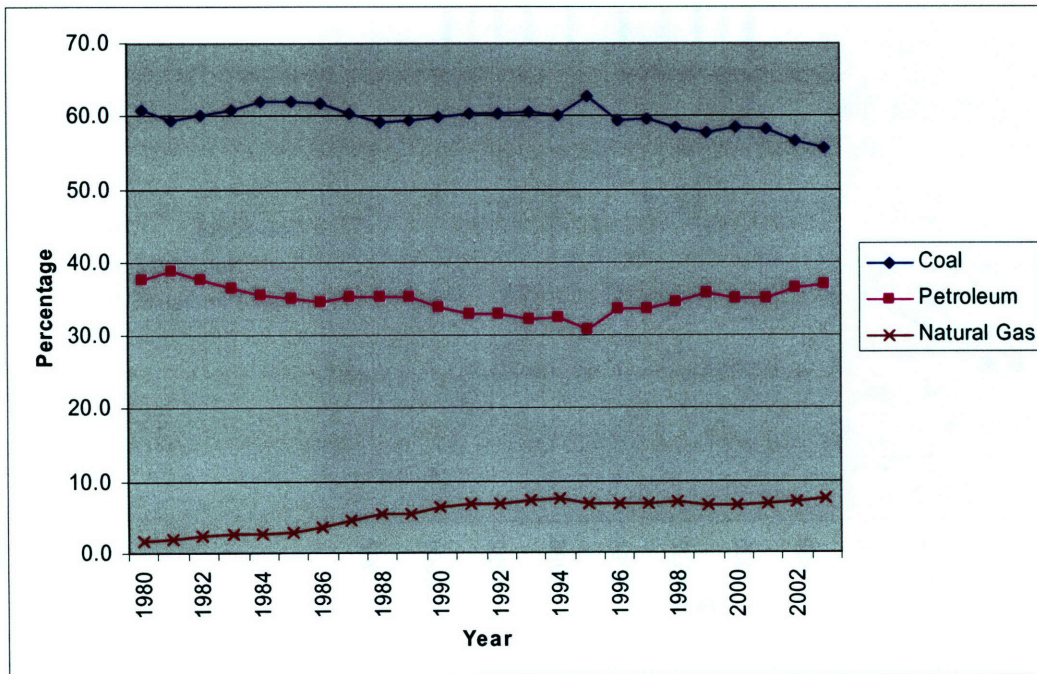
Source: Energy Information Administration, 2003

Figure 7 Primary Energy Consumption by Source in India, 1980-2003



Source: Energy Information Administration, 2003

Figure 8 Share of Primary Energy Consumption by Source in China, 1980-2003



Source: Energy Information Administration, 2003

Figure 9 Share of Primary Energy Consumption by Source in India, 1980-2003

Summary

Generally speaking, the energy intensity in China is higher than in India overtime, although we must take great care in using such data for a comparison because of the use of the market exchange value (MER). From the economic structure side, China has a larger share of output from industry, while India has a larger share of output from services. Such a disparity in economic structure helps to explain the fact that China has a higher energy intensity than India. From the energy-consumption side, China consumes more coal than India, which also contributes to the higher energy intensity in China. However, China reduced its energy intensity more than India. This is largely because China had extremely high energy intensities in the 1980s, and it therefore had a greater potential to reduce its energy intensity compared to India.

However, in the industrial sector, although both China and India reduced the energy consumption share, China increased its GDP share, while India decreased its GDP share. This indicated that China decreased its energy intensity in industrial sector, while India did not, or reduced its energy intensity to a lesser extent than China.

To explore the energy-intensity change in the industrial sector in each country, and then further examine the determinants of energy-intensity change in industrial sector, I conduct a shift-share analysis.

Chapter 4

Shift-Share Analysis of the Energy Intensity in India, 1982-1998

Using the Shift-Share technique, described in Chapter 2, I decompose the components of energy intensity in India's industrial sector. I obtain the major indicators for energy consumption and industrial output for this analysis from the India Annual Industrial Survey, 1982-1998 (see Appendix 1 for the detailed data construction).

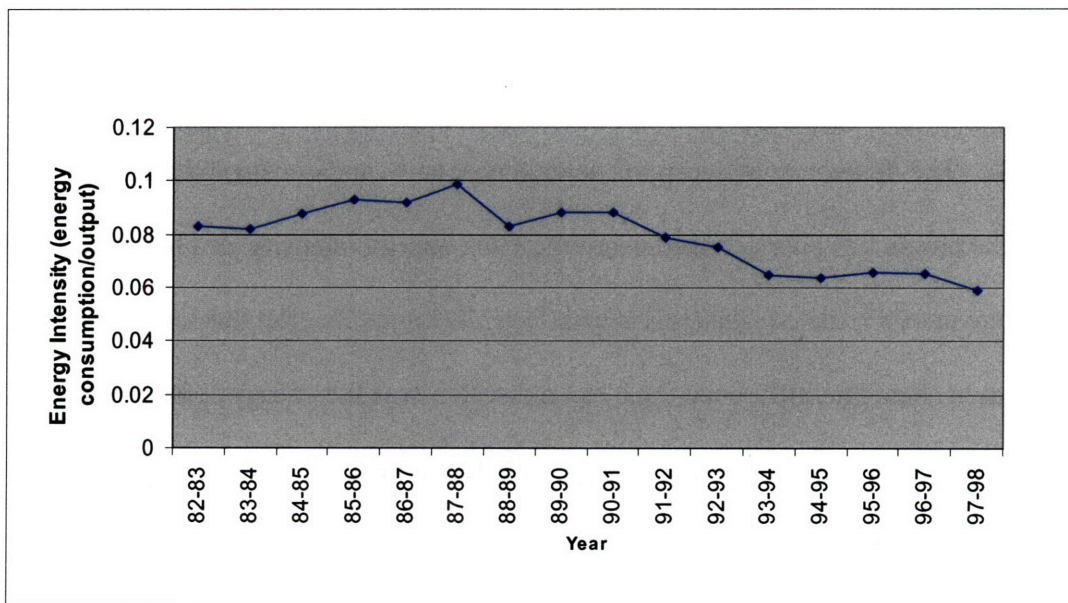
Overall results

By dividing the energy consumption by output, I obtain the energy intensity of industrial sector (Figure 10) and sub-sectors over time. Here, the value of energy consumption and output are both in monetary value of Rs. Lakhs. I deflated the energy consumption value by the Wholesale Price Index (WPI) (Base: 1981 = 100) of fuel, which measures the changes of fuel prices over time. For industrial output, I deflated the value by the Index of Industrial Production (IIP) (Base: 1981= 100), which eliminates price changes.

Therefore, the value of energy intensity has no unit. It indicates the proportion of energy consumption and output. For example, the energy intensity of the food industry in the year 1982-1983 is 0.026, which means to produce one Rs. output of food product, this industry needs to spend 0.026 Rs. on energy. This calculation is different from the method using physical value of energy consumption. However, due to the data limitation, I could not find physical energy consumption for each sub-sector in India. Besides, by using the WPI of fuel, I can use the value of energy consumption to approximate the real energy consumption change. I believe using monetary values to calculate the energy

intensity is also a reasonable and useful way to measure how much energy is needed in order to produce one unit of output.

Meanwhile, I use energy consumption per unit of output, instead of GDP to measure the energy intensity of the industrial sector. Although there are arguments against using gross output value because of its double-counting, in the sense that it counts both inputs and outputs. I am comparing energy intensity across time and countries, using the same criteria; therefore, the double-counting should not be a major issue. Besides, in most of the industry data, the value of output is given rather than the value of GDP. Furthermore, I intend to show the general pattern rather than an exact estimate of components of the intensity changes.



Note: 1) Energy intensity = energy consumption (Rs)/ value of industrial output (Rs)
2) Period of fiscal year in India is April to March, e.g. year shown as 1982-83 relates to April 1982 through March 1983.

Source: India Annual Survey of Industries, 1982-1983 to 1997-1998

Figure 10 Industrial Energy Intensity, India, 1982-1997

As shown in Figure 10, the energy intensity of the industrial sector in India during 1982-1997 declined slightly with some fluctuations (for convenience, throughout, I refer to the fiscal year only by the first year; for example, 1982 for FY 1982-1983). It increased from 0.083 in 1982 to 0.098 in 1987, and since then, it dropped to 0.083 but increased again between 1987 and 1990. After 1990, the energy intensity kept decreasing from 0.088 to 0.059 in 1997.

The Shift-share analysis decomposes the change of energy intensity during time into two impacts: structural change and efficiency change.

Table 1 shows the actual energy consumption in India's industrial sector for each year between 1982 and 1997 and its constant share, industrial-mix, and efficiency-shift components. The constant-share component indicates the amount of energy the industrial sector would consume in a given year if its energy intensity in that year were the same as that in 1982. The difference between the actual energy use and constant share, therefore, measures the amount of energy saved using the 1982 energy intensity as a benchmark. For example, in 1983, the constant share was 719,758 Lakhs Rs., but the actual use was 708,086 Lakhs. Rs. The difference, 11,673 Lakhs. Rs., was the energy consumption saved in 1983. Summing the energy savings of different years, India saved 2,133,722 Lakhs. Rs of energy between 1982 and 1997.

