ENERGY-INTENSITY FACTORS FOR SHANXI PROVINCE AND CHINA: SHIFT-SHARE AND INTERREGIONAL STRUCTURAL DECOMPOSITION ANALYSIS

By

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ABSTRACT

In this study, I examine the underlying factors for the current energy-intensity levels in China, and its major coal-producing provinces, Shanxi Province, using an interregional (spatial) Structural Decomposition Analysis (SSDA), and shift-share analysis (SSA). The results of SSA show that Shanxi Province consistently had energy-intensity levels three times as great as China for the 1986-1995 period. Furthermore, in almost every year, in both China and Shanxi Province, the primary reason behind reductions in energy-intensity levels was an improvement in energy efficiency, due to the growth of the economy, and the introduction of new technologies. However, the sector most responsible for this shift was the heavy-industrial sector in China, but the transportation sector in Shanxi Province. The SSDA analysis showed that in 1992, only 12.8 percent of the difference in Renminbi (RMB) of energy input between Shanxi Province and China can be attributed to changes in final demand. Production-technology differences in the five energy sectors accounted for almost ninety percent of the difference, while the differences in the 28 nonenergy sectors accounted for over 450 percent of the 545 percent of the total.

Four policy options were recommended to bridge the gap in energy-intensity levels between Shanxi Province and China. (1) continuing the market reform of Shanxi Province based on the lessons learned on China's coastal regions; (2) further incorporating Shanxi Province's economy into the global economy; (3) clarifying the roles of central and Shanxi Province's governments during the transition period; and (4) implementing a regional development strategy that emphasizes building infrastructure, particularly in the transportation sector, and environmental preservation.

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I would like to thank my thesis reader, Stephen Connors of the Energy Laboratory at MIT for taking the time to read my thesis, and for his valuable suggestions. In addition, I want to thank my thesis advisor, Professor Karen R. Polenske, for her support, encouragement, advise, knowledge, and suggestions, throughout the year that this work was in progress. Furthermore, she gave me the opportunity to work on the research behind this thesis through two grants from the Alliance for Global Sustainability (Account numbers: 66849, 28036). Third, I want to thank my wife, Melanie Ueland, for keeping our " ship" from sinking, while I was busy making charts and tables. This would certainly not have happened without her efforts, support, and love. Finally, I want to thank my son for reminding me that it is a joy to learn; every day.

NOTE ON UNITS OF MEASUREMENT

In this study, all references to tons are to long tons, which is equivalent to 2,200 pounds.

CHAPTER 1

INTRODUCTION

Historically, economic growth, as measured by an increase in real per capita Gross Domestic Product (GDP), is accompanied by an increase in energy consumption. Hafele (1981) examined the historical relationship between fuel use and GDP in 25 different countries, and his results indicate that, on average, the ratio of change in fuel use to change in GDP was about 0.99, or very close to unity. What this implies is that for economic activity to increase there has to be a proportional increase in energy consumption. However, in the early 1970s, the link between economic growth and rising energy use seemed to be broken. In the United States, for example, real GDP grew by about 2.5 percent between 1972 and 1985, but energy use increased at an annual rate of only about 0.3 percent, resulting in about a 25 percent reduction in the overall energy intensity, that is, the amount of energy consumed per unit of GDP. During this period, the same phenomenon also occurred in other industrialized countries, such as Austria, France, Germany, Japan, Sweden, and the United Kingdom (Office of Technology Assessment (OTA), 1991).

Related to this, is the notion that as a country moves through various stages of economic development, its energy intensity first increases, then falls, and finally levels off at a certain point, that is the income elasticity of energy tends towards unity in the long term. This is sometimes called the "development effect" (Lin, 1996, p. 7). As such, there appears to be a close, but flexible, link between energy use and economic development, which may change as economic, institutional, technological, and resource conditions change (Lin, 1996, p. 8).

China is one of the few emerging countries to have broken this link between energy use and economic development. In China, since the late 1970s, there has been a dramatically slower growth in energy use than in output growth; however, there seems to be substantial disagreement about the underlying causes of this fall in overall energy intensity. The disagreement focuses on whether the fall has been due to reductions in energy use in individual industries or to structural changes in output mix, such as shifts in production from energy-intensive heavy industry to light industry. Lin and Polenske (1993) and Sinton and Levine (1993) have argued that changes in energy intensity are due to technological improvement, with the change in the industrial mix accounting for only 17 percent of the decrease in energy intensity. However, Smil (1990), and Kambara (1992) have argued that structural change has been more important.

This issue is important because it is related to the degree of substitutability of energy for other inputs and the income elasticity of demand for energy. These are, in turn, crucial for the design of environmental and tax policies and forecasts of future energy use and pollution emissions. If, for example, the fall in overall energy use is due to different goods being produced, and the production of each good uses the same amount of energy inputs, despite the rather substantial rise in the relative price of energy, then analysts must conclude that there is a very low degree of substitutability and be prepared for substantial further increases in the price to induce conservation. On the other hand, if the past reduction in the energy-output ratio is due to new production techniques and increased efficiency, then analysts may look forward to future zero-cost reductions in energy use as the economic structure moves toward new production methods as well as less energy-intensive services.

The economic development path that China has taken for the past twenty years has been very effective in reducing the energy-intensity levels in China. Furthermore, Shanxi Province appears to be following the same path as China, in terms of reducing its energy-intensity levels (Chapter 3). On the other hand, China's overall energy consumption has increased drastically during the past twenty years, swelling from 603.59 Mtce in 1980 to 1113.14 Mtce in 1993 (Sinton, 1996, p. IV-11). As the result of this dramatic increase, China is now one of the most polluted countries in the world. In addition, if the development-effect theory that I described in the introduction of this paper is valid, there is a possibility that China cannot continue along the same path of declining energy-intensity levels that it has followed for the past twenty years. What this implies, is that China's overall energy consumption may very well increase at even a faster pace in the future. It is then imperative to understand the factors behind energy-intensity levels in China, and it's heterogeneous provinces. In this study, I will attempt to accomplish this task for China and Shanxi Province.

KEY CHARACTERISTICS OF CHINA

In this section, I will give an overview of some of the key characteristics of China that are affecting the overall levels of energy consumption, as well as energy intensity: population, economic growth, infrastructural bottlenecks, and environmental considerations.

Population

China is the most populous country in the world and the population will continue to grow for the coming three decades, albeit at slower rates than for most developing countries. China's population is forecasted to grow at the rates of 1.1, 0.8, and 0.6 percent for the decades 1991-2000, 2001-2010 and 2011-2020, reaching a population of 1.45 billion people by the year 2020 (World Bank, 1997). This is assuming that China's family planning policy (one-child policy) is continued (Table 1.1). At the same time, China has a relatively young population. In 1990, about 6 percent of her total population was 65 years or older. The percentage of this cohort in the total population increases to about 12 percent in 2020 according to estimates by the United Nations, a level similar to that of Japan and the United States in 1990. The percentage of China's labor force in the total population is projected to be 61 percent, 71 percent, and 74 percent in the years 2000, 2010, and 2020, respectively. This trend is a result of both the current population distribution and the assumption that China's birth-control policy continues. Meanwhile, as China's economy grows, urbanization will be accelerated. The World Bank's projections are that the percentage of urban residents rises from 26 percent in 1990, to 31 percent, 37 percent, and 42 percent in 2000, 2010 and 2020, respectively. (Junfeng, Johnson, Changyi, Taylor, Zhiping, and Zhongxiao 1995)

TABLE 1.1

POPULATION PROJECTIONS

Projected Data	**1990**	**2000**	**2010**	**2020**
Population (million)	1,140	1,280	1,370	1,450
Growth rate (percent/year)	NA	1.1	0.8	0.6
Labor force ratio of total population (percent)	61	66	71	74
Urban resident ratio Of total population (percent)	26	31	37	42

Source: China Statistical Yearbook, 1993; World Bank Projections;
NA: Not Applicable.

Economic Growth

From 1978 to 1990, the average annual GDP growth rate in China was 9 percent. In the early 1990s, the economic growth rate accelerated. GDP grew 8 percent in 1991, 13.2 percent in 1992, and 13.4 percent in 1993. However the growth rate has slowed for the past two years returning to 8 percent in 1998. However, even though China has not managed to retain the double-digit growth rate of the early 1990s, even the moderate growth of 8 percent per annum will result in an average growth rate for 1990s of above 9 percent.

There are a number of factors specific to China's economy, which is conducive to high growth in the coming decades. The economic reform program, which is likely to continue and deepen, will create new opportunities and incentives for expansion of the domestic market and international trade. China's high savings rate, which has increased since the 1980s, is essential for providing investment funds to continue the economic expansion. It is assumed that the ratio of capital formation to GDP in China will follow that of its Asian neighbors. Without exception, the savings rate of Japan and other fast-growing economies of Asia were all relatively high during their growth period, at times surpassing 40 percent. Though relatively poor, China's saving rate is already very high; in 1990 it was over 30 percent. It is assumed that China's saving and investment rate will average 36 percent during the 1990s, increasing to 37-40 percent from 2000 to 2010, before slowing to 35 percent from 2010 to 2020. The reform of housing, health care, retirement, education, and other social programs as a result of China's economic reform program will also require that Chinese citizens save more. In addition, because of China's age structure, that is, a young population, there is an ample supply of workers and relatively few retirees for the active workforce to support. There are currently 100-200 million surplus laborers in rural China who will provide a relatively low-cost pool of workers for the industrial and services sectors. (Junfeng, Johnson, Changyi, Taylor, Zhiping, and Zhongxiao 1995)

The sheer size of China's economy represents an almost limitless market for goods and services. By conservative estimates, China will have over 4 trillion (1990) dollars of purchasing power by 2020, the second largest in the world (World Bank, 1997). Therefore, unlike other developing nations of Asia, domestic demand will be important for sustaining China's development and the country will not be as dependent on the growth of other economies. Nevertheless, export-led growth has been important to China over the past decade and will continue to be beneficial during the current phase of development.

The growth rate of the economy is assumed to decline in the next century, especially after 2010. The reasons are that: (1) industrial growth falls off; (2) the supply of energy and other raw materials becomes a constraint; (3) the incremental capital output ratio (ICOR) increases; and (4) the high savings rate gradually decreases (Junfeng, Johnson, Changyi, Taylor, Zhiping, and Zhongxiao 1995).

Infrastructure Bottlenecks

Infrastructure bottlenecks pose a threat to future growth in China. Investments in transport, telecommunications, and energy have lagged behind that of industry, resulting in chronic shortages of transport services and increased urban congestion. Transport congestion, in turn, contributes to power shortages, because coal accounts for 70 percent of China's power generation and is mostly transported by rail throughout the country.

Raising capital for infrastructure improvements is a major task: at least 750 billion U.S. dollars will be required over the next decade. Although the private sector is expected to play a key role in meeting China's huge infrastructure needs, public spending will also be required. Legal and regulatory changes, such as establishing a regulatory and tariff-setting structure, amending property titling and mortgaging laws, refining corporate bond markets, and developing a legal framework for the issuance of asset-backed securities would improve financing mechanisms for infrastructure projects (Junfeng, Johnson, Changyi, Taylor, Zhiping, and Zhongxiao 1995).

Environmental Considerations

China's past two decades of rapid economic growth, urbanization, and industrialization have been accompanied by a steady deterioration of the environment. The concentration of both air and water pollutants are among the highest in the world, causing damage to human health and lost agricultural productivity, and major Chinese cities have particulate and sulfur levels from three to five times World Health Organization and Chinese standards. Soil erosion, deforestation, and damage to wetlands and grasslands have resulted in deterioration of China's national ecosystems and pose a threat to future agricultural sustainability.

China has already taken some steps to reduce pollution and deforestation, and has staved off an abrupt worsening of environmental conditions in general. A system of pollution-control programs and institutional networks for environmental protection is now in place at the national and local levels. As part of the recent government reorganization, China's environmental agency, the State Environmental Protection Agency (SEPA), has been upgraded to full ministerial rank and its coverage expanded to include the "green" issues. For better urban and industrial pollution control, China has focused increasingly on river-basin management, greater use of economic incentives, and increasing use of public information campaigns. Issues of motorization/vehicle emissions in urban areas are being tackled through improved traffic management, public transport initiatives, changes in transport fees and phasing out of leaded gas, which has already been implemented in the largest city centers. Coastal zone management has been introduced, and energy conservation efforts and the development of renewable sources of energy has been expanded (World Bank, 1996). [1]

SHANXI PROVINCE AT A GLANCE

Tables 1.1, 1.2, and 1.3 show the primary nonenergy characteristics of Shanxi Province and future projections of those features. Table 1.1 shows the population and economic situation in Shanxi Province for the years 1990 to 2010. There are two critical trends that needs notice. First is the large discrepancy in the rate of population growth versus that of Gross Domestic Product (GDP) growth. This is important because it follows the policies that are set by the central government, which promotes economic growth, while enforcing the one-child policy. The difference is important for energy consumption, because it indicates that for the foreseeable future, the driver behind increasing energy consumption will continue to be economic growth, rather than population growth.

[1] See Appendix 1.A for summary statistics for China, along with China versus other East Asia and Pacific

The second point to notice, is the different rates of growth among the primary, secondary, and tertiary industry that occurred between 1990 and 1995, and the growth rate that is expected for the years 2000 and 2010. During the 9th Five-year plan, the secondary industry, that is light and heavy industries, along with construction experienced the largest rate of growth at 12.6 percent annual growth, while primary industry, agriculture, experienced the least rate of growth at 8.7 percent. The forecasts in this table show that while agricultural growth rate will continue to lag behind the other two sectors, the growth of tertiary industry, transportation and commerce, will surpass that of secondary industry. As you will see in Chapter 4, this is significant in terms of energy consumption because the transportation sector has the highest energy-intensity levels, while the energy-intensity levels in the commerce sectors actually increased between 1986 and 1995.

TABLE 1.2
POPULATION AND ECONOMIC SITUATION

ITEM	UNIT	1990	1995	2000	2010	GROWTH RATE OF 9TH FIVE-YEAR PLAN	2001-2010 EST. GROWTH RATE
Population	1 M people	28.9	30.7	32.4	35.4	1.0	0.9
GDP	1 B RMB	42.9	108.9	240.0	1255.0	12.0	11.8
Primary Industry	1 B RMB	8.1	14.9	24.0	75.3	8.7	7.3
Secondary Industry	1 B RMB	21.0	56.4	120.0	552.2	12.6	10.7
Tertiary Industry	1 B RMB	13.8	37.6	96.0	627.5	11.0	15.1

Source: Minematsu, Shin, Hisae Sakata, Xiao-ping Zheng and Junichi Yamada. 1997. *The Major Issues of the Regional Development Strategies in China.* Tokyo: Research Institute of Development Assistance, p. 125.
RMB: Renminbi, the Chinese currency equivalent to 0.125 US Dollar; **GDP:** Gross Domestic Product; **M:** Million, **B:** Billion.

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and Lower-Middle-Income countries

At the same time, while the growth rates of the primary sector have lagged and will continue to lag behind those of secondary and tertiary industries, it will continue to employ the most number of people in Shanxi Province, with secondary and tertiary industries placing second and third, respectively. I should caution the reader in interpreting the employment numbers. A great number of workers of Shanxi Province have more than one job, with one job usually being a seasonal agricultural position (World Bank, 1997). As such the numbers below do not necessarily reflect the importance of each sector in employment in Shanxi Province.

TABLE 1.3
TYPE OF EMPLOYMENT

ITEM	UNIT	1990	1995	2000
Total Working Population	1 M People	13.04	14.03	16.42
Primary Industry	1 M People	6.26	6.37	6.56
Secondary Industry	1 M People	3.82	4.39	5.25
Tertiary Industry	1 M People	2.95	3.26	4.59

Source: Minematsu, Shin, Hisae Sakata, Xiao-ping Zheng and Junichi Yamada. 1997. *The Major Issues of the Regional Development Strategies in China.* Tokyo: Research Institute of Development Assistance. p. 125.
M: Million.

Finally, Table 1.3 shows the income and expenditure of the local-government in Shanxi Province. For our purposes, the most important number is the almost three-fold increase in construction expenditure. This is critical, because as I point out in Chapter 4, the energy-intensity levels for the construction sector have been increasing rather dramatically since 1990. As such, if the rate of growth in energy intensity continues, at the same time as government expenditure in construction, it could have a dramatic effect on the overall energy consumption in Shanxi Province.

TABLE 1.4
INCOME AND EXPENDITURE OF LOCAL-GOVERNMENT FINANCE BY ITEM

ITEM	UNIT	1990	1995	2000
Income of Local Government Finance	1 B RMB	5.2	7.1	27.0
Expenditure of Local Government Finance	1 B RMB	5.5	11.4	28.0
Construction Expenditure	1 B RMB	1.3	2.1	5.8
Current Expenditure	1 B RMB	4.3	9.3	22.2

Source: Minematsu, Shin, Hisae Sakata, Xiao-ping Zheng and Junichi Yamada. 1997. The Major Issues of the Regional Development Strategies in China. Tokyo: Research Institute of Development Assistance. p. 125.
RMB: Renminbi, the Chinese currency equivalent to 0.125 US Dollar; **B:** Billion.