**Table 1 Shift-Share Analysis of Energy Consumption in
India's Industrial Sector, 1982-1997**
(Rs. Lakhs)

Year	Actual Use (1)	Constant Share (2)	Industrial Mix (3)	Efficiency Shift (4)	Difference [(1)-(2)] (5)
1982	743,631	743,631	0	0	0
1983	708,086	719,758	22,221	-33,894	-11,673
1984	786,797	746,037	437,478	-396,718	40,759
1985	871,983	780,445	413,285	-321,747	91,537
1986	876,029	794,618	358,364	-276,953	81,411
1987	1,010,298	852,640	302,242	-144,584	157,658
1988	946,941	947,118	317,808	-317,985	-177
1989	1,146,916	1,081,705	571,867	-506,656	65,210
1990	1,238,210	1,164,553	537,135	-463,477	73,658
1991	1,230,309	1,293,792	796,582	-860,065	-63,482
1992	1,413,290	1,563,921	1,035,400	-1,186,032	-150,632
1993	1,322,986	1,702,578	1,294,013	-1,673,605	-379,591
1994	1,447,905	1,897,555	1,387,851	-1,837,501	-449,650
1995	1,703,404	2,153,943	1,653,206	-2,103,745	-450,539
1996	1,749,211	2,220,196	1,954,315	-2,425,300	-470,985
1997	1,649,065	2,316,292	2,262,905	-2,930,132	-667,228
Total	18,845,060	20,978,782	1,334,467,102	-1,547,839,306	-2,133,722

Note: 1 Lakh=100,000, 1 Lakh Rs=2241 USD

Source: Calculated from data in *Annual Industrial Survey*, 1982-1998.

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It is obvious that the efficiency shift of each year is negative and it has kept decreasing over time, which indicates that efficiency improvement drives the energy consumption to decrease. However, the industrial mix factor is always positive and it kept increasing, indicating that the industrial mix causes the increase of energy consumption. Therefore, all the energy saving should be attributed to the improvement in energy efficiency.

In Table 2, I present the results of the Shift-Share analysis on energy intensity in India's industry sector. Because I use 1982 as the reference year, the constant share component for all years was equal to the 1982 intensity. The industrial mix component indicated the

degree to which an industrial sector specializes in energy-intensive sub-sectors. The larger (smaller) the industrial mix, the higher (lower) the share of energy-intensive industrial sub-sectors. The efficiency-shift component tells us the relative level of energy efficiency in a given year. A smaller number indicates a higher efficiency. It is not surprising to see that for each year, the industrial-mix number was positive and increasing, meaning that the share of energy-intensive industries in the industrial sector has increased over time. In contrast, the efficiency shift was negative and kept decreasing, which means that the industrial sector used energy more efficiently. The industrial mix and energy-efficiency shift components are at work simultaneously, but in different directions. The negative impact of industrial mix offset the positive impact of efficiency shift, therefore causing the general energy intensity to change only slightly since 1982.

**Table 2 Shift-Share Analysis of Energy Intensity in
India's Industrial Sector, 1982-1997**

Year	Energy Intensity	Constant Share	Industrial Mix	Efficiency Shift
1982	0.083	0.083	0	0
1983	0.082	0.083	0.003	-0.004
1984	0.088	0.083	0.049	-0.044
1985	0.093	0.083	0.044	-0.034
1986	0.092	0.083	0.037	-0.029
1987	0.098	0.083	0.029	-0.014
1988	0.083	0.083	0.028	-0.028
1989	0.088	0.083	0.044	-0.039
1990	0.088	0.083	0.038	-0.033
1991	0.079	0.083	0.051	-0.055
1992	0.075	0.083	0.055	-0.063
1993	0.065	0.083	0.063	-0.082
1994	0.063	0.083	0.061	-0.080
1995	0.066	0.083	0.064	-0.081
1996	0.065	0.083	0.073	-0.091
1997	0.059	0.083	0.081	-0.105

Note: Energy Intensity =Value of energy consumed to produce 1 constant 1981 Rs. Output.
Source: Calculated from data in *Annual Industrial Survey, 1982-1998*.

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Table 3 presents the changes in the energy intensity in India's industrial sector, their structural-change and efficiency-shift components. Both components change very little, and in most of the years, they offset each other. When the factors driving energy intensity down were greater than the factors driving energy intensity up, the energy intensity declined. For example, from 1982 to 1983, the efficiency shift decreased 0.004, while the industrial mix drove the energy intensity up by 0.003; therefore, the overall energy intensity decreased 0.001. From 1986 to 1987, the industrial mix changes made overall energy intensity decrease 0.008, but the efficiency shift increased 0.015, thus the overall energy intensity increase 0.007. Only when the two components both decreased did the overall energy intensity show large changes. However, such a situation only

occurred during 1987-1988, when both components decreased, and overall energy intensity decreased by 0.015, which is the largest decline over the study period. Generally, during 1982-1997, both industrial mix and efficiency shift played important role in determining energy intensity in India's industrial sector.

Table 3 Changes in Energy Intensity in India's Industrial Sector, 1982-1997

Year	<u>Total Energy</u>	<u>Industrial Mix</u>		<u>Efficiency shift</u>	
	Intensity change	Change	% of Total [(2)/(1)]	Change	% of Total [(4)/(1)]
	(1)	(2)	(3)	(4)	(5)
82-83	-0.001	0.003	-190.371	-0.004	290
83-84	0.006	0.046	784.071	-0.040	-684
84-85	0.005	-0.005	-90.739	0.010	190
85-86	-0.001	-0.007	529.556	0.005	-429
86-87	0.007	-0.008	-117.051	0.015	217
87-88	-0.015	-0.002	10.225	-0.014	89
88-89	0.005	0.016	319.354	-0.011	-219
89-90	0.000	-0.006	-2274.376	0.006	2374
90-91	-0.009	0.013	-137.521	-0.022	237
91-92	-0.004	0.004	-98.111	-0.008	198
92-93	-0.011	0.008	-77.371	-0.019	177
93-94	-0.001	-0.002	204.419	0.001	-104
94-95	0.002	0.003	130.018	-0.001	-30
95-96	0.000	0.009	-3799.215	-0.010	3899
96-97	-0.006	0.008	-127.377	-0.014	227

Source: Table 2. Each cell except constant share in Table 2 for each year was subtracted from the corresponding number for the previous year.

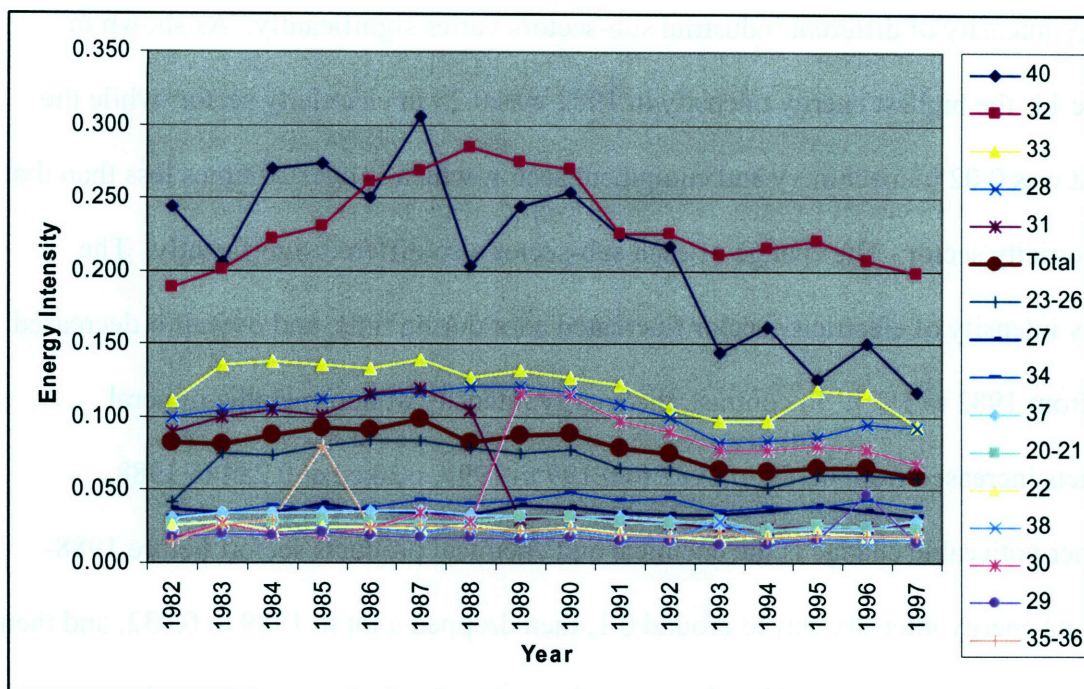
The effects of structural change

Energy intensity in an industrial sector depends in part on the mix or composition of industries within the sector. The energy intensity will be high if most industries in the sector are energy intensive. An increasing share of energy-intensive industries will increase the energy intensity of the industrial sector, and vice versa (Lin, 1992).

Energy intensity of different industrial sub-sectors varies significantly. As shown in Figure 11, the highest energy intensity in 1982 was 0.25 in electricity sector; while the lowest was 0.02 in machinery and equipment sector, which is over 20 times less than that of electricity sector. The change of each sub-sector also differed significantly. The energy intensity of electricity sector fluctuated a lot during time, and overall it decreased 0.13 from 1982 to 1997. In contrast, the energy intensity of non-metallic mineral products increased from 0.189 in 1982 to 0.199 in 1997, peaked at 0.284 in 1988. Another noticeable change is the chemical and chemical products sector: before 1988-1989, its energy intensity stayed around 0.1, then dropped a lot in 1989 to 0.032, and then kept around 0.030. Compared to the energy intensity of industry as a whole, there are four sub-sectors having higher energy intensity than the industry energy intensity: electricity, non-metallic mineral products, basic metal and alloys industries, and paper, printing, publishing and allied industries. The energy intensity of chemicals and chemical products was higher than the overall industrial energy intensity before 1988; the energy intensity of rubber, plastic, petroleum and coal products was higher than the overall industrial energy intensity after 1989.