COMPOSITION OF THE STUDY

In this study, I examine the underlying factors for the current energy-intensity levels in China and one of its major coal producing provinces, Shanxi Province. I have chosen China, because it is the largest consumer of energy among the emerging countries; however, as I mentioned earlier, it has broken the link between economic development and increased energy consumption. Moreover, I have chosen Shanxi Province as a point of comparison for two reasons. First, Shanxi Province is the largest coal-producing province in China, producing over 26 percent of the total coal production in 1993, while coal represented 76 percent of total energy production in China (Sinton , 1996, pp. II-12, 13). The province also relies heavily on coal for its industrial output and household energy requirements. Second, the energy intensity in Shanxi Province surpasses that of China, and is, in fact, one of the highest among the 30 regions.[2] Although we do not have historical data for the Province, the energy intensity in Shanxi

[2] At the present, China has 31 regions, the latest being Chongqing, but comparable data are unavailable for this city for these early years.

Province decreased by 28 percent between 1988 and 1990, declining from 1.63 Million tons of coal equivalent (Mtce) per current billion yuan (cby) in 1988, to 1.17 Mtce per cby in 1990 (Figures 3.4 and 3.5).

I have two objectives in doing this study. First, I will use an interregional (spatial) Structural Decomposition Analysis (SDA) and a Shift-Share Analysis (SSA) to analyze and uncover the factors behind energy-intensity levels in Shanxi Province and China (Chapters 4 and 5). Second, I will use my findings from the first part to analyze a set of relevant policy options and their implications for the economic development in Shanxi Province and China (Chapter 6). In addition, I will give an overview of the methodologies that were used in conducting the analysis in Chapter 2. I will also give the significant regional disparities among China's 30 provinces in key economic aspects in Chapter 3, along with specific comparisons in energy consumption and energy intensity levels between Shanxi Province and China.

I will try to answer the following questions: what are the factors behind these differences in energy-intensities in Shanxi Province and China? If the factors differ, the corollary to the question is why are the factors different between the country and the Province, considering Shanxi Province's heavy reliance on coal as an energy source? Shanxi Province depends more heavily on coal as a fuel than China; furthermore, its economy and economic growth are based more on heavy industry than China as a whole. In 1990, the per capita coal consumption in Shanxi Province was 2.64 tons per year, whereas in China it was 0.92 tons per year. In fact, the per capita coal consumption in Shanxi Province was the greatest among the regions in China in 1990 (Sinton, 1996, p. IV-21). Furthermore, in terms of coal consumption in the commercial sector, Shanxi

Province is second only to Liaoning Province, consuming 64.91 million tons of coal in 1990 compared to 65.85 million tons in Liaoning Province (Sinton, 1996, p. IV-53).

Having said that, I hypothesize that the factors behind energy-intensity levels in Shanxi Province are the same as in China, albeit more exaggerated. I believe that in Shanxi Province, even more so than in China, there is very little opportunity for fuel substitution. Therefore, the factors behind energy intensity in Shanxi Province have a great deal more to do with improvement in production techniques and improvement in efficiency than to do with change in industrial mix, and fuel substitution. As such I concur with Polenske and Lin, with the caveat that I believe that the change in the industrial mix in Shanxi Province accounted for even less than the 17 percent they calculated for China.

CONCLUSION

The economic development path that China has taken for the past twenty years, has been very effective in reducing the energy-intensity levels in China. In addition, Shanxi Province appears to be following the same path as China, in terms of reducing its energy-intensity levels (Figure 1). On the other hand, China's overall energy consumption has increased drastically during the past twenty years, swelling from 603.59 Mtce in 1980 to 1113.14 Mtce in 1993 (Sinton, 1996, p. IV-11). As a result of this dramatic increase, China is now one of the most polluted countries in the world. In addition, if the development-effect theory that I described in the introduction of this paper is valid, there is a possibility that China cannot continue along the same path of declining energy-intensity levels that it has followed for the past twenty years. What this implies, is that China's overall energy consumption may very well increase at even a faster pace in the future. It is then imperative to understand the factors behind energy-intensity levels in China, and its heterogeneous provinces. In this study, I will attempt to accomplish this task for China and Shanxi Province.

CHAPTER 2

THEORETICAL BACKGROUND AND FRAMEWORK ON STRUCTURAL DECOMPOSITION AND SHIFT-SHARE ANALYSIS

In this chapter, I will develop two economic tools, structural decomposition analysis and shift-share analysis, to examine the underlying factors for the current energy-intensity levels in China and one of its major coal-producing provinces, Shanxi Province. Structural decomposition analysis (SDA) is a practical tool that makes it possible to quantify fundamental factors of change in a wide range of variables, including economic growth, energy use, employment, trade and material intensity of use.

The conceptual foundation of SDA is input-output economics. Input-output analysis, first introduced by Leontief (1936) is specifically designed as a tool for systematic analysis of mutual interdependencies between different parts of the economy. The empirical basis of input-output analysis is the transactions table, which provides a detailed statistical account of the flows of goods and services among all the producing and consuming sectors of a given economy, that is, among all the various branches of business, households, and government. The table displays not only complete details of the income and product accounts, but also all intermediate transactions among producers and purchasers within a consistent accounting framework. The basic rationale for SDA is to split an identity into its components. This division can be as simple as a three-part basic form or as complex as desired. According to Rose and Casler, "the advantage of this formal derivation is that it ensures that equations have the desirable properties of being (1) mutually exclusive and (2) completely exhaustive." SDA is a popular tool of analysis for several reasons. First, it overcomes many of the static features of input-output models and can be used to examine changes over time in technical coefficients and sectoral mix.

Thus far, we believe that it has only been used for historical analysis, but there has also been some recent work that indicates how it might be used as a forecasting tool.

Another reason for the increasingly widespread use of SDA is that it is a practical alternative to econometric estimation. Analysis of similar topics using econometrics requires a time-series covering fifteen years or more, and not only for output and primary factors of production but all intermediate inputs as well. On the other hand, SDA requires only two input-output tables: one for the initial year and one for the terminal year of analysis. Still another asset of SDA arises from its input-output base, which is its comprehensive accounting of all inputs in production. This is especially appropriate in the environmental arena, where as environmental and natural resource issues become more prominent and serious, there is a greater need to look at the root causes of pollution and depletion. These are more readily linked to intermediate sectors which are ignored in the more standard economic approaches.

Energy is one of the areas where different types of SDA have been used extensively. Strout (1966) analyzed how changes in technology and in the level and composition of final demand affected the United States (US) energy use changes from 1939 to 1954. Reardon (1976) conducted an input-output analysis of US energy use changes from 1947 to 1958, 1958 to 1963, and 1963 to 1967. Hannon (1983) compared the energy costs of providing goods and services in the United States in 1963 and 1980. Proops (1984) decomposed changes in the energy-output ratio into three factors: changes in energy intensities, changes in final demand, and changes in the structure of interindustry trading. Ploger (1985) assessed the effects of changes in output mix and energy coefficients on energy consumption in the Danish manufacturing industries. The Office of Technology Assessment (OTA) staff performed an SDA on US energy-use changes between 1972 and 1988. Finally, and relevant to this paper, Lin (1996), and Lin and Polenske

(1995) used SDA to explore factors behind the drop in China's energy intensity between 1981 and 1987.

Shift-share analysis is the second economic tool that I will employ in my analysis. First put forth by Perloff *et al.* (1960), shift-share analysis is "a method of disaggregating regional employment change in an industry in order to identify the components of that change." Although shift-share analysis (SSA) has traditionally been used to analyze employment trends, many analysts have successfully used SSA to understand the underlying factors behind energy consumption and energy-intensity levels. SSA decomposes the sources of change in a dependent variable (energy intensity) into region-specific components (the shift) and the portion that follows national growth trends (the share). Similar to SDA, SSA is based in splitting an identity, and has mainly been used for historical analyses. Polenske and Lin (1993) used SSA to analyze energy-intensity changes in China in the material production sector from 1980 to 1988, in order to understand how the factors behind conserving energy can help reduce carbon dioxide emissions in China.

Although SSA and SDA are useful tools of economic analysis, they do have their shortcomings. There are three major limitations for most existing energy SDAs. First, most researchers only distinguish between effects attributable to final demand changes and an aggregated set of technical changes. Second, analysts typically specify their models in an arbitrary manner and do not generate a set of estimation equations or factors that are mutually exclusive and completely exhaustive. Third, analysts frequently construct some interactive effects that are large but difficult to interpret. This limitation, to some extent, defeats the purpose of identifying individual sources of structural changes.

Like SDA, SSA should be undertaken with full awareness of its limitations. One limitation arises from its ability to focus on only a single variable at a time. Furthermore, the analysis does not account explicitly for the variable under question, and it remains for the analyst to relate data on changes, in this case, energy intensity to the findings of SSA. Second, SSA is fundamentally a descriptive tool, and, as such, it does not explain why a different industry mix prevailed in the base year compared with the current year, why different industry categories experienced different growth rates nationally, or why changes in regional shares of national sectors took place. Nor does it evaluate whether or not the changes that took place were desirable. Therefore, SSA has the potential to answer a few, but also to raise important, questions about the factors behind economic trends.

SHIFT-SHARE ANALYSIS FRAMEWORK

The SSA equations I will use to conduct my analysis are taken directly from Polenske and Lin (1993). However, I will expand to 1995 their time-series analysis, which covered the period 1981 to 1987, and will also conduct the same calculations for Shanxi Province.

As I mentioned earlier, SSA is usually used as a method of disaggregating regional employment in an industry in order to identify the components of that change. In this paper, I will use the method used by Polenske and Lin to apply shift-share to understanding the components in the reduction in China's energy intensity. In this method, energy is divided into three components: constant share, industrial mix, and efficiency change.

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

Where E_t = actual energy consumption in the material production sector in year t;

O_t = gross material product in year t;

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

e_o = energy intensity (amount of energy consumed per unit of output) of the material production sector as a whole in the base year;

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

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

The first term is the constant-share component, which indicates the energy consumption that would have occurred if the energy intensity had remained at the same level as in the initial year. The second term, the industrial-mix component, shows the effect of changes in the industrial structure on energy use. The third term, efficiency changes, measures the change in energy efficiency between a given year and the initial year.

The above equation describes the relative importance of the efficiency change and industrial mix on *total* energy consumption. By dividing both sides of the equation by total output, O_t, we can obtain the following equation that describes the impact of changes in industrial structure and energy efficiency on energy intensity.

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

Where e_t is E_t/O_t, which is the energy intensity for the material production sector as a whole in a given year. This equation shows that the combined effect of the industrial-mix effect and energy-efficiency effect determines the relative level of energy intensity in a given year.

STRUCTURAL DECOMPOSITION ANALYSIS FRAMEWORK

For the SDA analysis, I will reconfigure the SDA equation developed by Lin (1996) in order to make it appropriate for a spatial SDA. As I stated in Chapter 1, what makes this study unique, is that for the first time that I am aware of, I will be using SDA to do a regional comparison of the factors behind energy-intensity disparities between Shanxi Province and China, rather than a temporal analysis involving China, which is the subject of Lin's (1996) book. Mathematically, the structure of an input-output model is simple and can be expressed as:

$$AX+Y=X \quad (3)$$

where X is the vector of the gross output; Y is the vector of final demand and A is the matrix of direct input coefficients, which show the inputs required to produce one unit of gross output. The product of A and X indicates the intermediate outputs or inputs, that is the amount of output that is used by production sectors to deliver final goods and services. We can rearrange equation (3) to calculate the total amount of inputs form each sector required to provide particular sets of final goods and services:

$$X=(I-A)^{-1}Y \quad (4)$$

Where I is the identity matrix; and $(I-A)^{-1}$ is the matrix of total input requirements, which are inputs required to deliver one unit of final demand, including final demand itself. Equations (3) and (4) will serve as mathematical *foundations* of the SDA analysis for this study. There are two basic approaches to incorporating energy into the conventional monetary input-output analysis: output conversion and hybrid units. Analysts (e.g., Ploger, 1985) using the output-conversion approach first compute energy requirements in terms of output values and then convert those values into physical energy units using output-to-energy ratios. Analysts (e.g., Lin, 1996) using the "hybrid units" method replace the energy rows of the standard monetary input-output table with energy flows in physical units to construct a transaction table in hybrid units, that is, energy rows in physical units and non-energy transactions in monetary units.

In my analysis, I will use the hybrid method to construct an energy input-output model, one for China and another for Shanxi Province. As such, I will replace the energy rows of the standard monetary input-output table with energy flows in physical units and non-energy transactions in monetary units. Miller and Blair show that the hybrid method is generally superior to the conversion approach because the latter introduces inconsistencies in accounting for energy consumption and often needs to be adjusted to satisfy energy-conservation conditions.

Using the energy input-output model, I will be able to identify two parts of the energy consumption: intermediate and direct. Intermediate energy consumption is the energy used by production sectors as an input to production, that is, energy used in production activities. Direct energy consumption is the energy used or sold directly to final users, such as households and government agencies. Using SDA, analysts can show whether energy use in the economy changes because of variations in final demand and/or because of changes in production technology. They can further decompose the final-demand-shift components along three dimensions, namely, the energy-use changes associated with changes in the level, distribution, and pattern of final demand. The level of final demand refers to the overall level of total demand, which equals the sum of all final output or expenditures. The distribution of demand refers to the allocation of total demand among the individual final-demand sectors, such as personal consumption, government expenditures, capital investments, exports, and imports. The pattern of demand refers to the mix of goods and services within the individual final-demand sectors.

In this case, we can obtain information about the amount of intermediate energy required in the economy by combining and rearranging equations (3) and (4):

$$\begin{aligned} E_g &= eAX = e(X - Y) \\ &= e[(I-A)^{-1} Y - Y] \\ &= e[(I-A)^{-1} - I]Y \end{aligned} \tag{5}$$

where E_g is the vector of intermediate energy consumption; and e is the matrix consisting of ones and zeroes, with ones in the row locations corresponding to energy sectors and zeroes in all other elements of the matrix. The matrix selects the energy rows from input-output table.

To calculate direct energy consumption, we need to adjust final energy consumption for energy exports, imports, and inventory changes. This is represented mathematically as follows:

$$E_d = E_y + E_u - E_v - E_w = eYn \tag{6}$$

Where E_d = vector of direct energy consumption;

E_y = vector of final energy consumption;

E_u = vector of imported energy;

E_v = vector of exported energy;

E_w = vector of net energy-inventory change;

n = a matrix consisting of ones and zeroes, with ones in the diagonal locations corresponding to those columns that are not imports, exports, and inventory changes and zeroes in all other elements of the matrix. It excludes energy imports, exports, and inventory changes from calculation of direct energy consumption.

As such, the total energy consumption in the economy, E, is the sum of intermediate and direct energy consumption:

$$E = E_g + E_d = e[(I-A)^{-1} - I]Y = eYn = FY + eYn \tag{7}$$

Where $F = e[(I-A)^{-1} - I]$. This equation shows that total energy consumption in an economy is determined by total intermediate energy requirements, F, and final demand, Y. F, in turn, is a function of production technology, measured in terms of the technical coefficient matrix, A, which includes both energy and non-energy inputs. As such, energy use in the economy can change because of changes in final demand and/or because of changes in production technology.

Up to this point, these equations and concepts have been used to understand the changes in energy consumption in *one* region from one year to another. Lin (1996) developed these equations to uncover the factors behind the decline in energy intensity in China between 1981 and 1987. In his case, the equation that depicted this change would look like the following:

$$\begin{aligned} \Delta E &= E_{87} - E_{81} \\ &= (F_{87}Y_{87} + eY_{87}n) - (F_{81}Y_{81} + eY_{81}n) \\ &= (F_{87}Y_{87} - F_{81}Y_{81}) + e(Y_{87} - Y_{81})n \qquad (8) \end{aligned}$$

The first item in this equation represents changes in intermediate energy use, which depends on both changes in production technology, F, and changes in final demand, Y. The second item, measures changes in direct energy consumption, which is solely a function of final-demand shifts.

In the above case, Lin used 1981 as the reference year by which to measure the changes in energy consumption between 1981 and 1987. In this paper, I will develop a spatial SDA equation which will have China as the reference point from which to understand the factors behind energy consumption in Shanxi Province. There are two questions that my analysis will answer. First, what are the factors behind the discrepancies in energy intensity between Shanxi Province and China? The second question is what would have been the energy consumption in Shanxi Province if its factors behind energy consumption were the same as in the nation? To answer these two questions, equation (8) becomes:

$$
\begin{aligned}
\Delta E &= E_{S92} - E_{C92} \\
&= (F_{S92} Y_{C92} + eY_{S92} n) - (F_{C92} Y_{C92} + eY_{C92}\, n) \\
&= (F_{S92} Y_{S92} - F_{C92} Y_{C92}) + e(Y_{S92} - Y_{C92}) n
\end{aligned} \tag{9}
$$

where c stands for China and S stands for Shanxi Province, while the first item in this equation represents changes in intermediate energy use, which depends on both changes in production technology, F, and changes in final demand, Y. The second item, measures changes in direct energy consumption, which is solely a function of final-demand shifts.

In order to devise the spatial SDA equations, I introduce a hypothetical economy with China-as-a-whole production technology in 1992, F_{c92}, and Shanxi Province's final demand, Y_{s92}. The energy consumption in this hypothetical economy is:

$$
E_{Fc92Ys92} = F_{c92}\, Y_{s92} + eY_{s92}\, n \tag{10}
$$

Where $E_{Fc92Ys92}$ measures the amount of energy that would have been consumed in Shanxi Province if China's production technology were used to deliver Shanxi Province's final demand. As such, using $E_{Fc92Ys92}$ as a reference point, we can rewrite the energy-use changes as following:

$$
\begin{aligned}
\Delta E &= E_{s92} + E_{Fc92Ys92} - E_{Fc92Ys92} - E_{c92} \\
&= (F_{s92} Y_{s92} + eY_{s92} n) + (F_{c92} Y_{s92} + eY_{s92} n) - (F_{c92} Y_{s92} + eY_{s92} n) - (F_{c92} Y_{c92} + eY_{c92} n) \\
&= F_{c92}(Y_{s92} - Y_{c92}) + e(Y_{s92} - Y_{c92}) n \qquad \text{(final-demand shift)} \\
&\quad + (F_{s92} - F_{c92}) Y_{s92} \qquad \text{(production-technology change)}
\end{aligned} \tag{11}
$$

The final demand shift indicates the energy impact of final-demand changes holding production technology constant. Production-technology change quantifies the energy effect of changes in production technology with a given final demand.

In this paper, I am using $E_{Fc92Ys92}$ as the reference point, that is, I am asking what would happen to Shanxi Province's energy consumption, if it possessed the same production technology as China as a whole. However, I could have also used another reference point, by asking what would have happened to China's energy consumption, if it used the same production technology as Shanxi Province. There are two reasons for my choice. First, China is a very heterogeneous country with 31 provinces, which as I will show in chapter 3, have very disparate energy-intensity levels. As such asking the second question would be contradictory, because the whole point of this analysis is to understand how much of this disparity is due to technological variations among the provinces. The second reason is that there have not been many studies showing how technology transfer within China could reduce energy intensity and hence energy overall energy consumption. This paper could answer the question of what the difference between the regions, or at least Shanxi Province, and China has to do with different production technologies that is available in China as a whole, or whether the difference has more of a structural basis behind it.

The power of spatial SDA comes from the fact that both components of the changes in energy consumption given our hypothetical economy, that is the final-demand shift and production- technology changes, can be decomposed further. The final-demand shift can be seperated into three components. The first is the changes in the level of final demand, which refers to the overall level of total demand, which equals the sum of all the final output or expenditures. The second is the distribution of demand, which refers to the distribution of total demand among the individual final-demand sectors, such as personal consumption, government expenditures, capital investment, exports, and imports. The third is the pattern of demand, which refers to the mix of goods and services within the individual final-demand sector.

In matrix notation, the vector of final demand is the product of its level, distribution and pattern components:

$$Y = MDL \tag{12}$$

Where M = matrix of spending mix of individual final-demand sectors;

D = diagonal matrix with sectoral distribution of total demand on the diagonal;

L = diagonal matrix with the overall total demand level on the diagonal. Mathematically we can quantify the energy effects of final-demand level, distribution, and pattern changes as follows:

$$\Delta Y = Y_{s92} - Y_{c92} = M_{s92}D_{s92}L_{s92} - M_{c92}D_{c92}L_{c92} \quad (13)$$

$$\begin{aligned}
\Delta E_y &= F_{c92}(Y_{s92} - Y_{c92}) + e(Y_{s92} - Y_{c92})n \\
&= F_{c92}[M_{s92}D_{s92}L_{s92} - M_{c92}D_{c92}L_{c92}] + e[M_{s92}D_{s92}L_{s92} - M_{c92}D_{c92}L_{c92}]n \\
&= F_{c92}M_{c92}D_{c92}(L_{s92} - L_{c92})L_{s92} + eM_{c92}D_{c92}(L_{s92} - L_{c92})n \quad \text{(Level effect)} \\
&+ F_{c92}M_{c92}(D_{s92} - D_{c92})L_{s92} + eM_{c92}(D_{s92} - D_{c92})L_{s92}n \quad \text{(Distribution effect)} \\
&+ F_{c92}(M_{s92} - M_{c92})D_{s92}L_{s92} + e(M_{s92} - M_{c92})D_{s92}L_{s92}n \quad \text{(Pattern effect)} \quad (14)
\end{aligned}$$

Second, we can calculate the amounts of energy-use changes originating in individual final demand sectors, such as personal consumption, investment, exports and imports. Mathematically, this can be expressed as follows:

$$\Delta E_y = \sum_h \Delta E_y^h = \sum_h F_{c97}[(Y_{s97}^h - Y_{c97}^h) + e(Y_{s97}^h - Y_{c97}^h)n] \quad (15)$$

Where ΔE_y^h is the change in energy use due to changes in final demand sector h. Third, we can determine how changes in the purchase of an individual product or product group affect energy consumption. The following equation describes this relationship:

$$\Delta E_y = \sum_k \Delta E_{y,k} = \sum_k F_{c97}K(Y'_{s97} - Y'_{c97}) + eK(Y'_{s97} - Y'_{c97})n \quad (16)$$

Where $\Delta E_{y,k}$ = a matrix of energy-use changes associated with each product k by fuel types;

Y'_{s92} and Y'_{c92} = diagonal matrices of the total demand vector in Shanxi Province and China respectively;

K = matrix consisting of one(s) and zeroes, with one(s) in the row location(s) corresponding to product(s) k and zeroes in all other elements of the matrix.

As such from equation 16, we can calculate how much of the energy use changes are due to final-demand shifts comes directly from purchases of energy products and how much comes indirectly from purchases of non-energy products.

In order to decompose the production-technology-change component, we can rewrite Equation 11 as follows:

$$\Delta E_T = (F_{s92} - F_{c92})Y_{s92}$$
$$= [e(G_{s92} - I) - e(G_{c92} - I)]Y_{s92} = (eG_{s92} - eG_{c92})Y_{s92} = e(G_{s92} - G_{c92})Y_{s92} \quad (17)$$

where $G_{s92} = (I - A_{s92})^{-1}$ and $G_{c92} = (I - A_{c92})^{-1}$

Using linear algebra, we can reach the following equation:

$$G_{s92} - G_{c92} = G_{s92}(A_{s92} - A_{c92})(I - A_{c92})^{-1} = G_{s92}(A_{s92} - A_{c92})G_{s92} \quad (18)$$

We must split the production technology into two portions. The energy portion represents the direct use of energy inputs, like coal, oil and electricity, by sector. It measures energy requirement per unit of output. The non-energy portion contains all the other inputs by production sectors, such as plastics, steel and chemical fertilizers. We can use Equation 18 to separate the effect of changes in direct energy requirements and direct non-energy requirements of energy use by partitioning and writing the changes in technical coefficients, $(A_{s92} - A_{c92})$ as following:

$$A_{s92} - A_{c92} = (A_{s92,E} - A_{c92,E}) + (A_{s92,E} - A_{c92,N}) \quad (19)$$

Where A_E represents the energy rows of the technical coefficients matrix and A_N represents the non-energy rows. Equation 15 then becomes the following:

$$\Delta E_T = eG_{s92}(A_{s92} - A_{c92})G_{c92}Y_{s92}$$
$$= eG_{s92}(A_{s92,E} - A_{c92,E})G_{c92}Y_{s92}$$
$$+ eG_{s92}(A_{s92,N} - A_{c92,N})G_{c92}Y_{s92} \quad (20)$$

We can now identify production-technology changes with the following equation:

$$\Delta E_T = \sum_j \Delta E_T^j = \sum_j [eG_{s97}(A_{s97,E^j} - A_{c97,E^j})G_{c97}Y_{s97} + eG_{s97}(A_{s97,N^j} - A_{c97,N^j})G_{c97}Y_{s97}] \quad (21)$$

Where ΔE_T^j is the change in energy use due to production-technology changes in sector j. Using Equation 21, we can identify production-technology changes in individual sectors or sector groups—in this case agriculture, energy, the non-energy industrial sector, construction, transportation and commerce—and assess their relative contribution to intermediate energy changes.

CONCLUSION

In this chapter, I developed the equations that I will use in my analysis of the factors behind the differences in energy intensity between Shanxi Province and China. In the next chapter, I give an overview of historical disparities between China and Shanxi Province. As will become apparent, there are significant differences between the two areas under consideration, and the changes over time have also followed disparate paths.

CHAPTER 3

AN ANALYSIS OF THE PROVINCIAL ENERGY INTENSITY DISPARITIES IN CHINA

The purpose of this chapter is to show regional disparities in a number of key variables among China's provinces and the country as a whole. Although the focus of this study is on disparities in energy intensity between Shanxi Province and China, I will show factors such as energy consumption, Gross Domestic Product (GDP) and population, that influence the energy-intensity levels. This analysis is meant to provide a broad background for the SSDA and SSA analysis I will be conducting in later chapters.

CURRENT STATUS OF REGIONAL DISPARITIES

There are several problems associated with regional disparities. The first problem is lack of development in regions of poverty. In fact, according to Chinese statistics, 80 percent of the 80 million living below the official poverty line in 1995, lived in inland regions (China Statistical Yearbook 1997). The second problem is the deterioration of existing industrial zones. This has resulted in increased unemployment, creating a class labeled "the new poor," which is causing new social problems, such as social unrest and uprisings. This is particularly true of the inland provinces. The third problem is environmental pollution. As an example, despite the fact that China generates less electricity than Japan, it produces thirteen times as much sulfur dioxide (Sinton 1996). The fourth problem is the backwardness of the infrastructure in inland areas. Finally, although migration has not been a serious problem in the past due to restraints on traveling, it may become so in the future, as the economic and political reform continues. If migration does become a serious problem, it could produce regions of extremely high and low population density, resulting in over-population in the cities and under-population in the rural areas. These problems, in turn, cause a bottleneck in regional economic development. (Minematsu, Sakata, Zheng, and Yamada 1997)

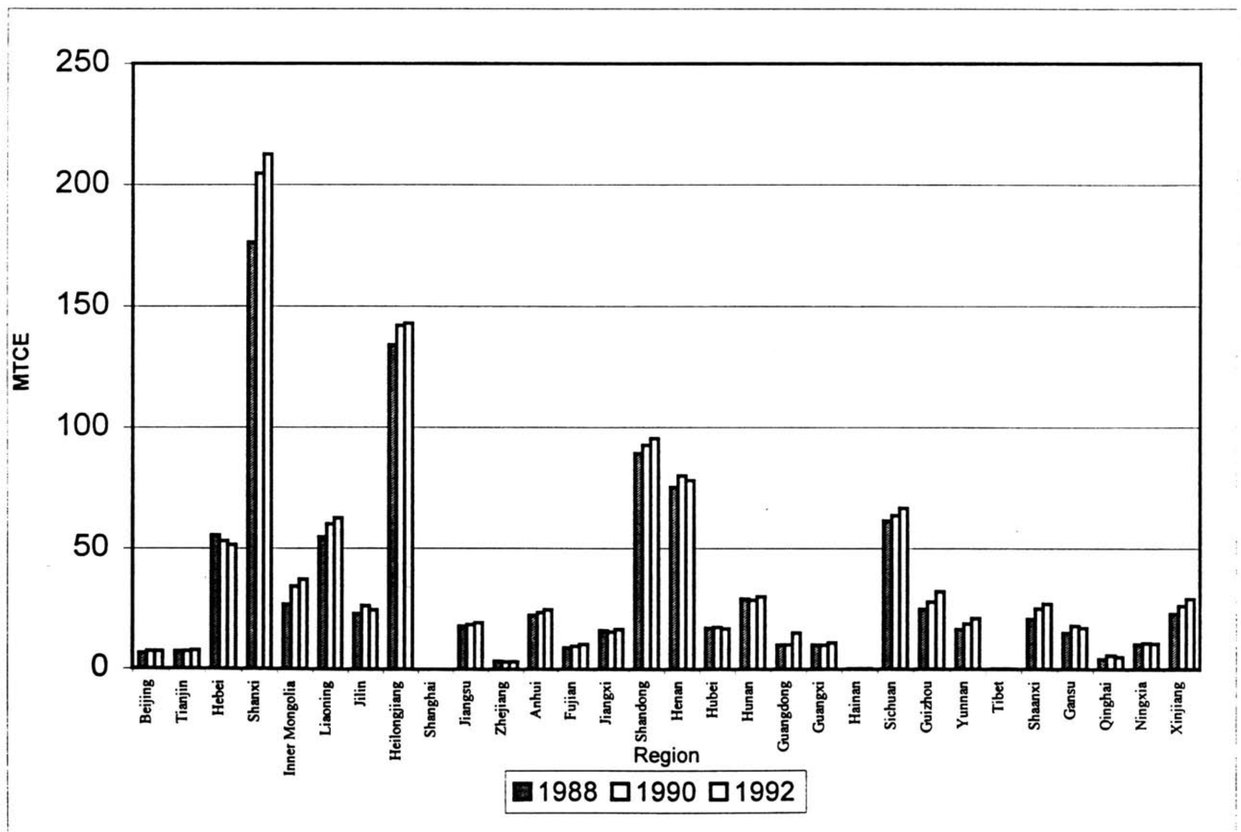
Here, I concentrate on five categories of regional disparity: primary energy production, population, GDP, primary energy consumption in the household and industrial sectors, and energy intensity in the household and industrial sectors. I have chosen the above categories for two reasons. First, to show the importance of Shanxi Province in China in terms of energy production. Second, to show the provincial differences in the factors that contribute to energy-intensity levels.

Regional Energy Production

In my analysis, I have divided energy production into five categories, and Figure 3.1 shows the aggregate of these factors as primary energy production on the provincial level for the years 1988 and 1990. The five categories in energy production are coal, natural gas, crude oil, thermal power, and hydroelectric power. It is important to emphasize that coal is by far the largest contributor to the overall primary energy production in China. Furthermore, Shanxi Province dominates coal production in China, producing approximately twenty percent of all the coal produced in China in the years 1988 and 1990. This proportion of coal production has since increased to over 25 percent of the total coal production, showing a trend that may continue in the future, as China moves further along in its economic reform. Furthermore, overall coal production accounted for approximately 75 percent of the primary energy production in China for the above-mentioned years (Sinton 1992, 1996).

Having said that, it is apparent then that Shanxi Province's importance in coal production results in its overall dominance in primary energy production. Heilongjiang Province is the next largest producer of primary energy, producing almost 150 million tons of standard coal equivalent (Mtce) of primary energy in each of the two years (Figure 3.1). The main reason behind the impressive primary energy production in Heilongjiang Province, is in its dominance in crude oil production (Sinton 1992, 1996). In fact Heilongjiang Province produced approximately 55 million tons of crude oil in each of the above years, surpassing all the other provinces. Shandong Province produced about 32 million tons. As such, these two provinces combined, produced almost 75 percent of all the crude oil in China in 1988 and 1990 (Sinton 1992, 1996).

FIGURE 3.1
REGIONAL PRIMARY ENERGY (INCLUDING ELECTRICITY) PRODUCTION 1988, 1990,1992 (MILLION TONS OF COAL EQUIVALENT)



Source: China Energy Databook, 1992 and 1996 Editions, Ernest Orlando Lawrence Berkley National Laboratory, University of California-Berkley, Sinton et al. Editors.
MTCE: Million Tons of Coal Equivalent.

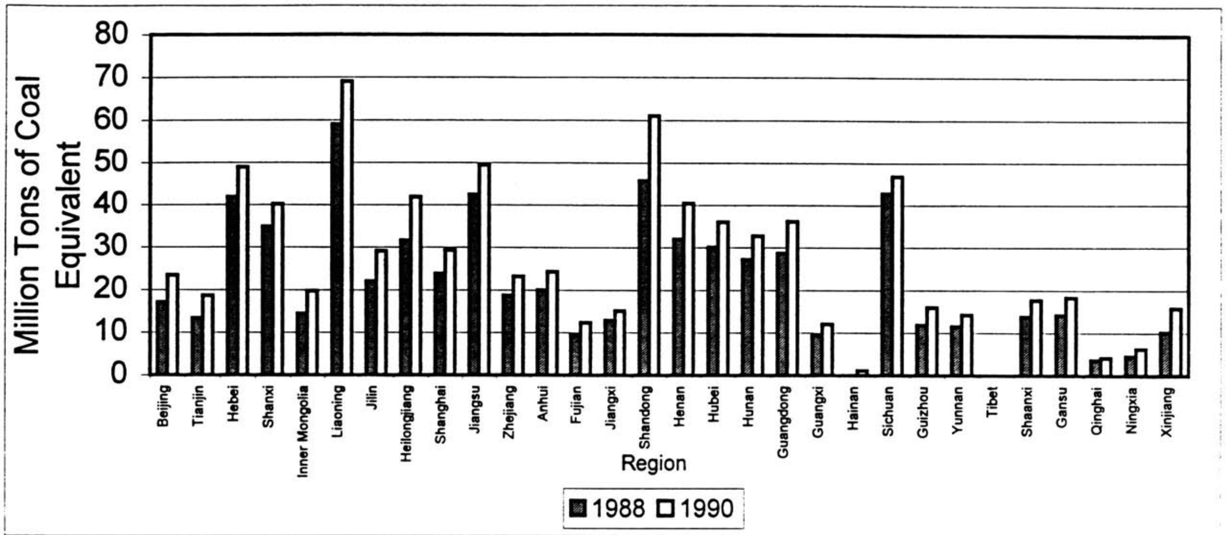
Rounding out the top five primary enery producers are Henan and Sichuan Provinces. The strength of Henan Province lies in its diversity of energy production, producing a modest amount in all five categories. Sichuan Province, on the other hand is by far the largest producer of natural gas in China, while being second only to Hubei Province in hydroelectric power generation. This regional distribution may change in the not too distant future as the electricity from the Three Gorges dam comes on line, and if oil and gas exploration in the western provinces is fruitful.