Figure 11 also explains why the industrial mix plays an important role in determining energy intensity in India's industrial sector. Using shift-share analysis, I calculate the industrial-mix impact by taking the difference between sub-sectoral energy intensity and overall energy intensity of industry:

$$\text{Industrial Mix} = \sum_i [(e_{i,82} - e_{82}) * O_{i,t}] / O_t$$



Note: Energy intensity = energy consumption / value of industrial output

Industrial classification used in Figure 11:

- 40 Electricity
- 32 Non-metallic mineral products
- 33 Basic metal and alloys industries
- 28 Paper, printing, publishing and allied industries
- 31 Chemicals and chemical products
- 23-26 Textiles
- 27 Wood and wood products
- 34 Metal products, except machinery and equipment
- 37 Transport equipment and parts
- 20-21 Food products
- 22 Beverages, tobacco and related products
- 38 Other manufacturing industries
- 30 Rubber, plastic, petroleum and coal products
- 29 Leather and products of leather
- 35-36 Machinery and equipment

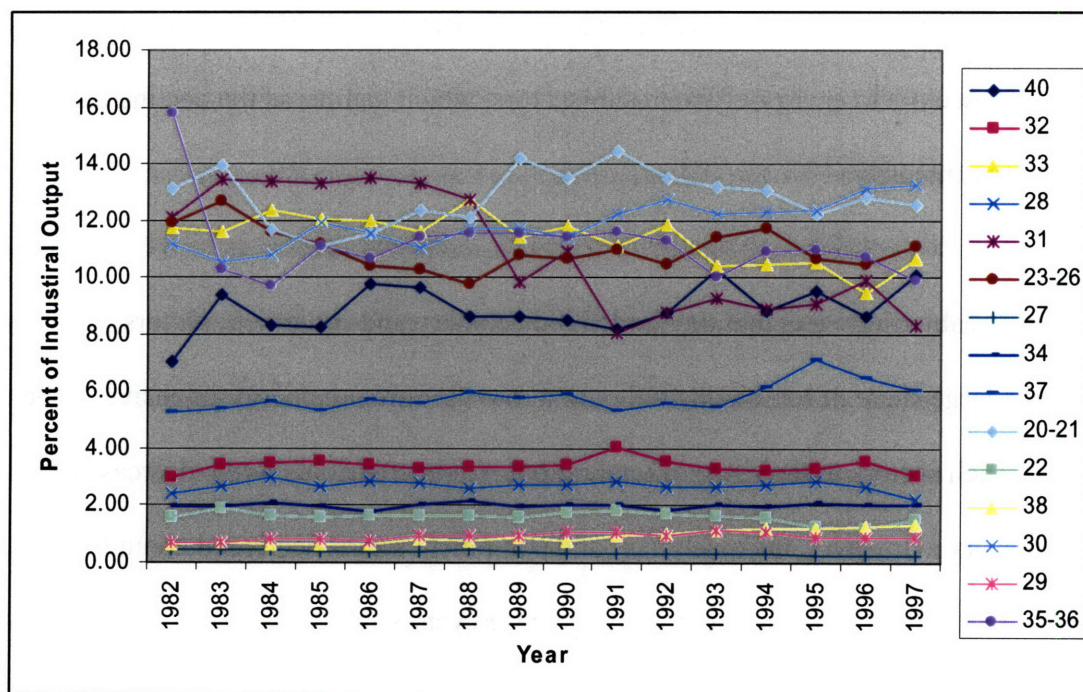
Source: India *Annual Survey of Industries*, 1982-1997

Figure 11 Energy Intensity of Industrial Sub-Sectors in India, 1982-1997

Figure 11 shows that the difference between the energy-intensive sub-sectors and overall energy intensity is larger than that between less energy-intensive sub-sectors and overall

energy intensity. This makes the sum of the industrial-mix impact to be positive, which offsets the impact of energy-efficiency shift.

Therefore, the industrial structure has impacts on energy intensity. Figure 12 shows the structural composition of sub-sectors in India's industry.



Industrial classification: Same as Figure 11

Source: India Annual Survey of Industries, 1982-1983 to 2002-2003

Figure 12 Composition of Industrial Output in India, 1982-1997

In Figure 12, among the six most energy-intensive sectors, there are four sectors belonging to the large-share group (share of composition of industrial output above 8%): electricity, paper, basic metal and alloys industries, chemicals and textiles. This indicates that the structure of India's industrial sector is fairly energy-intensive. The electricity sector increased from 7% in 1982 to 10% in 1997; the basic metal and alloys industries fluctuated slightly during 1982 to 1997, overall it dropped from 12% to 11%; the chemical

and chemical products sector was above 12% before 1998, then decreased and reached 8% since 1991; and the textile sector always stayed around 11%. Totally, these four sectors comprise 43% of total industrial output in 1982, then increased and kept the level at 45% till 1986, after which their share began to drop and in 1997 it was 40%. The overall change from 1982 to 1997 is below 3 percentage points. This indicates that India's industrial mix made very small improvements in terms of shifting from energy-intensive sub-sectors to energy-efficient sub-sectors, which hampered the decline of overall energy intensity.

Another noticeable finding is that the food and machinery and equipment sectors composed a large share of total industrial output, but they are not energy-intensive. The increase of such sectors in the share of total output would contribute to the decrease of energy intensity. However, the machinery and equipment sector decreased about 6% during this period, and the food sector only increased very slightly.

Generally speaking, the composition of industrial output in India is a complex mix of both energy-intensive sub-sectors and less energy-intensive sub-sectors. The share of energy-intensive sectors is always larger than that of less-energy-intensive sectors. Such a composition indicates that India's industrial sector is fairly energy intensive. The change of industrial structure did not contribute to the decrease in energy intensity, because the share of energy-intensive sectors increased over time, while the other decreased. Such a finding is consistent with the calculation result of shift-share analysis,

which shows that the industrial structure played a negative role in determining the energy intensity in India's industry sector.

The effects of efficiency change

Efficiency change is another factor determining the energy intensity. The energy intensity will decrease if the efficiency is improved. The improvement in energy efficiency can be achieved by a variety of means, such as improving operation and management of existing plants, replacing and upgrading energy-intensive equipment, and using less energy-intensive technologies and production processes (Lin, 1992). In the shift-share analysis, the changes in energy efficiency are revealed by the changes in energy intensity at the individual industry level over time:

$$\text{Efficiency change} = \sum_i [(e_{i,t} - e_{i,82}) * O_{i,t}] / O_t$$

If the energy intensity of industry i is decreased, which means it uses energy more efficiently, the difference between it and its energy intensity in the base year would be negative, then the total energy intensity of industry would be decreased by such impact.

Looking at Figure 11 again, almost all of the five most energy-intensive sectors encountered intensity change overtime compared to the base year. The most remarkable one is the electricity sector: its energy intensity fluctuated over the study period and overall decreased from 0.25 in 1982 to 0.12 in 1997.

Comparing the trends of electricity energy intensity and industrial energy intensity, they moved fairly much in unison: increasing during 1983 and 1987, decreasing from 1987 to 1988, increasing from 1988 to 1990, and then decreasing since 1990. This indicates that the electricity sector might have a larger impact on overall industrial energy intensity than other sub-sectors because of its large industrial output share and high energy intensity.

The energy intensity of non-metallic mineral products sector also changed over time: it increased from 0.19 in 1982 to 0.28 in 1988, since then it dropped to 0.20 in 1997.

Overall, the energy intensity increased slightly from 1982 to 1997. This indicates that the energy efficiency did not improve much in the non-metallic mineral products sector and it might have a negative impact on the industrial energy intensity.

The chemicals and chemical products sector decreased its energy intensity remarkably in the year 1989 and since then kept a low level of energy intensity. The overall change of energy intensity is from 0.09 in 1982 to 0.03 in 1998, a decrease of 56%. Such an improvement of energy efficiency would have a positive impact to decrease the industrial energy intensity.

Overall, the absolute value of India's industrial energy intensity decreased. It is obvious that the energy efficiency of each sub-sector in India improved during 1982-1997, and each contributed to the decline in the industrial energy intensity.

Summary

In this chapter, I examined the energy intensity in India's industrial sector. From 1982 to 1997, the energy intensity of India's industrial sector decreased by 29% from 0.08 to 0.06. The change of energy intensity was determined by two factors: structural shift and efficiency improvement. The energy efficiency of each sub-sector generally improved hence drove the energy intensity of industry to decrease; however, such a positive impact was offset by the industrial structure. The industrial structure became more energy-intensive because of the increasing share of energy-intensive sub-sectors.

There are several major industrial sub-sectors playing key roles in the determination of India's industrial energy intensity.

(1) Electricity

The electricity sector is fairly energy intensive and it comprises about 10% of the total industrial output. On one hand, the increasing share of electricity in the total industrial output caused the industrial energy intensity to increase; on the other hand, the energy efficiency of electricity improves over time, which caused the industrial energy intensity to decrease over time. The electricity sector provides energy to almost every industrial sector, and the generation of electricity has to be expanded to meet the demand (EIA, 2005). Therefore, the key means of reducing energy intensity through the electricity sector is to improve its energy efficiency. The energy intensity of electricity is very unstable in India in past years, indicating the possible immature use of energy technology by the sector.

(2) Non-metallic mineral products

This sector only takes a share of 3% in total industrial output but consumes above 10% of the total energy consumption. Its energy intensity is the highest of all sectors in most of the years during 1982-1998. Therefore, it is very important to improve the energy efficiency in this sector in order to reduce the energy intensity in India.

(3) Basic metal and alloys

This sector shares a larger output than electricity, but it consumes less energy than the electricity sector. Therefore, its energy intensity is much lower than that of the electricity sector. However, the energy efficiency of this sector did not change overtime, and there should be a potential space for this sector to improve its energy efficiency.

(4) Chemicals and chemical products

The energy intensity of this sector declined from 0.09 in 1982 to 0.03 in 1989, and remained at a low level since then. However, its share of output also decreased since 1989, remaining below 10%. Keeping the low energy intensity level of this sector and increasing its share in industrial output could be a way to decrease the industrial energy intensity.

(5) Textile industry

The textile sector produced about 11% of total industrial output in India, and its energy intensity is less than the overall industrial energy intensity over time. This pattern is beneficial to the industrial energy intensity and should be kept or further improved.

(6) Food industry

The food industry has the lowest energy intensity among those sectors having a large share of output. Its energy intensity was fairly stable around 0.03 during the past 20 years. On the other hand, its output decreased during 1983-1988, and then increased, and it was the highest-output sector from 1989 to 1995.

The other sub-sectors with both stable low energy intensity and a low share of output are leather and products of leather, other manufacturing industries, beverages, tobacco and related products. By increasing the output of these sectors, India could have a positive impact on overall energy intensity. However, whether to increase their output will also depend on many other factors, such as profitability and resource availability.

Chapter 5

Shift-Share Analysis of the Energy Intensity in China, 1980-2003

Overview of previous study results

Lin (1992) studied the energy intensity of China's industrial sector during 1980 and 1998 using shift-share analysis. His major finding was that energy efficiency was the most important factor causing the variations in energy intensity. The result of Lin's study is shown in Table 4. During 1980 and 1988, the efficiency shift and industrial mix both forced the energy intensity to decline. However, the change of efficiency shift dominantly determined the change in energy intensity of China's industrial sectors. According to Lin's finding, the efficiency shift reduced overall energy intensity by 37 Gce/RMB per year, while the structural change decreased the industrial energy intensity only by an average of about 7 Gce/RMB annually.

Table 4 Shift-share Analysis of Energy Intensity in China's Industrial Sector, 1980-1988

Year	Energy Intensity	Constant Share	Industrial Mix	Efficiency Shift
1980	783.8	783.8	0.0	0.0
1981	731.4	783.8	-15.0	-37.4
1982	720.7	783.8	-8.5	-54.6
1983	691.2	783.8	-9.7	-83.0
1984	625.9	783.8	-15.8	-142.1
1985	568.7	783.8	-26.6	-188.6
1986	594.9	783.8	-33.0	-155.9
1987	577.9	783.8	-6.7	-199.2
1988	453.1	783.8	9.9	-340.5

Note: Energy intensity= grams of standard coal equivalent per Renminbi of output.

Source: Lin, 1992. *The Journal of Energy and Development*, 16 (2), 1992, p. 205

In 1999, Ali Shirvani-Mahdavi used the same approach of Shift-Share analysis to analyze the energy intensity in China's material production sector from 1986 to 1995. His study (Table 5) also showed that during 1986-1995, the improvement in energy efficiency was the major contributor to the overall reduction in energy intensities in the material production sectors of China.

Table 5 Shift-Share Analysis of Energy Intensity in China's Material Production Sector, 1986-1995

(Unit: Grams of Standard Coal Equivalent per Constant 1980 RMB of Output)

Year	Energy Intensity	Constant Share	Industrial Mix	Efficiency Shift
1986	414.2	421.2	6.9	-14
1987	382.7	406.7	0.4	-32
1988	352.9	382.7	7.6	-37.3
1989	351.5	352.9	17.8	-19.2
1990	335.7	351.5	-7.7	-8.1
1991	315.4	335.7	4.9	-25.1
1992	272.6	315.4	24.1	-66.9
1993	257.8	272.6	-7.4	-7.5
1994	255.5	257.8	3.6	-5.8
1995	246.7	255.6	2.3	-11.2

Note: The Material Production Sector is actually the manufacturing sub-sectors within industrial sector. It is the same concept as the Industrial Sector in Lin's study. In China's national industrial classification, the industry includes mining and quarrying and manufacturing, but Lin and Mahdavi both only studied the manufacturing sub-sectors.

Source: Mahdavi, Master thesis. Cambridge MA: Department of Urban Studies and Planning. 1999, p. 136.

Lin and Mahdavi both studied energy intensity in China's industrial sectors from 1980 to 1995. They both used shift-share analysis, and their measurements of energy intensity are the same: energy consumption (in physical value) per unit of industrial output. The methodology and measurement of energy intensity of my research is consistent with Lin and Mahdavi's studies. I choose the time period of 1993 - 2001, which expands their time period by six years.

Construction of Data

The data for this analysis mainly come from two data sources. The output value of the industrial sub-sectors comes from the *UNIDO, Industrial Statistics Database, 2004*, and the unit is current Yuan (China's currency, also named Renminbi). I weighted the current value by the Price Index of Industrial Products (IIP), which comes from the *China Statistical Yearbook, 2003*. Energy consumption by industry data for each year and the energy consumption by each sub-sector data in the base year (1993) come from *China Energy Statistical Yearbook (1991-2002)*. I calculate the energy intensity of industry for each year by dividing energy consumption by industrial output.

The data in the industrial classification of the *UNIDO* data and *China Energy Statistical Yearbook* are mostly the same with only minor differences. I aggregated the 28 industries into the 15 categories listed below:

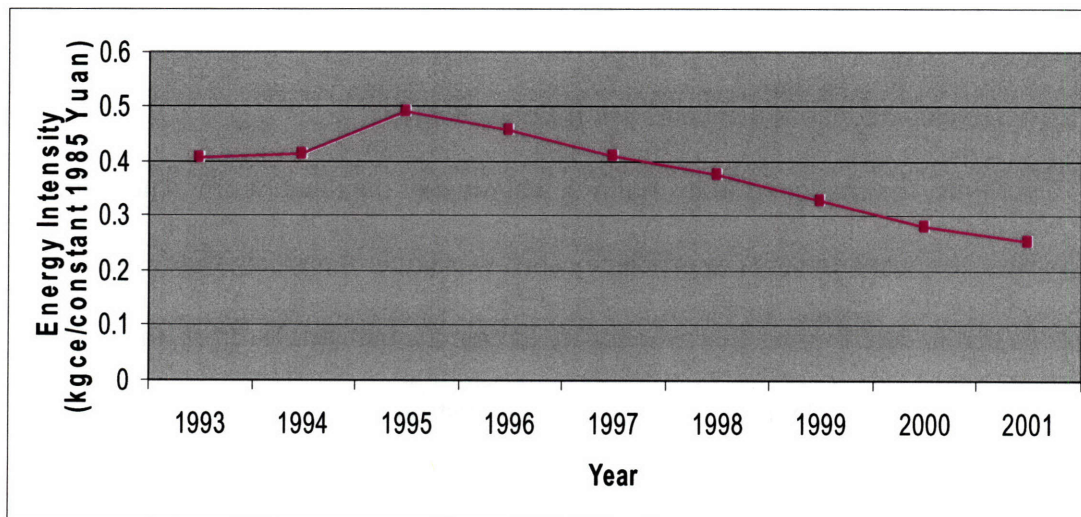
- 1 Food, Beverages, and Tobacco
- 2 Textiles and Apparel
- 3 Leather products
- 4 Wood products
- 5 Paper, Printing and Publishing
- 6 Chemicals
- 7 Petroleum and Coal
- 8 Rubber and Plastic
- 9 Non-metallic mineral products
- 10 Iron and steel
- 11 Non-ferrous metals
- 12 Fabricated metal products
- 13 Machinery
- 14 Transport equipment
- 15 Other manufactured products

For the shift-share analysis of China's industrial sectors, I followed Lin's method to calculate the efficiency change by using the residual approach. To make the calculation,

I subtracted the constant share and industrial mix from the total energy intensity to estimate the impact of efficiency shift. For India, I calculated the industrial sector's efficiency change not by the residual approach, but by using the energy consumption of each industrial sub-sector. I find the results of the two methods of India's industrial sectors are exactly the same. This proves that the residual approach is sufficient to calculate the efficiency change in India.

Overall Results

Figure 13 shows the energy intensity of industry sectors in China from 1993 to 2001. The energy intensity increased from 0.41 Kgce/Yuan in 1993 to 0.49 Kgce/Yuan in 1995, and then kept dropping over years. After 1997, the energy intensity was lower than the level in 1993 and it reached 0.26 Kgce/dollar in 2001. Overall, it changed by 38%.



Energy intensity = energy consumption (Kgce) / industrial output (constant 1985 Yuan)

Source: Calculated from UNIDO, *Industrial Statistics Database*, 2004; *China Energy Statistical Yearbook* (1991-2002)

Figure 13 Energy Intensity of Industry Sector in China, 1993-2001

Again, using the shift-share analysis, I decompose the change of energy intensity during time into two impacts: structural change and efficiency shift.

Table 6 presents the changes of energy intensity in China's industrial sectors, their structural change, and efficiency-shift components.

Table 6 Shift-Share Analysis of Energy Intensity in China's Industrial Sectors, 1993-2001

	Energy Intensity	Constant Share	Industrial Mix	Efficiency Shift
1993	0.408	0.408	0	0
1994	0.415	0.408	-0.001	0.007
1995	0.490	0.408	-0.001	0.083
1996	0.459	0.408	-0.003	0.054
1997	0.410	0.408	-0.016	0.018
1998	0.378	0.408	-0.028	-0.003
1999	0.330	0.408	-0.028	-0.050
2000	0.281	0.408	-0.029	-0.099
2001	0.255	0.408	-0.034	-0.119

Energy intensity = energy consumption (Kgce) / industrial output (constant 1985 Yuan)

The efficiency change is calculated using a residual approach. It equals actual energy intensity minus the constant share and industrial mix.

Source: Calculated from UNIDO, *Industrial Statistics Database, 2004, China Energy Statistical Yearbook (1991-2002)*

There are three characteristics that stand out from this table.

(1) Over time, the change of industrial mix was smaller than that of efficiency shift.

In most years, the absolute value of efficiency shift was larger than that of industrial mix.

This means that in determining energy intensity of China's industrial sectors, the efficiency shift played a role more important than industrial mix did. This result is exactly consistent with Lin (1991) and Mahdavi's (1999) study of the industrial energy intensity for the time span of 1980 - 1995.