Provincial Primary Energy Consumption

For this analysis, I have divided energy consumption into two categories: household and industrial sectors. Figures 3.2 and 3.3 show the regional distribution of energy consumption between these two sectors. As it is apparent from the figures, one cannot reach any definitive conclusions about the trends in household and industrial energy consumption among the provinces; however, it is obvious that although industrial energy consumption increased in every province from 1988 to 1992, the same cannot be said about household energy consumption.

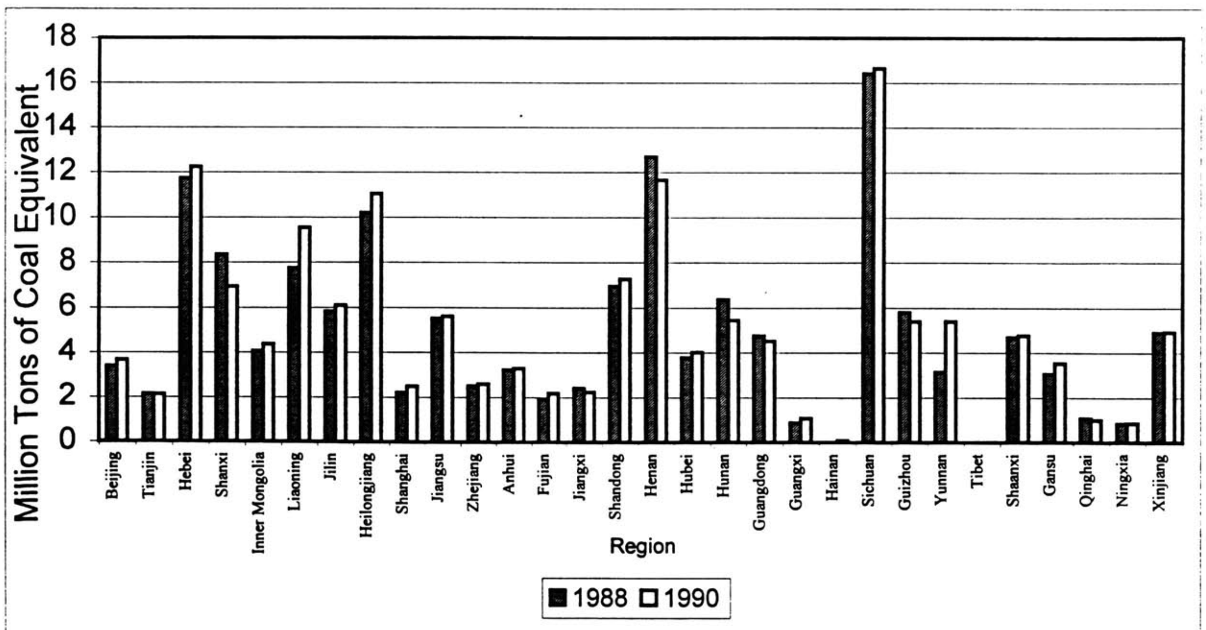
I have included these two charts in order to show that although aggregate primary energy consumption in the household and industrial sectors do not show a clear pattern, as I will show in the next section, energy intensities in these two sectors among the provinces do. Furthermore, it is also important to note that although energy production is concentrated among a small number of provinces, aggregate energy consumption, with a few notable exceptions, is distributed more evenly. Having said that, I will now turn my attention to industrial and household energy intensities, both on the provincial and temporal levels to show energy-intensity trends.

FIGURE 3.2
REGIONAL PRIMARY INDUSTRIAL ENERGY CONSUMPTION, 1988 AND 1990
(MILLION TONS OF COAL EQUIVALENT)



Source: China Energy Databook, 1992 and 1996 Editions, Ernest Orlando Lawrence Berkeley National Laboratory, University of California-Berkeley, Sinton et al. Editors.

FIGURE 3.3
REGIONAL HOUSEHOLD PRIMARY ENERGY CONSUMPTION, 1988 AND 1990
(MILLION TONS OF COAL EQUIVALENT)



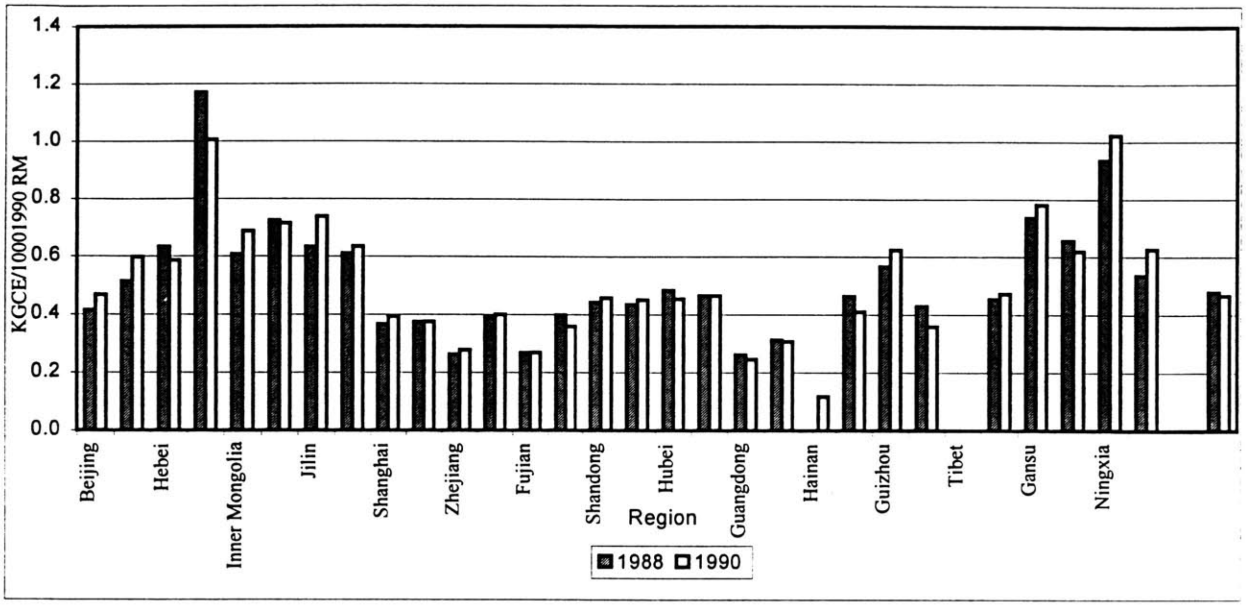
Source: China Energy Databook, 1992 and 1996 Editions, Ernest Orlando Lawrence Berkeley National Laboratory, University of California-Berkeley, Sinton et al. Editors.

Provincial Energy-Intensity Analysis

There are two clear patterns that become apparent when discussing China's energy intensities. First, there is a wide range of values in energy-intensity among the provinces. Second, China's industrial energy intensity has decreased, while energy intensity in the household sector has increased modestly. It is also important to emphasize that the data presented here are from eleven and nine years ago, and comparable data for later years are not available for every province, I will show in later chapters that energy intensity in China and Shanxi Province has continued to decline. It is therefore my conjecture that the same trends hold true for all the provinces in China. Figures 3.4 and 3.5 show the above-mentioned trends for the years 1988 and 1990.

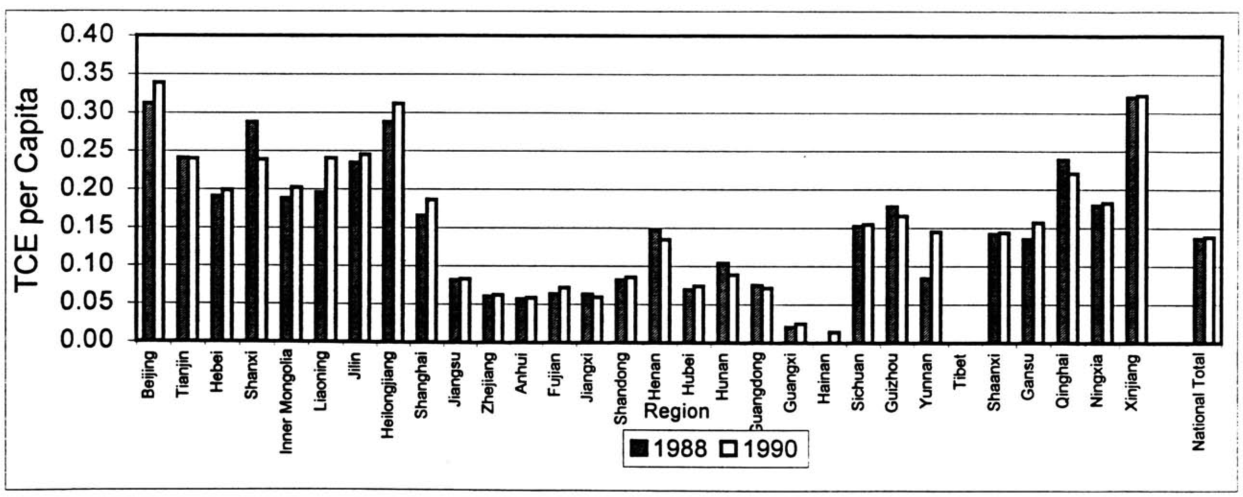
In the industrial sector there are two trends that stand out. First, there are large discrepancies in industrial energy intensities among the provinces, with Shanxi and Ningxia Provinces having energy intensities nearly twice as large as most of the other provinces. In the case of Shanxi Province, abundance of cheap coal in the province results in an increased reliance on coal as the main industrial fuel, therefore increasing its energy intensity. However, this factor could be behind the significant decrease in energy intensity in Shanxi Province between 1988 and 1990. I suspect that because of such an over-reliance on coal, the smallest improvements in coal-burning equipment and change in fuel use could result in a dramatic decrease in energy intensity. In fact, upon closer inspection of Figure 3.4, it is apparent that this dramatic decrease in energy intensity in Shanxi Province, is one of the main reasons that China's overall industrial energy intensity decreased. In Chapters 4 and 5 of this paper, I will show the factors behind the decrease in energy intensity between Shanxi Province and China.

FIGURE 3.4
REGIONAL INDUSTRIAL PRIMARY ENERGY CONSUMPTION PER GDP, 1988 AND 1990 (KGCE PER THOUSAND 1990 RMB)



Source: China Energy Databook, 1992 and 1996 Editions, Ernest Orlando Lawrence Berkeley National Laboratory, University of California-Berkeley, Sinton et al. Editors.
Kgce: Kilograms of Coal Equivalent; **RMB:** Renminbi, the Chinese currency, equivalent to about 0.125 U.S. Dollar; **GDP:** Gross Domestic Product.

FIGURE 3.5
REGIONAL HOUSEHOLD PRIMARY ENERGY CONSUMPTION PER CAPITA, 1988 AND 1990 (TCE PER CAPITA)



Source: China Energy Databook, 1992 and 1996 Editions, Ernest Orlando Lawrence Berkeley National Laboratory, University of California-Berkeley, Sinton et al. Editors.
TCE: Tons of Coal Equivalent

In the household sector, the trend that stands out most is the fact that the provinces in the north, northeast, and northwest have household energy intensities that are larger than the rest of the country. This is perfectly plausible due to the climatic differences, with these provinces experiencing colder seasons than the rest of China. This is further magnified by the fact that although household appliances are making their way into the Chinese households, the prevalence of air-conditioning is still quite insignificant for the southern provinces (China Urban Statistical Yearbook 1998). Furthermore, it is also obvious that certain provinces, such as Shanxi Province, have managed to decrease their energy intensity in the household sector. In the case of Shanxi Province, this could be due to the fact that the province introduced coal and coke gas as the main household fuel to some of its cities, thereby utilizing a byproduct that used to pollute the environment. Furthermore, in almost every province, there has been a dramatic increase in the electricity consumption, and a corresponding decrease in direct coal consumption, which may result in a decrease in energy intensity. However, the majority of electricity in China is produced in coal-fired plants, which would negate some of the efficiency gains that result in the decline in energy intensity. This scenario may change as China builds more efficient natural-gas power plants, nuclear plants, and hydropower facilities.

In this section I have shown the overall regional disparities among China's 31 provinces. This lays the groundwork for the later analysis. Although this study is concentrating on energy-intensity differences between Shanxi Province and China as a whole, this same type of analysis can and should be undertaken among all provinces and for China as a whole. In the next section, I will examine the specific differences in energy consumption of the material-production sectors between China and Shanxi Province.

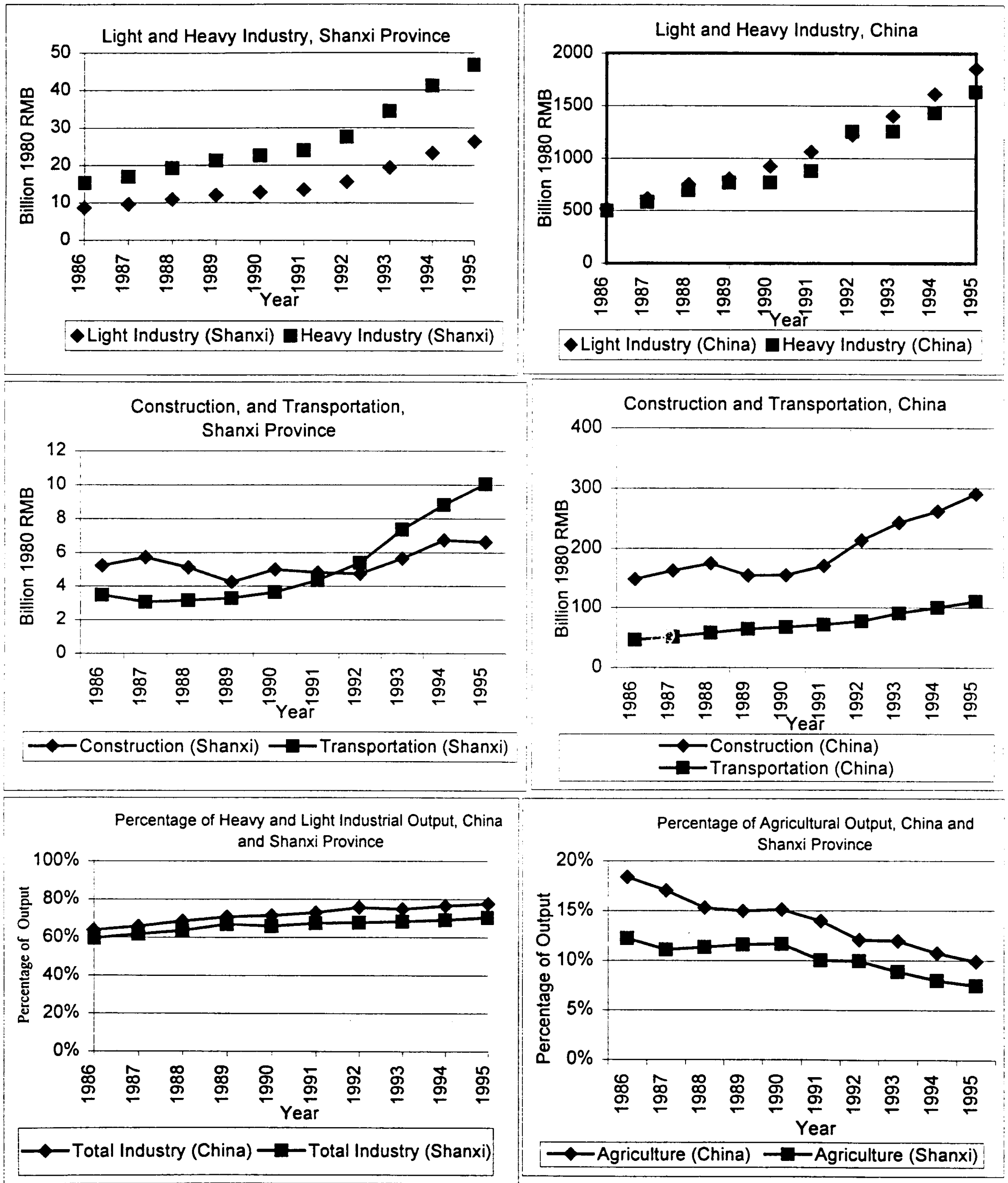
OUTPUT AND ENERGY CONSUMPTION OF THE MATERIAL-PRODUCTION SECTORS: CHINA AND SHANXI PROVINCE, 1986-1995

In this section, I show the trends in the composition of the overall output and energy consumption of the material-production sectors of Shanxi Province and China. The Chinese Statistical Bureau divides material-production into three broad sectors. The primary sector is agriculture. The secondary sector includes industry and construction. For my analysis, I have further disaggregated industry into light and heavy industry. The tertiary sector consists of commerce and transportation. Figures 3.A.1-3.A.4 in Appendix 3.A show the trends in total gross output and composition of the gross output of the six sectors for China and Shanxi Province for 1986 to 1995.