(2) The energy intensity level from 1994 to 1997 was larger than the 1993 level.

During my study period of 1993-2001, the industrial mix always had a positive impact on energy intensity. Compared to 1993, the industrial mix had been less energy-intensive in the following years. However, the efficiency shift had a negative impact on energy intensity from 1994 to 1997, although such an impact was decreasing from 1995-1997. Moreover, the industrial mix had been decreasing during the study period, indicating that the share of energy-intensive sub-sectors within the industry has been lower and lower.

(3) During 1993-1997, the efficiency shift was positive, meaning that in each of those years, the energy intensity of most sub-sectors was larger than that in 1993 ($\sum [(e_{i,t} - e_{i,93}) * O_{i,t}] / O_t$ is positive). Thus, the overall energy-efficiency level was lower in 1997 than in 1993. However, the efficiency shift was becoming smaller and smaller, indicating that the energy-efficiency level improved overtime; after 1997, it began to be negative, causing the overall energy intensity to be lower than that of 1993.

Table 7 presents the percentage share of impacts of industrial mix and efficiency shift in each year. It is obvious that the share of the efficiency shift was larger than that of industrial mix in most years. Between 1994 and 2001, the efficiency shift was the sole contributor of energy intensity. However, between 1994 and 1997, the efficiency shift had larger negative impacts on energy intensity, which offset the impact of industrial mix on energy intensity.

Table 7 Shares of Two Factors of Energy Intensity in China's Industrial Sector, 1993-2001

Year	Intensity Difference (1)	Industrial Mix (2)	Industrial Mix (%) [(2)/(1)] (3)	Efficiency Shift (4)	Efficiency Shift (%) [(4)/(1)] (5)
1994	0.007	-0.001	-10.276	0.007	110.28
1995	0.082	-0.001	-0.991	0.083	100.99
1996	0.051	-0.003	-6.676	0.054	106.68
1997	0.001	-0.016	-1148.069	0.018	1248.07
1998	-0.031	-0.028	91.032	-0.003	8.97
1999	-0.078	-0.028	35.979	-0.050	64.02
2000	-0.128	-0.029	22.451	-0.099	77.55
2001	-0.153	-0.034	22.226	-0.119	77.77

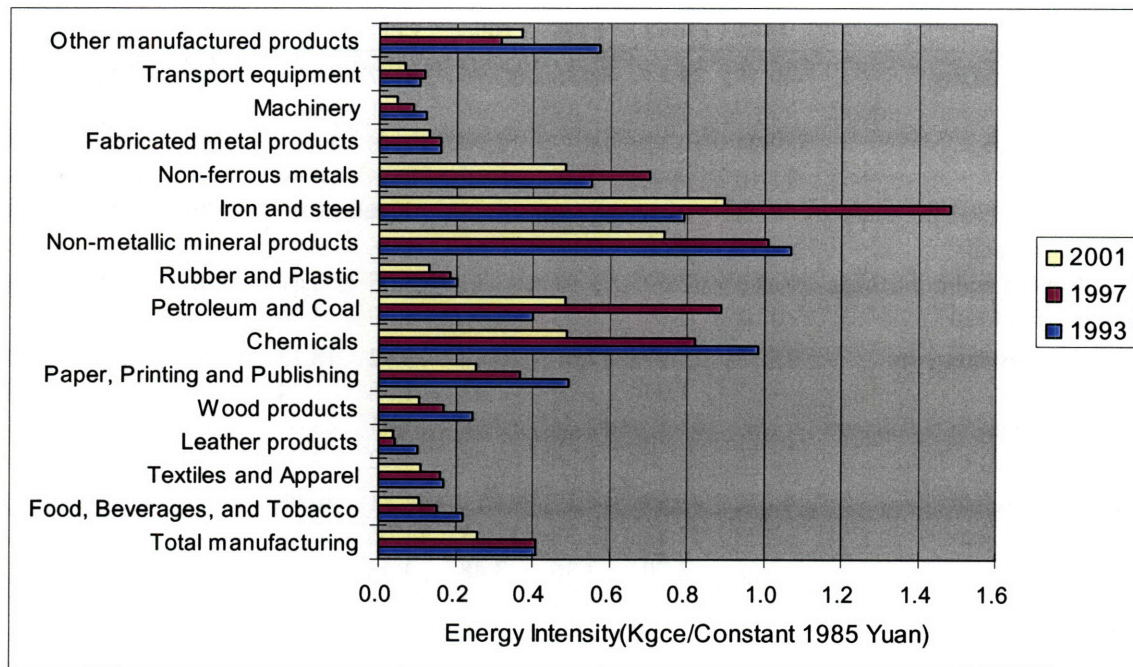
Source: Calculated from UNIDO, *Industrial Statistics Database, 2004, China Energy Statistical Yearbook (1991-2002)*

The effects of structural change

Energy intensity also varies across China's industrial sub-sectors. From Figure 14, in 1993, while the overall energy intensity of industry sector (total manufacturing) was 0.408 Kgce/Yuan, the sector with the largest energy intensity was non-metallic mineral products (1.071 Kgce/Yuan). In 1997, the energy intensity in the iron and steel sector was strikingly large, which was 1.481 Kgce/Yuan, almost 4 times larger than the overall level. The iron and steel sector also had the highest energy intensity in 2001.

In these three years, the five most energy-intensive industries were (1) iron and steel, (2) non-metallic mineral products, (3) chemicals, (4) non-ferrous metals, and (5) petroleum and coal. Such sectors are mostly the heavy industries that not only consume a large amount of heat or power, but also use energy sources as material input. The least energy-intensive sectors include machinery, transport equipment, fabricated metal products, textiles, food and tobacco, etc. Some of these are light industries. From 1993 to 1997, the energy intensity of iron and steel, non-ferrous metals, petroleum and coal, and

transport equipment were increased, especially the sectors of iron and steel, and petroleum and coal. This might be the reason why the industrial energy intensity during 1994-1997 was larger than that in 1993.



Source: Calculated from UNIDO, *Industrial Statistics Database, 2004, China Energy Statistical Yearbook (1991-2002)*

Figure 14 Energy Intensity of China's Industrial Sub-Sectors

Therefore, the composition of industrial structure has affected the level of energy intensity in China. Table 8 shows the composition of industrial output in China during 1993 - 2001. The share of the seven most energy-intensive sectors composed 39.9% of total industrial output in 1993, and dropped to 35.5% in 2001. The energy-efficient sub-sectors composed a larger share in total industrial output: 45.1% in 1993 and increased to 48.3% in 2001. The increasing share of the energy-efficient sectors and decreasing share of energy-intensive sectors both contributed to the decline of energy intensity in China. However, the overall structural change was only about 3 percentage point. This

explained why the structural change only played minor role in the determination of China's industrial energy intensity.

Table 8 Changes in Composition of Industrial Output in China, 1993-2001 (Percent of total industrial output)

Industry	1993	1994	1995	1996	1997	1998	1999	2000	2001
High energy intensity	39.39	38.44	38.35	37.75	36.47	34.79	35.09	36.32	35.54
Non-metallic mineral products	6.59	7.83	7.49	7.66	6.41	5.44	5.38	4.97	4.82
Chemicals	9.94	10.12	11.39	11.50	11.46	11.59	11.72	11.81	11.22
Iron and steel	11.10	9.02	7.46	6.70	6.46	6.59	6.49	6.37	6.83
Other manufactured products	2.23	2.28	2.18	2.24	2.34	1.40	1.36	1.29	1.31
Non-ferrous metals	2.75	2.60	2.80	2.55	2.46	2.77	2.84	2.94	2.84
Paper, Printing and Publishing	2.68	2.52	2.91	3.13	3.05	3.04	3.02	2.97	3.03
Petroleum and Coal	4.08	4.07	4.13	3.96	4.30	3.96	4.29	5.96	5.49
Medium energy intensity	15.51	15.97	17.48	18.14	18.72	18.23	17.60	16.30	16.11
Wood products	1.22	1.27	1.29	1.42	1.58	1.34	1.39	1.38	1.41
Food, Beverages, and Tobacco	11.02	11.50	12.63	12.98	13.41	13.05	12.40	11.27	11.07
Rubber and Plastic	3.28	3.20	3.56	3.74	3.72	3.84	3.81	3.65	3.63
Low energy intensity	45.10	45.59	44.17	44.12	44.81	46.98	47.31	47.37	48.36
Textiles and Apparel	12.75	13.83	12.38	11.63	11.06	10.86	10.40	10.02	9.84
Fabricated metal products	3.68	3.70	3.36	3.48	3.48	3.65	3.51	3.42	3.42
Machinery	19.72	19.34	19.71	20.24	21.38	23.29	24.13	24.90	25.46
Transport equipment	7.34	6.90	6.73	6.77	6.90	7.15	7.38	7.22	7.75
Leather products	1.61	1.83	1.99	1.99	1.99	2.02	1.90	1.81	1.88

Note: High energy intensity is greater than 0.4Kgce/Yuanr; medium energy intensity is 0.2-0.4Kgce/Yuan; and low energy intensity is less than 0.2 Kgce/Yuan.

Source: Calculated from UNIDO, *Industrial Statistics Database*, 2004

The effects of efficiency shift

In contrast to the minor change of industrial structure, the change of energy intensity of each industrial sub-sector was dramatic. As is shown in Table 9, except for the iron/steel and petroleum/coal sectors, all the other 12 sectors experienced an energy-intensity decline from 1993 to 2001. The largest decline was in the leather products sector (-64%), followed by machinery (-61%). Some sub-sectors with a large share of output also decreased their energy intensity remarkably. For example, from 1993 to 2001, the machinery sector's energy intensity declined by about 61%; the textile sector decreased

by 35%; and the food sector decreased by 52%. However, the iron/steel sector and petroleum/coal sector, which were both energy-intensive, increased their energy intensity from 1993 to 2001 by 13% and 20%, respectively. Overall, energy-efficiency improvement was the driving force behind the decline of energy intensity of China's industrial sectors.