There are three trends that stand out from these charts, as summarized in Figure 3.6. First, the light and heavy industries played a key role in the overall growth of the material-production sectors, and continued to be the largest output sectors among the six material-production categories between 1986 and 1995, accounting for almost 60 percent of the total output in this ten-year span. The second trend is that the remaining four sectors also grew at a brisk pace during this ten-year span, although the rate of growth for the construction and commerce sectors differed considerably between China as a whole and Shanxi Province (Tables 3.A.1-3.A.3). The third trend is the declining share of the agricultural sector in the total output of both Shanxi Province and China. The primary reason behind this decline is that the sector's rate of growth was far slower than the remaining five sectors, resulting in a net loss in its overall share of the material-production sector (Figure 3.6).

Although the above trends in total output of the material-production sectors are illuminating, what is important for the purposes of this paper, is how the above changes translated into changes in energy consumption for the six sectors. Figure 3.7, shows the trends

FIGURE 3.6
TRENDS IN CHINA AND SHANXI PROVINCE'S MATERIAL-PRODUCTION OUTPUT, 1986-1995 (BILLION 1980 RMB)



Source: The Gross Domestic Product of China, 1952-1995, pp. 192-199; China Provincial Statistics, pp. 66-67; China Energy Databook, 1996, Jonathan E. Sinton et. al. Editor; China Statistical Yearbook,
RMB: Renminbi, the Chinese currency, which is the equivalent of 0.125 U.S. Dollar.

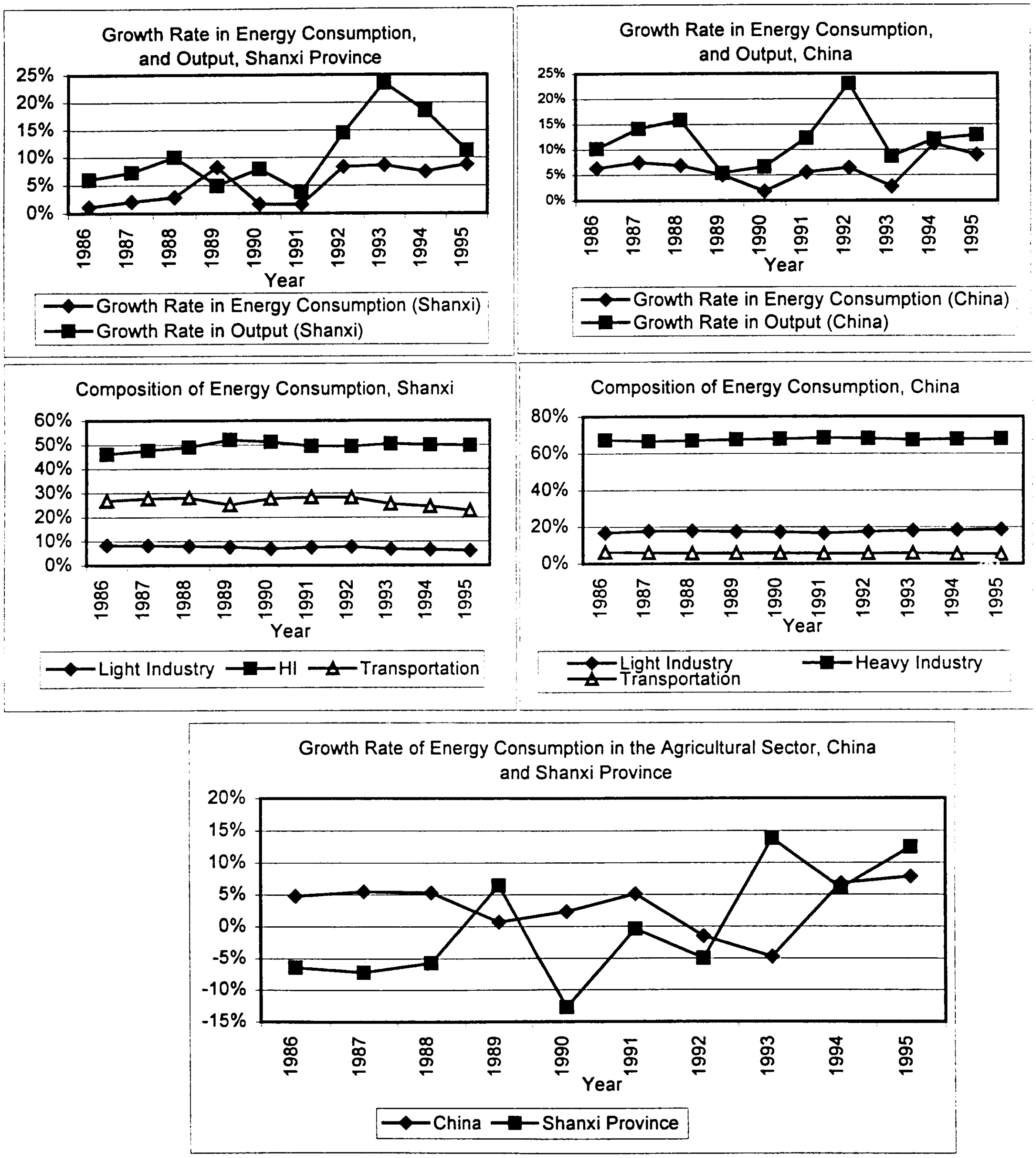
in energy consumption for the 1986-1995 period for the six sectors (see Appendix 3.B for detail charts and tables). There are three trends that are apparent from these charts and table. First and most important is the discrepancy in the rate of growth between total output and total energy consumption from Table 3.A.1, and Table 3.A.2. In almost every sector the growth in energy consumption is less than that of total output in both China and Shanxi Province, and overall the growth in total output is almost twice as much as that of total energy consumption.

The second trend that stands out is that in China, the industrial sector, that is, light and heavy industries, consumed between 70 to 75 percent of all the primary energy during this 10-year span of time. What is surprising though is that the same does not hold for Shanxi Province. Between 1986 and 1995, the two most energy-consuming sectors were the heavy industry and transportation sectors. Furthermore, the role of the commerce sector increased much more rapidly in Shanxi Province than in China as a whole. This may be due to different accounting techniques used between Shanxi Province and China, or due to inaccuracies in the data. The big increase in energy consumption in the commerce sector could also be due to the fact that a great deal more of Shanxi Province's commerce is in energy-related materials and products than for China, which could have contributed to the differences between Shanxi Province and China.

The third trend is the diminishing role of the primary sector, that is agriculture, in total energy consumption. The agricultural sector is the only sector that shows a clear decline as a percent of total output and total energy consumption. In fact the agricultural sector in Shanxi Province is the only sector that shows a decrease in total energy consumption among all the sectors between the regions.

FIGURE 3.7

SUMMARY OF TRENDS IN CHINA AND SHANXI PROVINCE'S ENERGY CONSUMPTION IN THE MATERIAL-PRODUCTION SECTORS 1986-1995



Source: The Gross Domestic Product of China, 1952-1995, pp. 192-199; China Provincial Statistics, 1949-1 pp. 66-67; China Energy Databook, 1996, Jonathan E. Sinton et. al. Editor; China Statistical Yearbook, 1989
RMB: Renminbi, the Chinese currency, which is the equivalent of 0.125 U.S. Dollar; **HI:** Heavy Industry.

Composition of the energy source is another important element in the energy consumption and output in China and Shanxi Province. Figures 3.C.1 and 3.C.2. in the Appendix show the shares of energy consumption by energy source for the two regions. I make two observations regarding these charts. First, it is apparent that Shanxi Province is lacking the natural gas category. The primary reason is that almost all the gas consumption in Shanxi Province is in the form of coal-bed, coke, or coal-oven gas, which is becoming an important household fuel, particularly in the larger cities in Shanxi Province. All of the above coal-derived gases are becoming an important by-product of the coal-mining and cokemaking industries in Shanxi Province, which has resulted in a reduction in the amount of pollution that is emitted into the atmosphere (World Bank, 1997).

The second point to remember about the charts in Appendix 3.C is the role of electricity as an energy source. In case of Shanxi Province, the majority of electricity is produced by coal-fired power plants, which makes the role of coal even more important as an energy source. In the case of China, hydropower plays a much bigger role, and, in fact, the percentage of electricity that is represented in Figure 3.C.1 is from hydropower. In short, coal accounts for almost 75 percent of the primary energy source in China, while in Shanxi Province, coal and coal-derived products, such as coke-oven gas, accounted for over 90 percent of the primary fuel.

CONCLUSION

The purpose of this chapter was to provide a background of the differences in energy-intensity levels and other relevant economic and social measures among China's provinces, and to provide the background in the differences in terms of output and energy consumption in the six materials production sectors in Shanxi Province and China. In the next chapter, I will expand on the findings from this chapter and analyze the importance of this shift in terms of declining energy-intensities in both Shanxi Province and China. I will show that although this shift in industrial mix is very important to the economy as a whole, the primary reason behind improvements in energy-intensity levels in the material-production sectors in China and Shanxi Province, has been the improvement in energy efficiency.

At the same time, I want to emphasize that by presenting an overview of the energy-consumption, and energy-intensity trends in China and Shanxi Province, I have posed more questions that I will answer in this study. The underlying reasons behind the differences in energy-intensity levels among the six sectors (Figure 3.6) are all important research questions that future researchers will have to decipher.

CHAPTER 4

SHIFT-SHARE ANALYSIS OF THE ENERGY-CONSUMPTION AND ENERGY-INTENSITY DISPARITIES IN THE MATERIAL PRODUCTION SECTORS BETWEEN CHINA AND SHANXI PROVINCE, 1986-1995

I have chosen the Polenske and Lin (1993) method to conduct the shift-share analysis of the energy-intensity levels in China and Shanxi Province for the years 1986-1995, which I described in detail in Chapter 3. However, before discussing the results of my findings, it is important to point out the shortcomings of shift-share analysis, along with the problems I faced in gathering the data. First, SSA is essentially a descriptive tool that identifies the source of the changes in energy intensity and consumption, but it does not explain why the changes occurred. Second, the results of shift-share analysis are not invariant to industrial disaggregation. As such, for any given year, the relative size of the industrial mix and efficiency shift will change with the fineness of the industrial classifications. Therefore, we must keep the level of industrial disaggregation in mind when we interpret the results of shift-share analysis.

It is also important to keep in mind that there are discrepancies in different sources for the energy and output data. I have tried to use official Chinese statistics whenever possible, but there are variations among different official statistical books. As such, the accuracy of the data is at times questionable. I have also resorted to using statistical tools to fill in some of the data gaps, for total output in the light and heavy industries in China for the years 1993-1995, and for energy consumption in Shanxi Province for the years 1986-1988 and 1993-1994. There are two reasons for this. First, China stopped disaggregating total industrial output into light and heavy industrial output after 1988. Instead, they began to split the industrial output by the type of ownership.

Although, this is a more appropriate method, because of the emergence of the private sector in the Chinese economy, it does make historical comparisons a rather tricky one.

Second, detailed energy consumption data for Shanxi Province are extremely hard to locate, and in most cases they are provided for specific years. For this analysis, I could locate the energy-consumption data for the six sectors under examination for the years 1985, 1989-1992, and 1995. This is somewhat fortunate, because it does allow for an accurate level of regression analysis to fill in the remaining years. In all the above cases, I have used binomial regression analysis to find the most plausible data possible. I believe that although using regression methods to obtain data is not the most accurate procedure to conduct analysis, it is the only available method, given the scarcity of published data. I have included the regression charts for all the estimated data in Appendix 4.A, but, first, I give an overview of the two broad factors that I am analyzing in this chapter regarding energy intensity: structural and technological factors.

STRUCTURAL FACTORS

Structural factors have played a key role in past reductions of energy intensity in both China and Shanxi Province, and they are expected to continue to play an important role in further energy-intensity reductions. There are four main reasons behind the importance of structural factors: economic growth, residential energy use, structural changes in the industry sector, and structural changes in other sectors.

First, faster economic growth can be expected to result in faster growth in energy use. The relationship between the two, however, is not linear. Energy/GDP growth elasticities are expected to be significantly lower if China's economy continues to grow faster than if the economy grows slowly. Faster growth is not expected to result in correspondingly higher energy consumption levels. One reason is that faster industrial growth provides an opportunity for a more rapid increase in the contribution of new, more-efficient industrial plants. Another reason is that faster growth is generally expected to be driven by more rapid structural change—much of the incremental value-added in industry under a higher growth scenario is expected to come from more specialized products that are less energy and material intensive. If this does not occur, the prospects for rapid growth are dim. (Junfeng, Johnson, Changyi, Taylor, Zhiping, and Zhongxiao 1995)

Second, the role of the residential sector energy use is of importance. Total energy use by households increases substantially slower than GDP as countries develop from low-income to middle and high-income countries. Electricity use by households tends to grow very fast, but the larger energy demands for solid and liquid fuels for cooking and heating tend to grow much more slowly than the orders-of-magnitude increases in GDP implied by the sustained rapid economic growth. This trend has played a role in past declines in China's energy intensity, and the trend is expected to continue, especially under high-growth scenarios, and especially with the expected concurrent improvements in the efficiency of cooking and heating in Chinese households. (Junfeng, Johnson, Changyi, Taylor, Zhiping, and Zhongxiao 1995) I will discuss the role of the residential sector in the differences in energy-intensity levels between Shanxi Province and China in 1992 in Chapter 5.

Third, the nature of changes in the structure of industrial production is a critical determinant of energy demand levels. With rapid growth, the most important issue is the characteristic of new capacity, rather than the rehabilitation of existing capacity. An important element is the extent to which the efficiency in the production of energy-intensive products, such as steel, can be increased. The most important shifts in industrial structure will come about through changes in the product mix of individual sectors due to changing market conditions. The energy per unit output value is expected to fall due to large increases in value-added due to quality improvements, specialization, and higher technological content (Junfeng, Johnson, Changyi, Taylor, Zhiping, and Zhongxiao 1995). Finally, structural changes in agriculture and various tertiary industries, such as construction, are expected to result in modest declines in energy use per unit of output value, primarily due to increases in the value side of the equation, especially through quality improvements.

EFFICIENCY FACTORS

Efficiency factors have played the largest role in reductions of the energy-intensity levels in China and Shanxi Province. There are three main reasons how efficiency factors improve energy-intensity levels: economies of scale, improvement in equipment and processes, and improvements in the fuel mix and industrial raw material inputs.

First, most industries in China suffer serious energy efficiency penalties because they do not operate at optimal scale. For example, about 80 percent of China's cement output is produced by medium and small plants. In the electric power sector, less than 15 percent of the thermal power capacity is supplied by 300 megawatt (MW) units or larger. As such without minimum production scale, many modern technologies or equipment cannot be adopted. Traditional energy conservation projects cannot close the efficiency gap caused by differences in production scale. With market-oriented reforms, capital market development, and efforts to reduce regional protectionism, China's economy clearly should be able to take better advantage of scale economies in key industries. (Junfeng, Johnson, Changyi, Taylor, Zhiping, and Zhongxiao 1995)

Second, the level of sophistication in industrial technologies and equipment affects overall energy intensity both in terms of the value produced, especially value derived from quality, and the energy efficiency of the production process. Because of the underdevelopment of domestic manufacturing equipment, such as industrial boilers, fans, pumps and motors, generally have lower energy efficiency than those made in developed countries. On the user side, due to poor operation and management, the actual utilization efficiency of this equipment is often even lower. China has been improving the technological sophistication of the machinery and electric equipment industry, which has resulted in raising the overall efficiency level. In addition, this improvement has also enhanced the competitiveness of China's machinery and electric equipment industry in the world market, and will continue to do so in the future. Furthermore, improvements in the equipment and processes used for new capacity is by far the most important, as new plants will soon dominate industrial capacity, given the rapid industrial growth envisaged (Junfeng, Johnson, Changyi, Taylor, Zhiping, and Zhongxiao 1995).