**Table 9 Energy Intensity of Industrial Sectors
(Unit: Kgce/Yuan)**

	1993	2001	Change	Change %
Non-metallic mineral products	1.07	0.74	-0.33	-31
Chemicals	0.99	0.49	-0.50	-51
Iron and steel	0.79	0.90	0.10	13
Other manufactured products	0.57	0.37	-0.20	-35
Non-ferrous metals	0.55	0.48	-0.07	-13
Paper, Printing and Publishing	0.49	0.25	-0.24	-49
Total manufacturing	0.41	0.26	-0.15	-38
Petroleum and Coal	0.40	0.48	0.08	20
Wood products	0.24	0.11	-0.14	-56
Food, Beverages, and Tobacco	0.22	0.11	-0.11	-52
Rubber and Plastic	0.20	0.13	-0.07	-36
Textiles and Apparel	0.17	0.11	-0.06	-35
Fabricated metal products	0.16	0.13	-0.03	-19
Machinery	0.12	0.05	-0.07	-61
Transport equipment	0.11	0.07	-0.04	-37
Leather products	0.10	0.04	-0.06	-64

Source: Calculated from UNIDO, *Industrial Statistics Database, 2004*, *China Energy Statistical Yearbook (1991-1996)*, *China Energy Statistical Yearbook (2000-2002)*

Summary

The energy intensity of China's industrial sector has declined by 38% from 1993 to 2001.

The driving force of the decline was the energy-efficiency improvement in most of the industrial sub-sectors. The average reduction of energy intensity of all 15 sub-sectors was 34%. Structural change also contributed to the energy intensity decline but modestly, because the industrial structure only changed slightly during the study period. From 1993 to 2001, the composition of energy-intensive sectors in the total industrial output only decreased by 3%, while the share of less energy-intensive sectors only increased by 3%.

There were several sub-sectors playing an important role in China's industrial sectors regarding the output and energy consumption.

(1) Iron and steel

Iron and steel is a heavy industry and it is very energy-intensive. It also has a large share of total industrial output (11% in 1993 and 7% in 2001). However, over the study period, the increase of energy consumption of this sector outpaced the increase of its output, indicating that the energy efficiency of this sector has not improved over time.

(2) Petroleum and coal

This sector has the same problem as iron and steel. Its energy intensity increased from 0.4Kgce/Yuan in 1993 to 0.48 Kgce/Yuan in 2001, which was 20% higher than the level of 1993.

(3) Machinery

This sector decreased its energy intensity from 0.12kgce/Yuan in 1993 to 0.05kgce/dollar in 2001, an overall decrease of 61%. More important, it also had 20% of total industrial output in 1993, increasing to 25% in 2001. This indicated that the energy efficiency in this sector had improved during the study time period. The reason is probably that this sector includes the electronic and telecommunications equipment, which are very energy-efficient but produce a large output.

(4) Chemicals

This sector accounted for about 10% of total industrial output, while it was fairly energy intensive. However, its energy intensity decreased by 51% from 1993 to 2001, and such a change should have positive impact on the overall energy intensity.

Some other sub-sectors, like textile/apparel and transport equipment, had lower energy-intensity and relatively higher share of output (10% and 7%, respectively). These sectors also have a positive impact of the overall energy intensity. In contrast, the energy-intensity of non-metallic mineral products was the highest in 1991 and the second highest in 2001, while its average share of industrial output was about 6% from 1993-2001.

Therefore, it is important to improve this sector's energy efficiency in order to decrease the overall energy intensity.

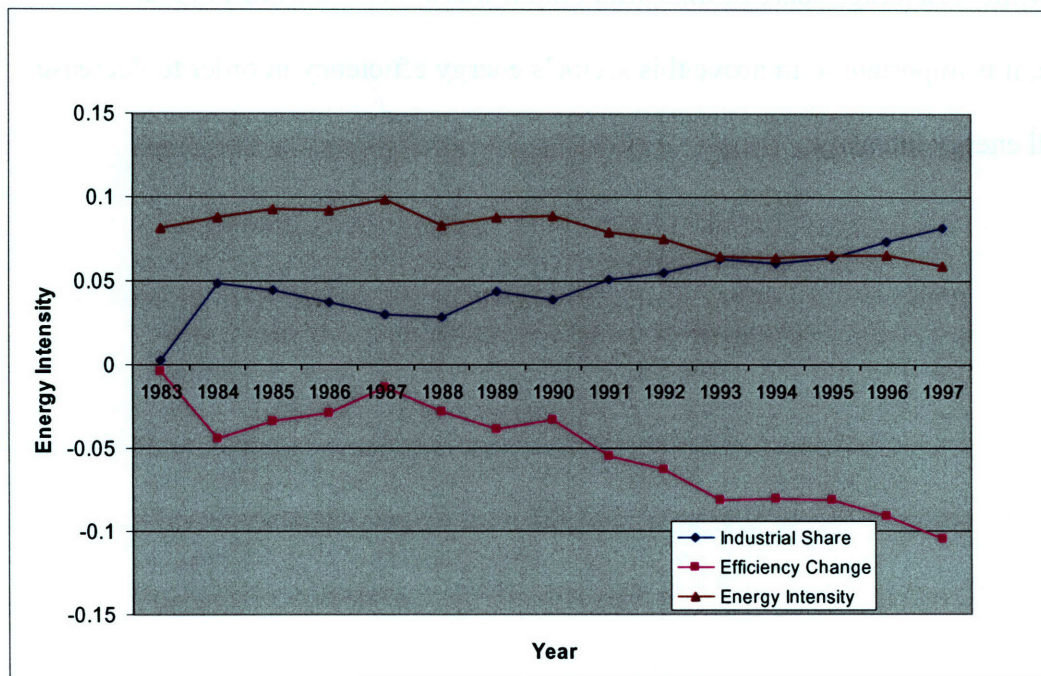
Chapter 6

Comparison of Energy-Intensity Determinants: China and India

Comparing the determining factors of energy intensity in China and India, I find that they performed differently overtime.

In Figure 15 and 16 shown below, I show the decomposition of industrial mix and efficiency change in determining the energy intensity in India and China, respectively.

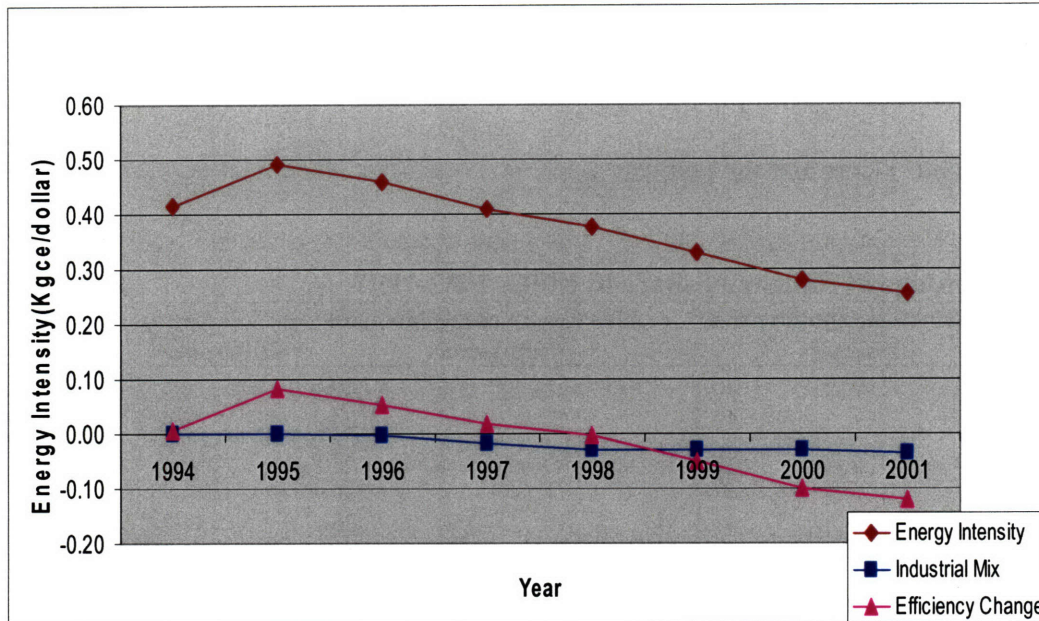
These two factors performed remarkably different in these two countries.



Energy intensity = energy consumption (Rs., weighted by fuel WPI)/ Industrial Output (Rs, weighted by IIP)

Source: Calculated from data in *Annual Industrial Survey*, 1982-1998. www.indiastat.com

Figure 15 Shift-Share Analysis of Energy Intensity in India (1983-1997)



Note: Energy intensity = energy consumption (Kgce) / Industrial Output (Yuan, weighted by IIP)

Source: Calculated from UNIDO, *Industrial Statistics Database*, 2004, *China Energy Statistical Yearbook* (1991-2002)

Figure 16 Shift-Share Analysis of Energy Intensity in China, 1993-2001

In India, the efficiency change was always negative and kept decreasing, indicating that the energy efficiency improved, driving the energy intensity to decline. In contrast, the industrial share was positive and kept increasing in most years, indicating that the industry mix became more and more energy intensive and it drove the energy intensity to increase. In China, both the efficiency change and industrial mix were decreasing, driving the overall energy intensity to decline.

To reveal the opposite impacts of industrial mix on energy intensity in India and China, I examine the industrial output share of the most energy-intensive sub-sectors and output share of the least energy-intensive sub-sectors in two countries. Because I classify each country's industrial sector into 15 sub-sectors, I choose the five most-energy-intensive

sub-sectors and five least-energy-intensive sub-sectors in each country; then, I examine their share of total industrial output.

Table 10 and Table 11 present the results.

Table 10 Percentage of industrial share in India, 1982-1997

	Five Most-energy-intensive sub-sectors	Five Least-energy-intensive sub-sectors	Difference
1982	36.3	29.8	6.5
1983	40.5	24.1	16.4
1984	40.5	23.6	16.9
1985	39.8	26.1	13.7
1986	41.5	25.3	16.2
1987	40.6	25.8	14.7
1988	40.0	26.6	13.5
1989	35.9	26.7	9.2
1990	37.3	26.5	10.8
1991	34.3	27.7	6.5
1992	35.5	27.7	7.8
1993	35.9	26.2	9.8
1994	34.1	27.1	7.1
1995	35.2	26.7	8.5
1996	34.2	27.2	7.0
1997	34.3	26.8	7.4

Note: industrial share = sub-sector output/total industrial output

Source: Calculated from data in *Annual Industrial Survey*, 1982-1998.

Table 11 Percentage of industrial share in China, 1993-2001

	Five most-energy-intensive sub-sectors	Five least-energy-intensive sub-sectors	Difference
1993	32.6	45.1	-12.5
1994	31.9	45.6	-13.7
1995	31.3	44.2	-12.9
1996	30.7	44.1	-13.5
1997	29.1	44.8	-15.7
1998	27.8	47.0	-19.2
1999	27.8	47.3	-19.5
2000	27.4	47.4	-20.0
2001	27.0	48.4	-21.3

Note: industrial share = sub-sector output/total industrial output

Source: Calculated from UNIDO, Industrial Statistics Database, 2004, *China Energy Statistical Yearbook (1991-2002)*

From Table 10, it is obvious that in each year in India, the share of the five most-energy-intensive (MEI) sub-sectors was larger than that of the five least-energy-intensive (LEI) sub-sectors. The share of MEI increased from 36% in 1982 to 40% in 1988, and then decreased to around 35% in 1990s. The share of LEI decreased 3 percentage points from 1982 to 1997. This indicates that the industrial structure in India was energy-intensive, and such a structure became even more energy-intensive over the study period.

Therefore, the structure shift always played a negative role in determining the industrial energy intensity in India. Although energy efficiency improved in India's industrial sector, which caused the decline of its energy intensity, the industrial mix offset this force and caused the overall energy intensity to decline only slightly.

Table 11 shows a different structure in China. The share of LEI was always larger than that of MEI, and the difference enlarged over the study period. From 1993 to 2001, the output share of MEI decreased about 5 percentage points, while the share of LEI increased about 3 percentage points. The industrial mix was moving toward a more energy-efficient direction, which had a positive impact on dropping the energy intensity in China. The force of industrial mix and efficiency improvement worked simultaneously and reinforced each other, thus causing the energy intensity in China to decline significantly.

Summary

Therefore, to reduce the energy intensity, both efficiency change and industrial mix should be improved, or these two forces may counteract each other. In India, the energy-

intensive sectors always had a larger output share than energy-efficiency sectors, thus the industrial mix had a negative impact on reducing the energy intensity. Although the energy efficiency was improved and it drove the energy intensity to decline, the overall energy intensity in India only declined slightly from 1982 to 1997. In China, most energy-intensive sectors decreased their output share, thus leading to a positive impact of industrial mix on reducing the energy intensity; the efficiency change was also improved greatly in China from 1993 to 2001. Therefore, with the improvement of both efficiency change and industrial mix, the overall energy intensity in China declined remarkably.

Chapter 7

CONCLUSION AND POLICY IMPLICATIONS

Energy is a critical and significant input for economic growth and human development. In today's world, affordable energy is a crucial ingredient of prosperity and a prerequisite for economic development. The amount of final energy per unit of economic output (usually in terms of gross domestic product, or GDP), known as energy intensity, is often used to measure the effectiveness of energy use and the consumption patterns of different economies. The structure and level of demand for energy services (structural shift), together with the performance of end-use technologies (energy efficiency), largely determine the magnitude of final energy demand and the level of energy intensity (WEA, 2000).

China and India are both developing countries with a large population and rapid economic growth. Both of their energy intensities are higher than that in developed countries. However, the energy intensity in China is much higher than that in India before the 1990s, although China decreased its energy intensity over time, while India almost kept a stable energy-intensity level. Part of the high energy intensity in China is caused by its large share of industry of the whole economy. In 2001, the industry sector share is 51% in China and 26% in India. In contrast, the service share of GDP in India is 49%, while that in China is 34% in 2001.

Compared to the developed countries, both China and India should have potential space to reduce their energy intensities. However, China has decreased its energy intensity by 67% from 1978 to 2003; while India only decreased its energy intensity by 5% over the same time period, recognizing that China started at a considerably higher energy-intensity level than India. The determinants of changing energy intensity are mainly relying on the structure and level of energy demand, together with the performance of end-use technologies. These two factors are also measured by examining structural changes and efficiency changes, respectively. By applying shift-share analysis on each country's industry sector, I decompose the changes of industrial energy intensity into these two factors, explore what are the determining factors of energy intensity in China and India, and analyze why they are different.

The result shows that, in China, the driving force of energy-intensity change was the improvement of energy efficiency, which decreased the energy intensity. Meanwhile, structural-mix played a small, but positive, role in decreasing the energy intensity. The share of energy-intensive sectors in industry was reduced while the share of energy-efficient sectors was increased over time. In China, these two forces worked together and caused the energy intensity to decline.

In India, energy efficiency also played a positive role. Energy efficiency was improved over time, causing the energy intensity to decline. However, the industrial structure became more energy-intensive because of the increasing share of energy-intensive sub-

sectors, which offset the impact of energy efficiency on energy intensity; thus, the overall energy intensity only decreased slightly over time in India.

Policy implications

Clearly, making an energy policy is difficult in part because there are so many factors the policy makers must get right simultaneously. Such factors include economy, environment, and national security. For an economy to grow, the sectors need more energy, but country policy makers also must assure that energy services are affordable; the environmental impacts of energy use have caused threats to human health, and therefore the energy policy makers are obligated to reduce the environmental damages; the dependence on imported fuels leaves many countries vulnerable to disruption in supply, which might pose physical hardships and economic burdens.

From the economic aspect, the multiple responsibilities of energy policy should cover the following aspects: limit consumer cost of energy; lower the economic vulnerabilities from imported oil; help provide an energy basis for economic growth elsewhere; and reliably meet fuel and electricity needs of a growing economy (WEA, 2000).

In my shift-share analysis on the industrial sector, I provide some insights in terms of decreasing energy intensity through restructuring and efficiency improvements. In terms of industrial structure, the policy maker should encourage the energy-efficient sectors to develop at a more rapid rate than in the past. This is especially important for India. In terms of efficiency improvement, the policy maker should focus on a policy that

stimulates the efficient use of energy. This includes using prices and other incentives to make enterprises adapt better energy management and energy-saving technologies.

My shift-share analysis for China and India's industrial sector also provide specific policy implications at the detailed industrial sub-sector level.

For India, the electricity sector is fairly energy intensive and has a large share of output. It is hard to reduce its output share because it provides the basic energy needed by most other sectors. In fact, currently, because India's electricity capacity cannot meet the demand of economic and population growth, the government is planning to double its capacity over the next ten years (EIA, 2005). Therefore, to improve the energy efficiency in the electricity sector is very critical. There are basically two ways to achieve this: one is to apply new technology in both the operation and maintenance process; the other is to shift away from the use of coal and oil towards natural gas and renewable energy sources for electricity generation.

The non-metallic mineral products and basic metal and alloys sector have high energy intensity however a low share of output. For these sectors, policy makers should focus on improving the energy efficiency by encouraging sectors through various forms of incentives to apply more energy-efficient technologies.

For China, iron and steel and petroleum and coal sectors have increased their energy intensity, and they take a large share of output. It is critical to improve the energy

efficiency in these sectors. In contrast, the machinery sector has been decreasing its energy intensity while increasing their output share. It would be beneficial to encourage the development of this sector to achieve the goal of efficient energy use while ensure the economic benefits.

Limitations and future studies

The major limitation for an international comparison analysis is the problem of data inconsistency, and it is also the case for this study. The measurement of overall energy intensity over time is energy consumption per unit of constant U.S dollar, converted by Market Exchange Rate (MER). Such a conversion might cause inaccuracies because the exchange rate differs across countries and time. A better measurement, such as using Purchasing Power Parity (PPP) should be applied if the data are available.

Another concern lies in China's GDP statistics. On December 20, 2005, China's National Bureau of Statistics (NBS) released a startling conclusion based on the 2004 economic census: China's GDP for 2004 was about 17% larger than originally thought. If this is true and if the additional value-added in 2004 was all due to additional real growth, as more than 90% was in the 1993 revision, China's service sector average annual real growth rate of 1993-2004 needs to be revised upward to 12% from 8%; average annual real GDP growth increased from 9% to 10.5% (Holz, 2006).

Consequently, the energy consumption per unit of GDP over this time period should be revised. However, revisions mainly happened in the service (tertiary) sector, 2.13 trillion yuan of the newly found 2.33 trillion yuan. As for this study, while the foremost analysis

of energy intensity is on the industry sector, the revision should not have a profound impact on it.

The change of industrial classification makes it difficult to compare the performance of industrial sectors in an ideal time period; besides, the different industrial classifications among countries prevent analysts from making comparisons at the same industrial disaggregation.

Therefore, future researchers who conduct international energy-intensity comparisons might consider the following issues.

First, a comprehensive and consistent set of data needs to be constructed: GDP (or gross output) is better to be converted using Purchasing Power Parity (PPP), instead of MER. The future researchers need to make the industrial classifications comparable over the study period and between countries, and use the same measurement of energy intensity in different countries, for example, using energy consumption with the same physical unit and GDP in international currency using PPP. Future studies should also take into account the revision of China's statistical data.