Finally, improving the fuel mix and industrial raw material inputs has been an important factor in improving efficiency levels. China's historical emphasis on self-reliance has caused many industries to adopt high-cost and low-efficiency processes. For example, the use of low-quality domestic iron ore is one of the major factors responsible for the high-energy intensity in Chinese iron and steel making. Compared to Japan, the Chinese steel industry uses 130 kilograms coal equivalent (kgce) more energy to make one ton of iron and 400 kgce more to make one ton of steel. Such inefficient production processes are fairly common in the chemical and paper industries as well. As China's economy becomes more open to the world market, Chinese industry can take advantage of the competitiveness of international energy and raw material markets to improve its fuel mix and raw-material inputs. Discoveries and development of new supplies of domestic natural gas also could yield substantial energy-efficiency gains. (Junfeng, Johnson, Changyi, Taylor, Zhiping, and Zhongxiao 1995)

ENERGY INTENSITY OF THE MATERIAL-PRODUCTION SECTORS: CHINA AND SHANXI PROVINCE, 1986-1995

In this chapter, I have defined energy intensity as the amount of energy consumed to produce one unit of output. From the discussion above, it is apparent that both the output and energy consumption of the material production sectors of China and Shanxi Province grew at a very brisk rate, with the output in China growing by 182 percent, and in Shanxi Province by 174 percent. At the same time, total energy consumption in the material production sectors grew at the rate of 71 and 63 percent in China and Shanxi Province respectively (Tables 3.A.1-3.A.3). It is then already obvious that the energy intensity of the material production sector as a whole decreased significantly, given the fact that the growth in output far outpaced the growth in energy consumption. However, it is important to emphasize that the decrease in energy intensity differed significantly among the sectors, and between the same sectors in China and Shanxi Province.

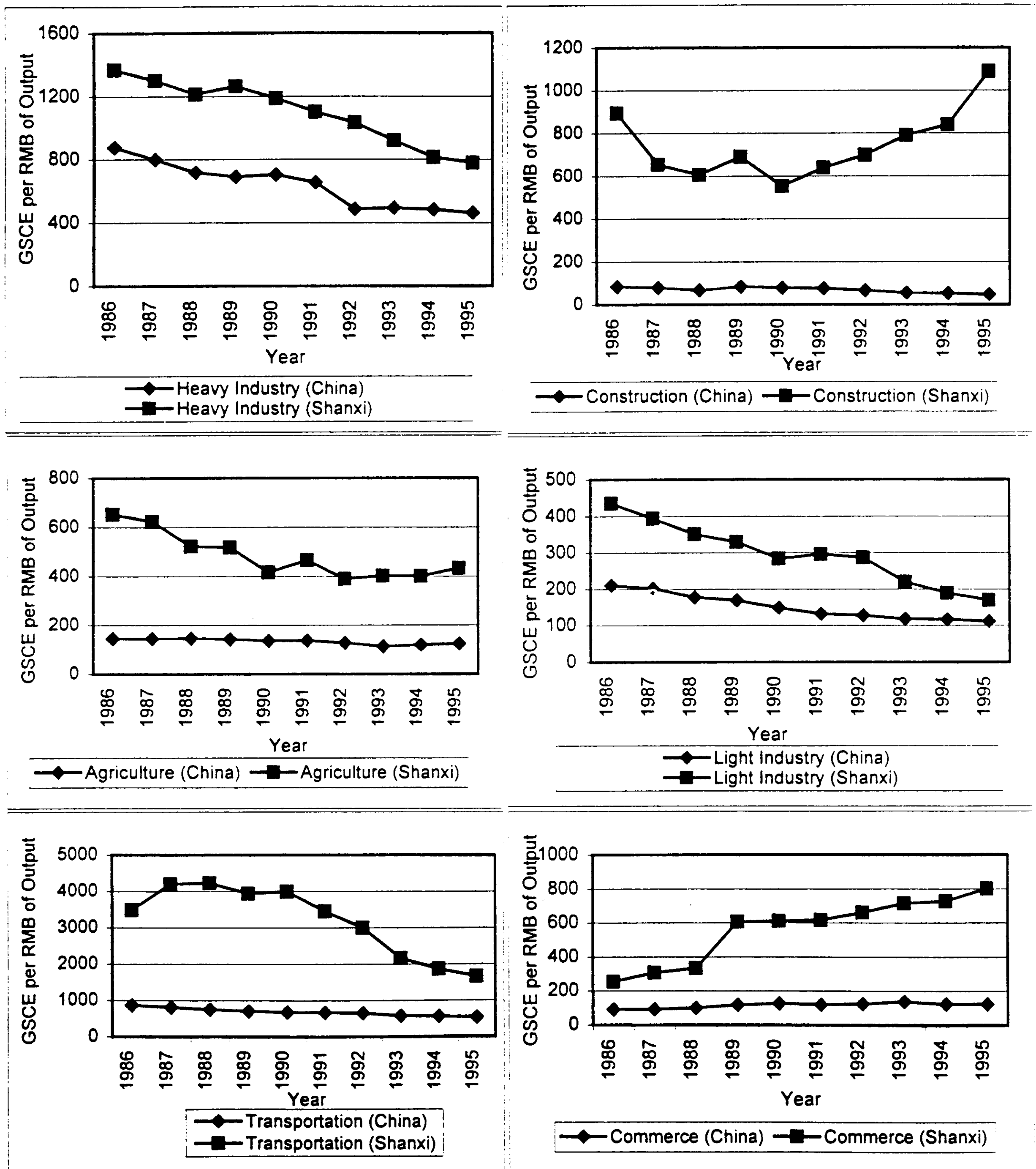
Figure 4.1 shows the decrease in energy intensity among the six sectors and between the two regions. There are four trends that stand out from these charts. First, there was a steady decline in energy intensity in all six sectors during this ten-year span, however, the rate of decline differed markedly among the sectors. The light and heavy industry sectors showed marked improvements, while the remaining sectors showed a more moderate rate of decline. At the same time, the light and heavy industrial sectors began this period with much higher energy-intensity levels than the remaining four sectors, and, as a result, they had a great deal more room for improving their energy intensities.

The second trend that is apparent is the marked difference of the energy-intensity levels in the transportation sector between Shanxi Province and China. Although transportation follows a similar path, in terms of its level of energy intensity and its rate of decline, as the commerce, construction, and agricultural sectors in China, the same does not hold true for Shanxi Province. In fact, the transportation sector is by far the most energy-intensive sector in Shanxi Province, but just as in light and heavy industries in China, it shows the most marked decline in energy intensity.

Another important point about the energy-intensity levels in both China and Shanxi Province is that unlike the other five sectors, the commerce sector showed an increase in energy intensity during this ten-year span. There is an additional difference between the two, with Shanxi Province showing a much larger increase in energy intensity in this sector than in China as a whole.

FIGURE 4.1

ENERGY INTENSITY FOR CHINA AND SHANXI PROVINCE'S MATERIAL-PRODUCTION SECTORS, 1986-1995 (GSCE PER 1980 RMB OF OUTPUT)



Source: The Gross Domestic Product of China, 1952-1995, pp. 192-199; China Provincial Statistics, 1949-1989 pp. 66-67; China Energy Statistical Yearbook, 1991, pp. 205-206; China Energy Annual Review, 1996, and 1994, p. 131; China Statistical Yearbook, 1997, p. 216; Shanxi Province Statistical Yearbook, 199
RMB: Renminbi, the Chinese currency=0.125 U.S. Dollar; **GSCE:** Grams of Standard Coal Equivalent.

Finally, and perhaps most important, is the marked quantitative differences in energy-intensity levels between China and Shanxi Province. A quick glance at the six charts reveals this profound difference. The most energy-intensive industry in China, heavy industry, consumed about 900 Grams of Coal Equivalent (GCE) per 1980 Renminbi (RMB) of output. By comparison, heavy industry in Shanxi Province consumed about 1400 GCE per 1980 RMB, and Shanxi Province's most energy-intensive sector, the transportation sector consumed over 3500 GCE per 1980 RMB. That figure is almost 4 times as much as the transportation sector in China as a whole in that year. Although the difference among the other sectors is not as dramatic, there is nonetheless a significant difference between all the points between the two charts. The primary purpose of this study is precisely to understand the factors behind these differences, both temporally and spatially, using SSA, and a very detailed spatial analysis using SSDA.

SHIFT-SHARE ANALYSIS: METHODOLOGY

The SSA equations I have used to conduct my analysis are taken from Polenske and Lin (1993). I have conducted my analysis for the years 1986-1995, for Shanxi Province and China. The equation I have used for this analysis is the following:

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

Where e_t is the energy intensity for the material-production sector as a whole in a given year t; O_t = gross material product in year t; $O_{i,t}$ = output of industry i in year t; e_o = energy intensity (amount of energy consumed per unit of output) of the material production sector as a whole in the base year; $e_{i,o}$ = energy intensity for industry i in the base year; and $e_{i,t}$ = energy intensity for industry i in year t.

As I stated in Chapter 2, in this equation, the first term is the constant-share component, which indicates the energy consumption that would have occurred if the energy intensity had remained at the same level as in the initial year. The second term, the industrial-mix component, shows the effect of changes in the industrial structure on energy use. The third term, efficiency changes, measures the change in energy efficiency between a given year and the initial year. This equation shows that the combined effect of the industrial-mix effect and energy-efficiency effect determines the relative level of energy intensity in a given year.

However, before discussing the results of my findings, it is important to justify my methodology. I have already discussed the shortcomings the shift-share analysis, but it is also necessary to consider the type of data I have chosen for my analysis. Most analysts use Gross Domestic Product (GDP) to calculate energy intensity. In this paper I have chosen gross output to calculate energy intensity. Both methods have their own set of shortcomings. There are two reasons for choosing GDP. The first is the fact that GDP statistics are more readily available and reliable than gross output values. In addition, because most analysts already use GDP values, there are better opportunities for comparison across studies. Furthermore, some analysts criticize gross output values because of what they consider double-counting, in the sense that it counts both inputs and outputs. This is not a major issue, considering that I am comparing energy intensity across time and regions, using the same criteria.

On the other hand, there are at least two shortcomings for using GDP values over gross output values in conducting energy intensity analysis using shift-share. The first is that GDP measures only the total sales to final demand consumers. As such it does not take into account the temporal variations in sales among industries. This is especially important in the case of material-production sectors because there are so many transactions among industries that are ignored when using GDP. As such, using gross output allows the intra-industry transactions to be accounted. The second reason for using gross output value in this case is that it takes into account intermediate energy consumption that does not appear in final demand, or GDP. I have included Table 4.2 to show a *sample* of differences in energy-intensity results between using GDP and output for the years 1986 to 1992.

TABLE 4.1

ENERGY-INTENSITY INDICATORS, 1986-1992, CHINA

Year	Energy Use per/GDP (tce/1000 RMB in 1980 Constant Prices)	Decline (percent)	Energy Use/Output Value(tce/1000 RMB in 1980 Constant Prices)	Decline (percent)
1986	0.584	NA	1.022	NA
1987	0.564	3.4	0.987	3.4
1988	0.544	3.5	0.952	3.5
1989	0.544	0.0	0.951	0.1
1990	0.532	2.2	0.930	2.2
1991	0.521	2.1	0.911	2.0
1992	0.485	6.9	0.845	7.2
Average	**0.539**	**NA**	**0.943**	**NA**

Source: Junfeng, Li, Todd M. Johnson, Zhou Changyi, Robert P. Taylor, Liu Zhiping, and Jiang Zhongxiao. 1995. *China: Energy Demand in China, Issues and Options in Greenhouse Gas Emissions Control.* Subreport Number 2, p. 7.
tce: Tons of coal equivalent; **RMB:** Renminbi, the Chinese currency, which is about 0.125 U.S. Dollar. **GDP:** Gross Domestic Product.

From the sample of years presented in Table 4.2, two important differences become apparent between using GDP or total output. The first and most important is the magnitude of difference in energy-intensity levels between using energy consumption per GDP and energy consumption per unit of output. In fact, on average the latter is 75 percent greater than the former, which is a significant difference. This difference represents the amount of energy that is consumed in intra-industry transactions that consume energy, and it is obvious that it contributes a great deal to the overall energy-intensity levels of the material-production sectors in China for these years. This is an important segment of the overall energy-intensity levels that would otherwise be ignored when measuring energy intensity per unit of GDP. The second difference between the two sets of values has to do with the decline in energy intensity levels from one year to the next. Although for this short span of time under analysis, the difference among the two columns is small, the sheer fact that there are differences in the magnitude of change is of significance. What these small changes imply is that intra-industry changes in energy efficiency or structural change can and do play a role in the overall energy-intensity levels in the economy. In the next chapter, I will decompose these changes for the 33 sectors of the economy for both Shanxi Province and China using SSDA for 1992.

SHIFT-SHARE ANALYSIS: RESULTS

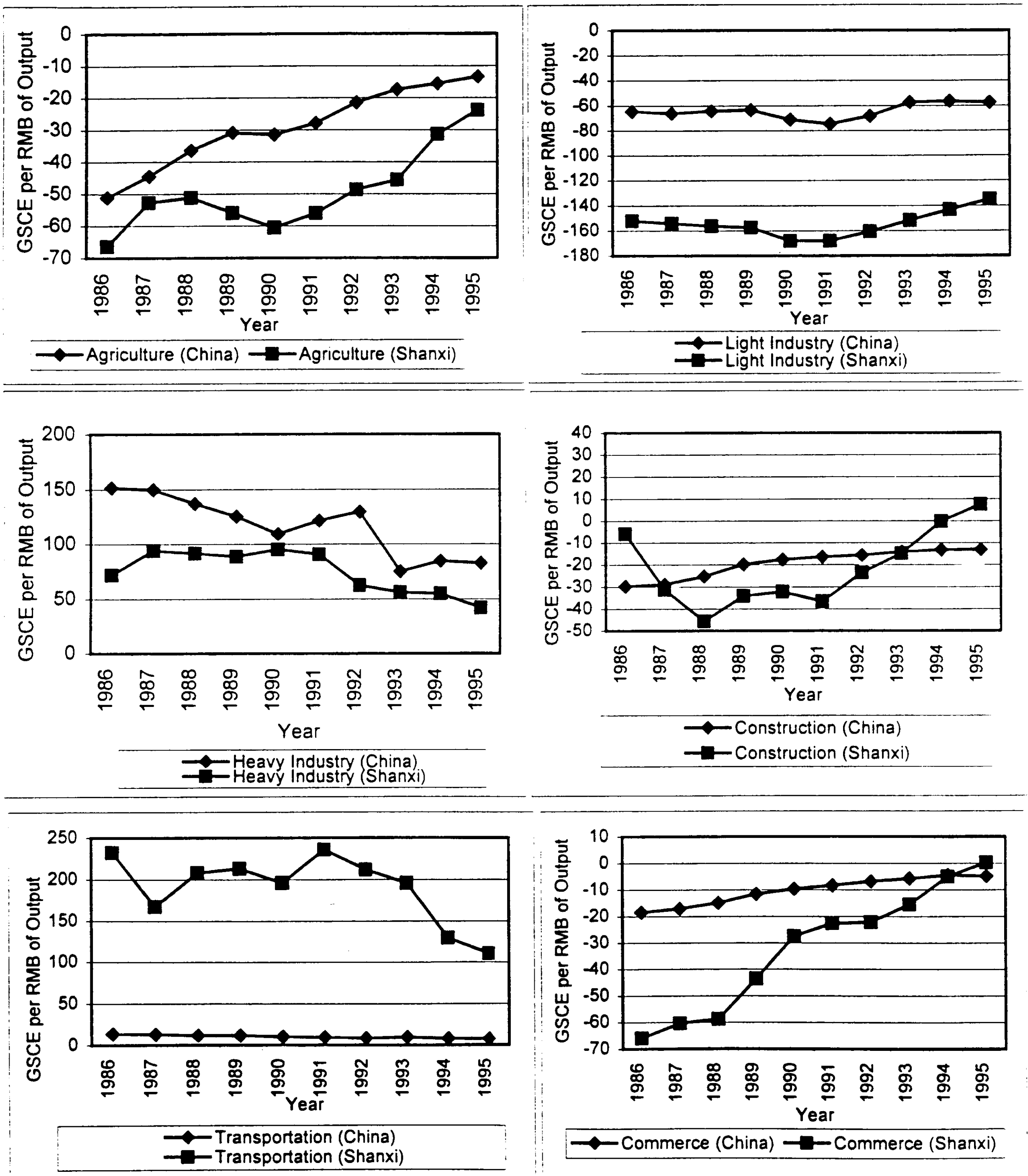
Figures 4.2-4.7 show the results of SSA for China and Shanxi Province and the comparative analysis of the industrial mix and efficiency share between China and Shanxi Province. The tables from which these charts were created are included in Appendix 4.B. The reason I have not included those charts in the body of this text is due to the fact that the trends they show are identical to the ones for energy-intensity charts presented below, due to the fact that the denominator for all the equations is the same, and that is output by sector. The only difference between the two sets of charts is that the ones in Appendix 4.B show the total reduction in energy consumption in million tons of coal equivalent (Mtce) that can be attributed to either energy efficiency or changes in industrial mix.

There are four trends that stand out. First, improvements in energy efficiency contributed to this reduction for every year that I have analyzed for China, and nine of ten years in Shanxi Province (Figure 4.8). Overall, my analysis shows that during this ten-year period, improvement in energy efficiency was the *sole* contributor to the overall reduction in energy intensities in the material production sector of China and the dominant factor in Shanxi Province. However, one has to be cautious in interpreting the results of this analysis. The fact remains that had the Chinese or Shanxi Province's economy followed the path defined by the "constant-share" factor, total energy consumption would have been greater, even without any improvements in energy efficiency. What this implies is that, changes in industrial mix contributed to reductions in overall energy consumption under "constant-share" circumstances, but not under the circumstances that actually occurred (Appendix 4.B).