Second, besides the industrial sector, the researchers should also consider the service, residential, and transportation sectors. The service sector is rapidly growing in developing countries, requiring additional energy consumption. Because of its nature of being less energy-intensive than industry, it can contribute largely to decreasing energy

intensity. The residential sector is especially important in China and India, because it accounts for a large share of energy consumption, and its energy consumption may keep increasing because of the rapid economic growth and urbanization in these two countries. The energy consumption of the transportation sector is projected to grow more rapidly in developing countries. Although the vehicles are more fuel-efficient, the positive impact of technology improvements on energy intensity might be offset by the increasing urbanization and traffic road congestion.

Third, besides industrial mix and efficiency improvement, more effects on energy intensity need to be taken into consideration: income, investment, price, and population. This will require a more complex econometric analysis.

Finally, the researchers need to explore the energy policy in developing countries, and compare them with developed countries, thereafter provide more sufficient policy recommendations.

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APPENDICES

1. Construction of Data for India's Shift-share analysis

The data for this analysis is subtracted from the India Annual Survey of Industries, ranging from 1982-1983. This survey contains selected characteristics by industry group at 3-digit level. I subtract the row of "Fuels Consumed" as energy consumption and the row "Value of Output" as industrial output. Then, I aggregate the 3-digit industry group into 2-digit according to India National Industrial Classification (NIC). For the 1980-1998 NIC, there are 24 categories. I aggregate some similar groups into one group - for example, aggregate "Manufacture of food products" and "Manufacture of other food products" into one group: "Manufacture of food products". The detailed industrial classification is listed as below:

1. Food products [NIC 21, 22].
2. Beverages, tobacco and related products [NIC 22]
3. Textiles [NIC 23, 24, 25, 26].
4. Wood and wood products [NIC 27].
5. Paper, printing, publishing and allied industries [NIC 28]
6. Leather and products of leather [NIC 29].
7. Rubber, plastic, petroleum and coal products [NIC 30].
8. Chemicals and chemical products [NIC 31].
9. Non-metallic mineral products [NIC 32].
10. Basic metal and alloys industries [NIC 33]
11. Metal products, except machinery and equipment [NIC 34].
12. Machinery and equipment [NIC 35, 36].
13. Transport equipment and parts [NIC 37].
14. Other manufacturing industries (including manufacture of scientific equipment, photographic equipment) [NIC 38].
15. Electricity [NIC 40].
16. Others (including gas and steam generation, water works and supply, storage and warehousing services and repair services) [NIC 41, 42, 74, 97]

Source: India Annual Survey of Industries, 1982-1998. www.indiastat.com

2. India: Value of Industrial Output, 1982-1998 (1981 = 100 Lakhs Rs)

	82-83	83-84	84-85	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98
Food products	11717	12058	10490	10401	11028	12678	13813	18445	18932	22536	25373	27027	29864	31745	34236	34922
Beverages, tobacco and related products	1398	1647	1489	1502	1559	1666	1894	2086	2468	2845	3216	3412	3566	3264	3234	4193
Textiles	10645	10973	10415	10455	9962	10546	11100	14026	14919	17028	19728	23335	26839	27590	27955	30884
Wood and wood products	380	383	397	370	391	418	500	466	465	471	546	645	663	635	747	671
Paper, printing, publishing and allied industries	2154	2307	2667	2526	2710	2874	2947	3521	3793	4445	4956	5501	6179	7375	7177	6163
Leather and products of leather	618	624	741	782	740	964	1068	1273	1501	1663	1779	2309	2471	2294	2362	2535
Rubber, plastic, petroleum and coal products	9985	9093	9688	11221	11055	11332	13383	15288	16024	19099	23944	25042	28054	32080	35132	36979
Chemicals and chemical products	10838	11650	12007	12496	12938	13640	14543	12786	15317	12543	16474	18971	20228	23428	26501	23201
Non-metallic mineral products	2693	2968	3132	3359	3270	3364	3804	4399	4787	6349	6696	6771	7439	8550	9536	8532
Basic metal and alloys industries	10518	10049	11114	11285	11438	11874	14496	14862	16500	17251	22332	21302	23916	27298	25169	29656
Metal products, except machinery and equipment	1734	1723	1877	1853	1677	2102	2491	2580	2823	3192	3429	4093	4443	5408	5469	5634
Machinery and equipment	14119	8914	8707	10420	10175	11721	13115	14998	16033	18105	21292	20576	24941	28472	28555	27505
Transport equipment and parts	4699	4673	5042	5017	5479	5707	6805	7538	8250	8339	10481	11208	13991	18483	17280	16750
Other manufacturing industries	571	617	576	617	622	844	836	1121	1101	1433	1941	2289	2796	3201	3366	3645
Electricity	6279	8153	7484	7735	9315	9899	9859	11194	11868	12756	16412	21099	20172	24610	22985	28042
Other	1162	803	3975	3901	3288	3002	3347	5620	5394	7675	9649	11358	12841	14834	17537	19496
Total	89510	86636	89799	93941	95647	102631	114003	130203	140175	155731	188246	204936	228405	259266	267241	278808

Source: India Annual Survey of Industries, 1982-1998. www.indiastat.com

3. India: Fuels Consumption, 1982-1998, (1981 = 100 Lakhs Rs)

	82-83	83-84	84-85	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98
Food products	315	341	294	303	317	362	389	594	603	626	690	785	680	822	838	824
Beverages, tobacco and related products	36	47	33	37	38	40	49	46	60	59	61	53	65	67	58	72
Textiles	453	824	776	844	841	879	880	1061	1165	1115	1258	1337	1387	1674	1676	1791
Wood and wood products	14	13	14	15	14	15	17	19	18	16	18	21	24	25	27	21
Paper, printing, publishing and allied industries	215	241	285	283	310	338	357	425	445	483	493	453	520	638	677	572
Leather and products of leather	10	12	14	16	14	17	19	21	26	25	26	27	31	37	110	33
Rubber, plastic, petroleum and coal products	175	247	192	225	255	394	378	1778	1841	1858	2146	1940	2187	2559	2748	2520
Chemicals and chemical products	970	1164	1255	1259	1493	1625	1529	383	501	364	447	478	472	609	649	641
Non-metallic mineral products	509	596	695	774	854	905	1081	1207	1291	1429	1506	1431	1607	1886	1973	1697
Basic metal and alloys industries	1166	1363	1528	1525	1528	1655	1832	1954	2100	2098	2357	2077	2317	3222	2931	2774
Metal products, except machinery and equipment	55	59	73	68	64	90	102	111	137	137	151	148	169	209	238	215
Machinery and equipment	212	227	261	834	248	298	301	339	366	359	393	424	435	543	511	498
Transport equipment and parts	146	160	172	173	194	203	226	240	261	267	308	286	335	431	398	494
Other manufacturing industries	10	12	12	13	14	18	21	19	25	24	34	65	40	52	51	57
Electricity	1535	1680	2016	2112	2328	3022	2009	2729	3012	2856	3557	3041	3264	3086	3456	3298
Other	1615	94	248	241	249	244	280	544	530	586	689	662	945	1175	1151	982
Total	7436	7081	7868	8720	8760	10103	9469	11469	12382	12303	14133	13230	14479	17034	17492	16491

Source: India Annual Survey of Industries, 1982-1998. www.indiastat.com

4. China: Industrial Output, 1993-2001 (Constant million 1985 Yuan)

Industrial Sectors	1993	1994	1995	1996	1997	1998	1999	2000	2001
Total manufacturing	1582649	1728341	1598065	1768046	1896214	1949123	2141755	2450263	2791253
Food, Beverages, and Tobacco	174348	198803	201891	229452	254306	254352	265558	276110	308979
Textiles and Apparel	201802	239110	197791	205663	209700	211663	222809	245479	274660
Leather products	25513	31553	31729	35196	37662	39455	40635	44380	52561
Wood products	19323	21893	20565	25155	30050	26046	29815	33882	39307
Paper, Printing and Publishing	42456	43520	46436	55278	57741	59191	64671	72817	84569
Chemicals	157382	174977	182058	203321	217352	225987	250925	289458	313069
Petroleum and Coal	64645	70347	66041	70003	81556	77108	91777	146130	153334
Rubber and Plastic	51853	55248	56904	66048	70611	74923	81537	89489	101284
Non-metallic mineral products	104288	135319	119629	135460	121509	106073	115151	121836	134559
Iron and steel	175734	155833	119187	118539	122423	128540	138988	156150	190752
Non-ferrous metals	43561	44982	44685	45081	46667	53914	60826	71931	79183
Fabricated metal products	58205	63898	53752	61512	65971	71191	75139	83793	95330
Machinery	312055	334269	314969	357868	405443	453987	516718	610087	710781
Transport equipment	116195	119184	107564	119778	130892	139424	158050	176999	216409
Other manufactured products	35290	39405	34864	39691	44332	27269	29156	31724	36476

Source: UNIDO, Industrial Statistics Database, 2004

5. Energy Consumption of Industrial Sector, 1993-2001 (10,000 tce)

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001
Energy Consumption	64631.36	71733.4	78367.7	81159.14	77705.32	73608.79	70720.09	68752.46	71216.37

Tce = Tones of coal equivalent

Source: China Energy Statistical Yearbook (1991-2002)

6. China: Energy Intensity of Industrial Sector, 1993-2001. (Kgce/constant 1985 Yuan)

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001
Energy Intensity	0.408	0.415	0.490	0.459	0.410	0.378	0.330	0.281	0.255

Energy Intensity = energy consumption/industrial output

Source: UNIDO, Industrial Statistics Database, 2004; China Energy Statistical Yearbook (1991-2002)