The second trend is the substantial difference in the degree of contribution from each factor from one year to the next between Shanxi Province and China. It is apparent that in Shanxi Province, the Industrial Mix (IM) and Efficiency Shift (ES) factors experience far greater degrees of gyration from one year to the next. This is perfectly plausible given the size differential in the material-production sectors between China and Shanxi Province. As a result, any change in efficiency shifts or industrial structure has a much more profound effect on the energy-intensity levels in Shanxi Province than in China (Figures 4.7, 4.8).

FIGURE 4.2

THE ROLE OF INDUSTRIAL-MIX IN SHIFT-SHARE ANALYSIS OF ENERGY INTENSITY IN MATERIAL-PRODUCTION SECTORS, CHINA AND SHANXI PROVINCE, 1986-1995 (GSCE PER 1980 RMB)

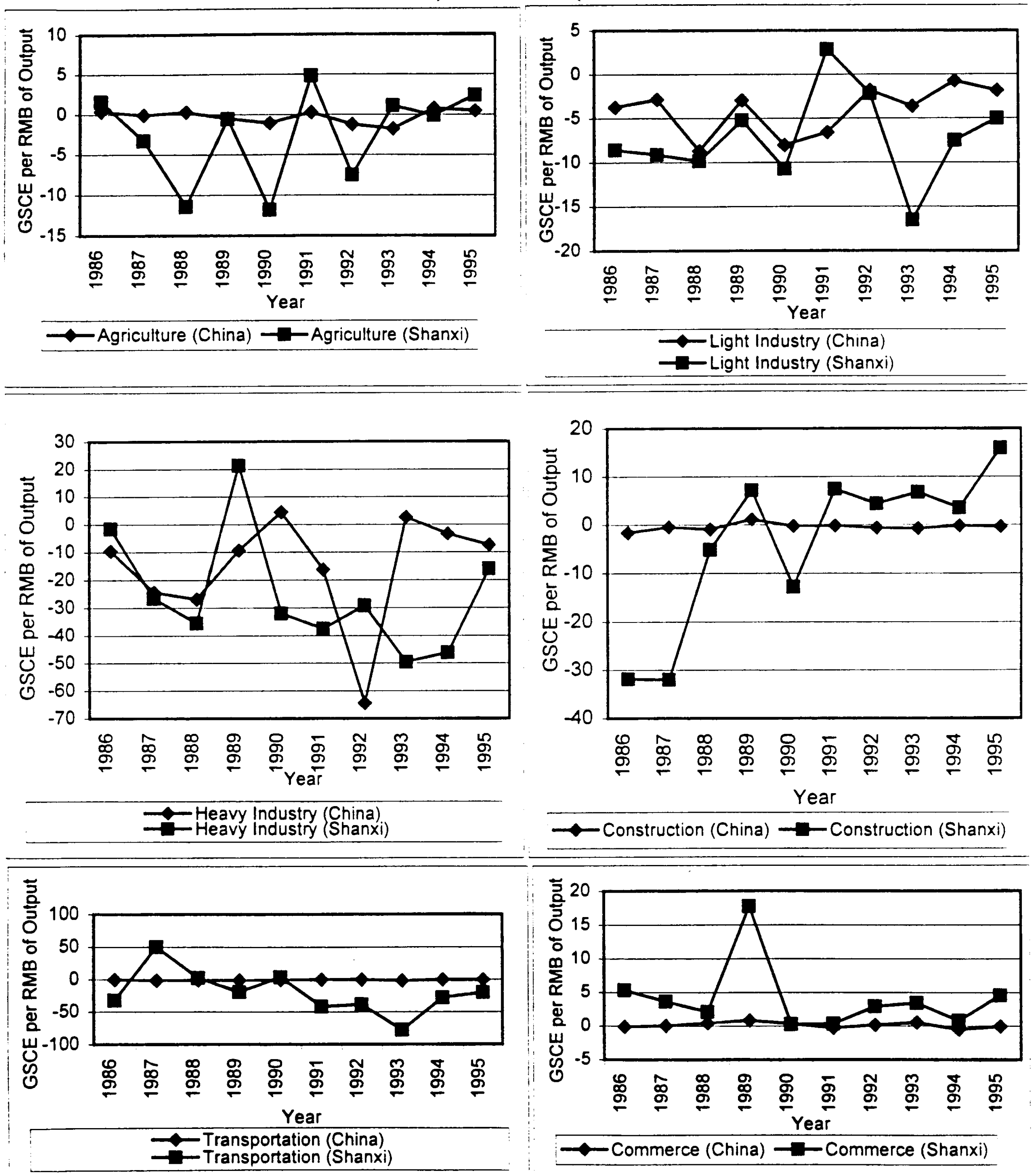


Source: Tables 4.3-4.6;

RMB: Renminbi, the Chinese currency=0.125 U.S. Dollar; **GSCE:** Grams of Standard Coal Equivalent.

FIGURE 4.3

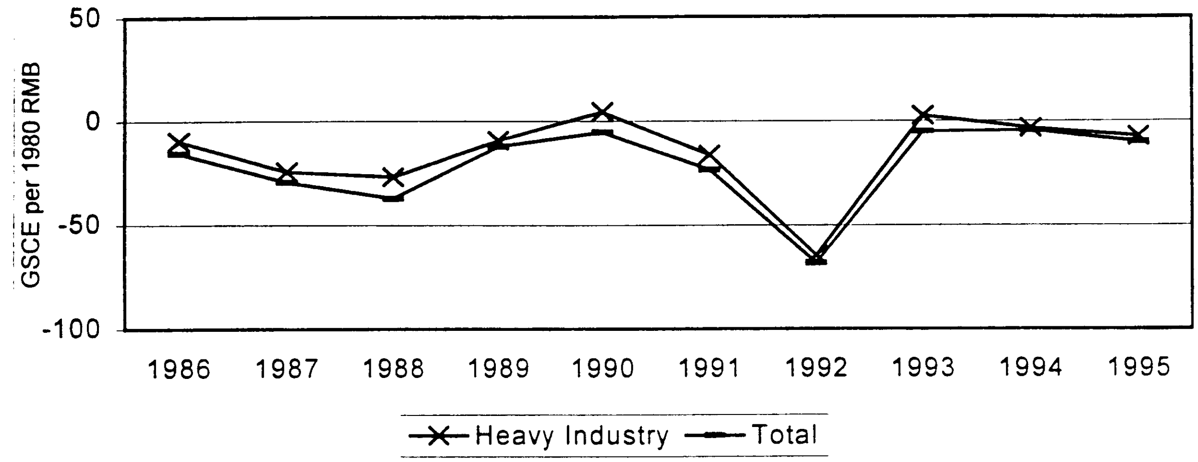
THE ROLE OF EFFICIENCY-SHIFT IN SHIFT-SHARE ANALYSIS OF ENERGY INTENSITY IN MATERIAL-PRODUCTION SECTORS, CHINA AND SHANXI PROVINCE, 1986-1995 (GSCE PER 1980 RMB)



Source: Tables 4.3-4.6;

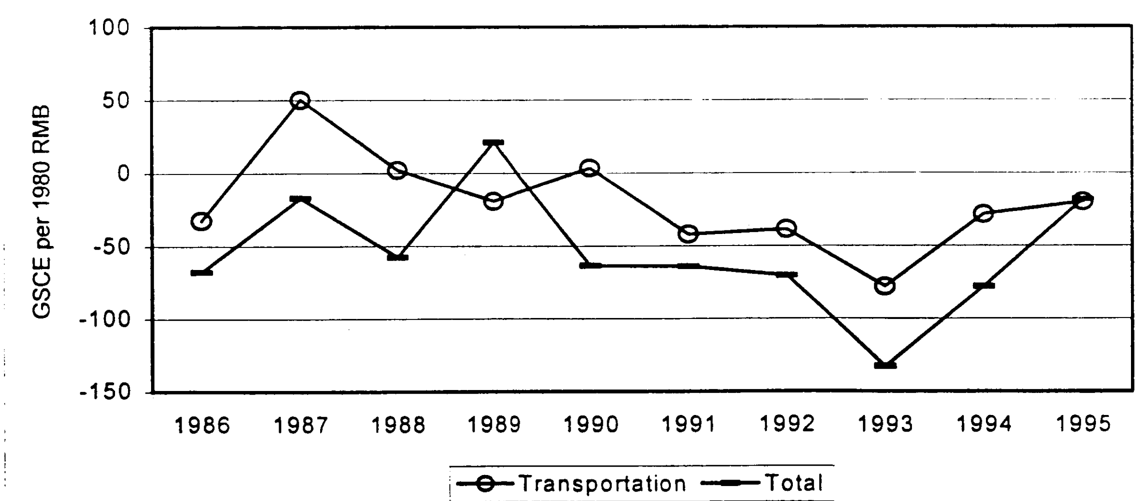
RMB: Renminbi, the Chinese currency=0.125 U.S. Dollar; **GSCE:** Grams of Standard Coal Equivalent.

FIGURE 4.4
THE ROLE OF EFFICIENCY-SHIFT IN SHIFT-SHARE ANALYSIS OF ENERGY INTENSITY OF HEAVY-INDUSTRY SECTOR, CHINA, 1986-1995 (GRAMS OF STANDARD COAL EQUIVALENT PER CONSTANT 1980 RMB)



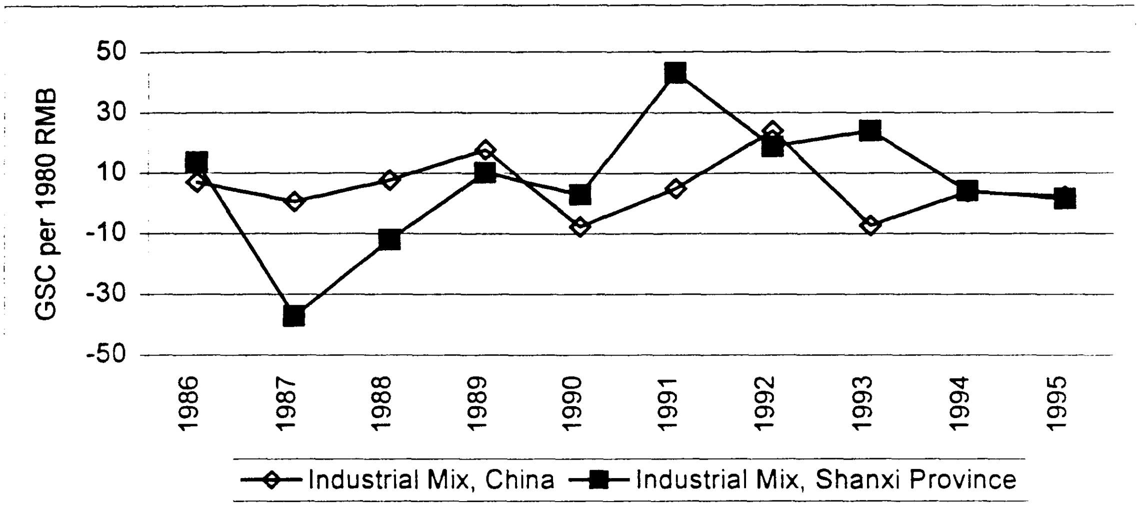
Source: Tables 4.3, 4.5;
RMB: Renminbi, the Chinese currency, which is the equivalent of 0.125 U.S. Dollar; **GSCE:** Grams of Standard Coal Equivalent

FIGURE 4.5
THE ROLE OF EFFICIENCY-SHIFT IN SHIFT-SHARE ANALYSIS OF ENERGY INTENSITY IN TRANSPORTATION SECTOR, SHANXI PROVINCE, 1986-1995 (GSCE PER CONSTANT 1980 RMB)



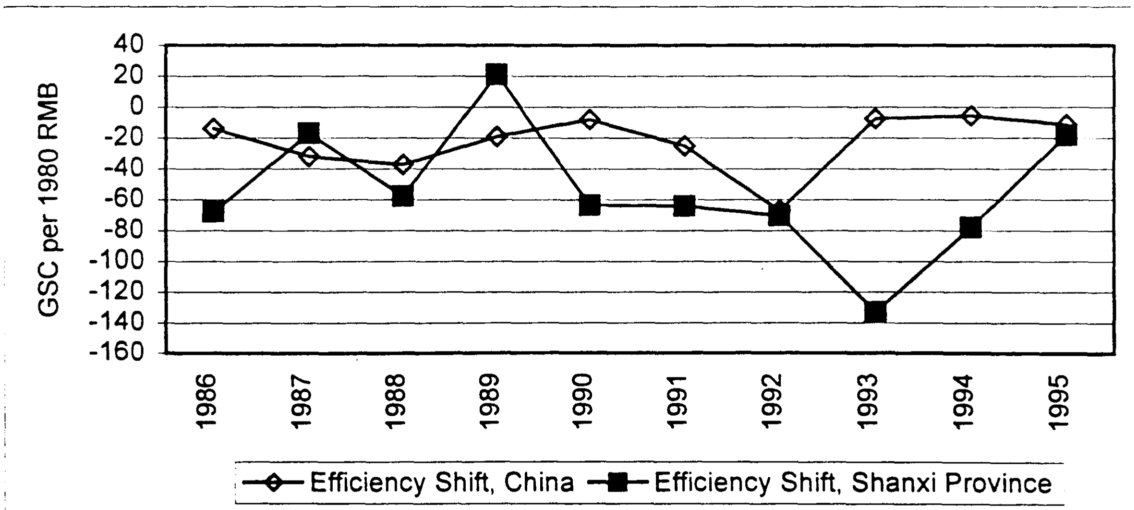
Source: Tables 4.4, 4.6;
RMB: Renminbi, the Chinese currency, which is the equivalent of 0.125 U.S. Dollar; **GSCE:** Grams of Standard Coal.

FIGURE 4.6
COMPARATIVE ANALYSIS OF THE INDUSTRIAL-MIX FACTOR IN ENERGY INTENSITY, CHINA AND SHANXI PROVINCE, 1986-1995
(GRAMS OF STANDARD COAL EQUIVALENT PER CONSTANT 1980 RMB)



Source: Table 4.4, 4.6; **RMB:** Renminbi, the Chinese currency, which is the equivalent of 0.125 U.S. Dollar; **GSC:** Grams of Standard Coal.

FIGURE 4.7
COMPA~ATIVE ANALYSIS OF THE EFFICIENCY-SHARE FACTOR IN ENERGY INTENSITY, CHINA AND SHANXI PROVINCE, 1986-1995
(GRAMS OF STANDARD COAL EQUIVALENT PER CONSTANT 1980 RMB)



Source: Table 4.4, 4.6; **RMB:** Renminbi, the Chinese currency, which is the equivalent of 0.125 U.S. Dollar; **GSC:** Grams of Standard Coal.

The third observation involves the differences in the IM and ES trends between China and Shanxi Province as captured in Figures 4.6 and 4.7. What is obvious from the figures is the fact that although Shanxi Province is influenced by the national trends in China as a whole, it is, nonetheless, influenced greatly by localized factors. What this implies is that provincial differences, which I discussed in Chapter 3, translate into profound differences at the microeconomics level, indicating that provincial economic policies are just as important in determining the outcome of the structure and energy-efficiency of the material production sectors as the national-level policies set by the Chinese government.

The last and most important trend is the role of different sectors in influencing the overall changes in the industrial mix and efficiency shifts in both Shanxi Province and China. I have already discussed earlier the important roles of the heavy industry and transportation sectors in China and Shanxi Province, respectively, in the reduction of energy-intensity levels. This phenomenon is captured very well in figures 4.4 and 4.6. In China, the total shift in energy efficiency is influenced mostly by the changes in the shift in energy efficiency in the heavy industry sector. In other words, improvements in energy efficiency in heavy industry has played a key role in the overall reduction in energy intensity in China as a whole (Figure 4.4). The same cannot be said for Shanxi Province. In Shanxi Province, the key sector in influencing the shifts in energy-efficiency was the transportation sector, which is corroborated by my analysis, discussed earlier, of the energy-intensity levels in Shanxi Province (Figure 4.6). However, it is important to emphasize that heavy industry also played an important role in the energy-efficiency shifts in Shanxi Province, though certainly not as large of a role as transportation or heavy industry in China.

Two factors seem to be primarily responsible for the energy efficiency improvements. The first is that the increase in energy efficiency is a response to the market mechanisms that have occurred in China that have resulted in energy price increases. For years, energy had been underpriced in China and even more so in Shanxi Province to promote industrial development. Furthermore, energy prices were not changed to adjust for inflation and increasing production costs. As such, the low prices of energy encouraged energy over-consumption and did not provide an incentive for energy efficiency improvements (Junfeng, Li, Todd M. Johnson, Zhou Changyi, Robert P. Taylor, Liu Zhiping, and Jiang Zhongxiao, 1995). The second reason is the result of energy-conservation policies. In China, since 1979, there has been a major shift in energy policy from conventional complete devotion to increasing supply and production to the priority given to conservation efforts (Polenske and Lin 1993). I will discuss policy options for both the Chinese and Shanxi Province policy-makers in Chapter 6 of this paper.

CONCLUSION

In this chapter, I examined the relative importance of the changes in the industrial mix and improvements in energy efficiency in energy-intensity reductions in China and Shanxi Province for the 1986-1995 period. The results of the shift-share analysis points to the fact that the primary factor behind the reduction in energy intensity were due to improvements in energy efficiency. However, there were significant differences between the degree of contribution from each of the underlying factors from year to year and between Shanxi Province and China. In the next chapter, I will look at energy-intensity changes in 33 economic sectors of Shanxi Province and China for 1992, in order to develop my findings from the analysis in this chapter further.

CHAPTER 5

STRUCTURAL DECOMPOSITION ANALYSIS OF THE ENERGY DISPARITIES BETWEEN CHINA AND SHANXI PROVINCE

In Chapter 4, I showed that there are significant differences in structural and efficiency considerations in the five economic sectors between Shanxi Province and China. In this chapter, I will use Spatial Structural Decomposition Analysis (SSDA) to further uncover the underlying factors behind the differences in energy consumption levels in 28 non-energy and 5 energy sectors. Appendix 5.A shows the energy and non-energy sectors under analysis, along with the definitions associated with the design of the input-output tables. In evaluating the results of the following SSDA, there are two points to keep in mind. First, the 33 sectors I have chosen come directly from the 33-sector input-output table of China and Shanxi Province. As such, I did not manipulate the sectors in order to fit a pre-defined notion of the sectors that would perhaps be more appropriate for this analysis. Second, all the values in the 33-sector input-output tables are in monetary units. As such, I have deviated from previous SDA energy analysis, in that I have not converted any of the monetary values into physical units. The primary reason behind this decision is the fact that I am conducting a spatial SDA, which means that I do not need to take into account inflationary or deflationary measures; all the values are in current 1992 Renminbi, which is equivalent to 0.125 U.S. Dollar.

As I stated in Chapter 2, using the energy input-output model, we can identify two parts of energy consumption: intermediate and direct. Intermediate energy consumption is the energy used by production sectors as an input to output, that is energy used in production activities. Direct energy consumption is the energy used or sold directly to final users, such as peasant or non-peasant households. In this chapter, I will present the results of my analysis for the energy consumption by the direct and indirect consumers, and show the differences in the amount of energy consumed per unit of output in both sectors for China and Shanxi Province.

For this chapter, I assume production technology to be that of China as a whole, and perform a set of computations to determine how final-demand shifts from China to Shanxi Province affect energy consumption in Shanxi Province's economy. I will calculate the impact of final-demand shifts from three different dimensions: (1) the final demand distribution (across final users), and pattern (that is spending patterns of final users); (2) the sources of final demand, such as peasant, non-peasant and institutional consumption; and (3) the types of final goods and services purchased. Although the three dimensions intercept one another, combined they provide a unique insight into the differences in final demand and energy consumption between Shanxi Province and China in 1992.

DISTRIBUTION AND PATTERN OF FINAL DEMAND

When conducting SSDA, we can split the final-demand shifts along three dimensions: distribution, pattern, and level of final demand. First, the distribution of final demand may change, that is different sectors of final demand may grow at different rates, therefore altering their relative importance as buyers of final goods and their share of total final demand. This is important for our analysis, because different demand sectors purchase a different mix of goods and services, which require different amounts of energy to produce. As such a change in the distribution of final demand can have profound effects on the amount of energy consumption. Tables 5.1, and 5.2 show the energy requirements of final-demand sectors for Shanxi Province and China, and their difference, that is Shanxi Province minus China, respectively.

TABLE 5.1
ENERGY REQUIREMENTS OF FINAL DEMAND SECTORS, CHINA AND SHANXI PROVINCE, 1992 (RMB OF ENERGY-USE PER RMB OF FINAL DEMAND)

	Coal		Coke and CG		CP and NG		RP		Electricity	
Sector	Shanxi	China	Shanxi	China	Shanxi	China	Shanxi	China	Shanxi	China
Peasant Consumption	0.0238	0.0091	0.0008	0.0024	0.0000	0.0000	0.0016	0.0009	0.0037	0.0078
NP Consumption	0.0109	0.0019	0.0046	0.0059	0.0000	0.0001	0.0024	0.0013	0.0065	0.0097
Inst.Consumption	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000	0.0008	0.0000	0.0014	0.0000
GFCF	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Changes in Stock	0.0068	0.0231	0.1069	0.0078	-0.0004	0.0207	0.0296	-0.0072	0.0000	0.0000

Source: SSDA calculations from 1992 China and Shanxi Province Input-output Tables.
RMB: Renminbi, the Chinese currency which is the equivalent of 0.125 U.S. Dollar. **NG:** Natural gas; **CG:** Coal Gas; **RP:** Refined Petroleum; **CP:** Crude Petroleum; **GFCF:** Gross Fixed Capital Formation; **Inst.:** Institutional.

TABLE 5.2
DIFFERENCES IN ENERGY REQUIREMENTS OF FINAL DEMAND SECTORS, CHINA AND SHANXI PROVINCE (1992) (RMB OF ENERGY-USE PER RMB OF FINAL DEMAND)

Sector	Coal	Coke and Coal Gas	Crude Petroleum and Natural Gas	Refined Petroleum	Electricity
Peasant Consumption	0.0147	-0.0017	0.0000	0.0007	-0.0041
Non-Peasant Consumption	0.0090	-0.0014	-0.0001	0.0012	-0.0032
Institutional Consumption	0.0000	0.0003	0.0000	0.0008	0.0014
Gross Fixed Capital Formation	0.0000	0.0000	0.0000	0.0000	0.0000
Changes in Stock	-0.0163	0.0991	-0.0212	0.0368	0.0000

Source: SSDA calculations from 1992 China and Shanxi Province Input-output Tables.
RMB: Renminbi, the Chinese currency which is the equivalent of 0.125 U.S. Dollar.

TABLE 5.3
DIFFERENCES IN FINAL-DEMAND DISTRIBUTION BETWEEN SHANXI PROVINCE AND CHINA, 1992

Demand Sector	Share in Shanxi Province (percent)	Share in China (percent)	Share Difference (percent)
Peasant Consumption	22.6	24.8	-2.3
Non-Peasant Consumption	22.1	22.2	-0.2
Institutional Consumption	14.3	15.6	-1.3
Gross Fixed Capital Formation	32.6	31.4	1.2
Changes in Stocks	11.1	5.0	6.1

Source: SSDA calculations from 1992 China and Shanxi Province Input-output Tables.

As is apparent from Table 5.2, Shanxi Province relies on coal more heavily than China for peasant and non-peasant consumption and less on electricity. Another significant difference is the changes in stocks between Shanxi Province and China. The Chinese government defines changes in stocks as being equal to the value of stocks required, minus the value of stocks disposed of in 1992 (1992 Input-Output Table of China). There is a significant difference between the two regions in this final-demand category, particularly in coke and coal gas. This makes sense considering that Shanxi Province is the largest coke producer in China, the majority of which is exported to other regions in China, and overseas.

Furthermore, Table 5.2 shows that there is a slight difference in the share of each demand-sector as a percentage of final demand between Shanxi Province and China. What Table 5.2 shows is that, in general, as a percentage of final demand in 1992, the consumption aspect of final demand (peasant, non-peasant and institutional consumption) was greater in China, while gross capital formation (gross fixed capital formation and changes in stocks) was greater in Shanxi Province. The largest difference was in the changes in stocks, which was over 6 percent greater in Shanxi Province than in China. This difference is a technical one, primarily because I have not taken the levels of imports and exports into consideration when discussing final demand changes. As I stated earlier, the reason I have not chosen to include imports and exports in my calculations, is due to the difficulties of differentiating between intra-China trade, and trade with foreign countries in the Shanxi Province input-output table.

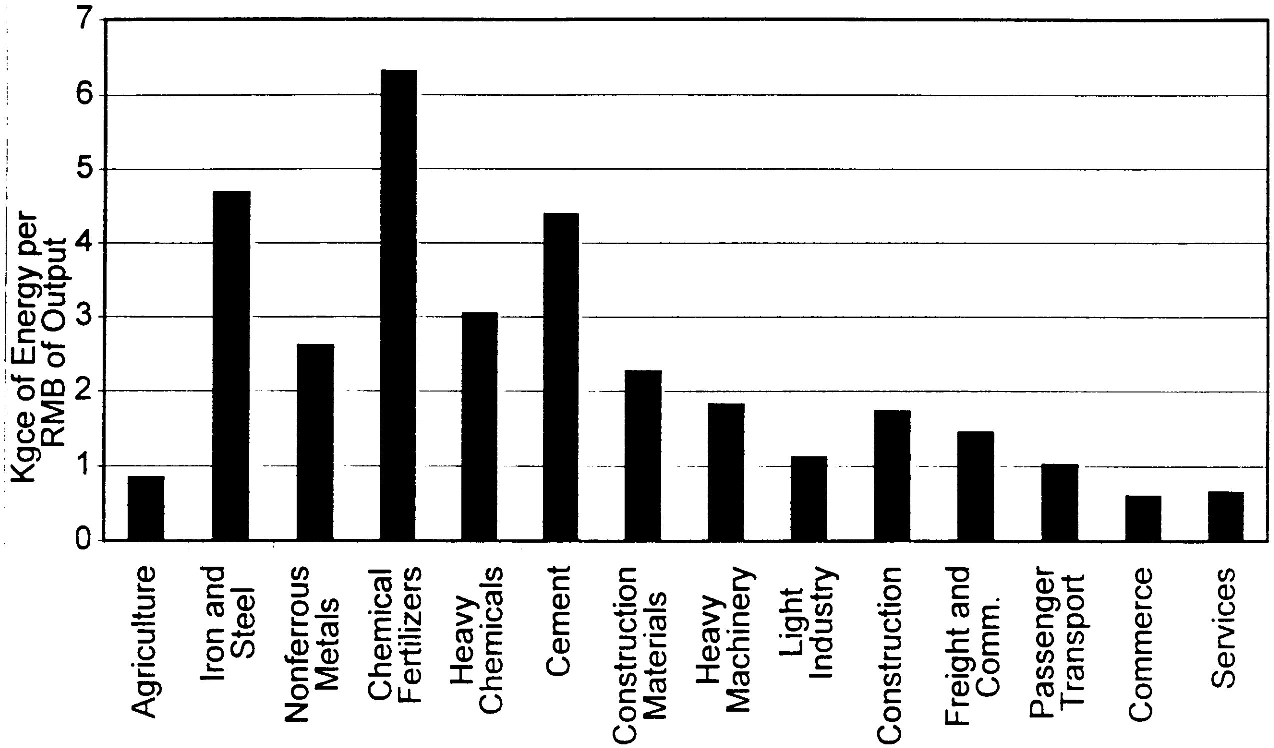
In addition to the distribution of final demand, the pattern of final demand, that is, the mix of goods and services within an individual demand sector, may be different between Shanxi Province and China. This is mainly due to large differences in product energy intensities, and, as such, changes in the mix of goods and services purchased by final customers can have an important impact on the energy consumption of an economy. Energy consumption, for instance, will increase if there is a shift in the spending pattern from less energy-intensive commodities, such as commerce and services, to more energy-intensive ones, such chemical fertilizers and cement. As a point of reference, Figure 5.1 shows the primary energy intensity of nonenergy products in China, in 1981. This figure is meant only as an illustration of the differences in *physical* units of energy to produce one unit of output in each of the product categories. Figure 5.1 shows that in China in 1981, heavy-industry products, such as iron and steel, cement, and chemical fertilizers, had the highest energy intensities. Many of these sectors used energy as a feedstock, as well as a source of heat or power. The service and commerce sectors, on the other hand had the lowest energy intensities.

For my analysis, I have used a monetary ratio of RMB of energy-use per RMB of final output, and the results of the differences between Shanxi Province and China is shown in Table 5.4.[1] A positive number indicates that energy intensity in China are larger than in Shanxi Province, while a negative number indicates the opposite. In addition, Table 5.4 shows that the mix of goods and services is different in our final-demand sectors, peasant, non-peasant and institutional consumption along with gross fixed capital formation and changes in stocks, between Shanxi Province and China.[2]

[1] See Appendix 5.C for the actual energy requirements of individual-demand sectors in China and Shanxi Province, from which Table 5.2 was derived.

[2] The product and service sectors in this table are an aggregation of the relevant sectors of the 33-sector input-output table.

FIGURE 5.1
PRIMARY ENERGY INTENSITY OF NONENERGY PRODUCTS CHINA, 1981 (KGCE OF INPUT PER RMB OF FINAL OUTPUT)



Source: Lin, Xinnuan. 1996. *China's Energy Strategy: Economic Structure, Technological Choices, and Energy Consumption*, p. 68.
Kgce: Kilograms of Coal equivalent; **Freight and Comm.:** Freight, Transportation and Communication; **RMB:** Renminbi, the Chinese currency which is the equivalent of 0.125 U.S. Dollar.

TABLE 5.4

DIFFERENCES IN THE SPENDING MIX OF SELECTED FINAL-DEMAND SECTORS BETWEEN SHANXI PROVINCE AND CHINA, 1992

	Energy (percent)	Agriculture (percent)	Industry (percent)	Transport (percent)	Construction (percent)	Services (percent)
Peasant Consumption	-8.2	-2.7	-4.2	0.0	0.1	15.0
Non-Peasant Consumption	-11.3	-4.2	7.3	0.0	0.2	7.9
Institutional Consumption	1.00	-1.9	-0.30	0.0	-0.0	1.2
Gross Fixed Capital Formation	9.0	2.6	10.4	-26.5	3.0	1.5
Changes in Stocks	-0.50	7.3	-0.80	0.0	3.5	-9.6
Total	-10.0	1.2	12.4	-26.5	6.8	16.1

Source: SSDA calculations from 1992 China and Shanxi Province input-output tables.
(See Appendix 5.A. for the explanation on the sectors that were included in each of above classifications.)

TABLE 5.5

DIFFERENCES IN ENERGY REQUIREMENTS FOR ALL SECTORS SHANXI PROVINCE MINUS CHINA (RMB OF ENERGY USE PER RMB OF FINAL OUTPUT)

Energy Sector	Coal	Coke and Coal Gas	Crude Petroleum and NG	Refined Petroleum	Electricity
Coal	-0.0137	0.0010	0.0001	-0.0034	-0.0160
Crude Petroleum and NG	0.0884	0.0000	-0.0161	0.0149	0.0407
Electricity	0.2370	-0.0001	-0.0377	-0.0309	-0.0114
Refined Petroleum	0.0284	0.0006	-0.5212	0.2795	0.0686
Coke and Coal Gas	-0.0074	0.0070	-0.0392	-0.0122	-0.0180
Nonenergy Sectors					
Agriculture	0.0064	0.0020	0.0000	-0.0017	0.0114
Metal Ore Mining	0.0017	0.0005	-0.0001	0.0333	0.0014
Other Mining	0.0119	0.0037	-0.0002	0.0562	0.0171
Food Manufacturing	0.0141	-0.0003	0.0000	-0.0002	0.0040
Textiles	0.0138	0.0001	0.0000	0.0028	0.0158
Apparel Products	0.0057	-0.0002	0.0000	0.0006	0.0047
Sawmills & Furniture	0.0605	0.0003	0.0000	0.0012	0.0057
Paper & Educational Articles	0.0356	-0.0002	0.0001	0.0029	0.0145
Chemical Industries	0.0279	0.0188	-0.0153	-0.0006	0.0165
Building Materials	0.0791	0.0204	-0.0033	-0.0052	0.0134
Primary Metal	0.0309	0.0390	-0.0055	0.0092	0.0007
Metal Products	0.0149	0.0075	-0.0003	0.0108	0.0077
Machinery	0.0285	0.0022	-0.0005	0.0039	0.0099
Transport Equipment	0.0179	0.0018	-0.0003	0.0031	0.0205
Electric Machinery	0.0064	0.0034	-0.0002	0.0050	0.0033
Electronic Equipment	0.0045	-0.0004	-0.0010	0.0002	-0.0010
Instruments and Meters	0.0157	-0.0004	-0.0013	0.0086	0.0149
Maintenance of Equipment	0.0252	-0.0014	-0.0014	0.0144	0.0053
Other Industries	0.0330	0.0187	-0.0026	0.0093	0.0280
Construction	0.0059	0.0002	0.0000	0.0135	0.0073
Freight Transport	0.0051	0.0000	-0.0025	0.0241	0.0017
Commerce	0.0164	0.0016	-0.0006	0.0094	0.0097
Restaurants	0.0215	-0.0020	-0.0029	-0.0029	0.0036
Passenger Transport	0.0071	0.0000	0.0000	-0.0334	0.0080
Public Utilities	0.0187	0.0144	-0.0011	-0.0003	-0.0048
Research Institutions	0.0170	0.0016	-0.0008	0.0109	0.0014
Finance and Insurance	0.0211	-0.0003	-0.0003	0.0146	-0.0037
Public Administration	0.0210	-0.0004	-0.0025	-0.0023	0.0169

Source: SSDA calculations from 1992 China and Shanxi Province Input-output Tables.
NG: Natural Gas; **RMB:** Renminbi, the Chinese currency which is the equivalent of 0.125 U.S. Dollar.

As is apparent from Table 5.5, Shanxi Province spends more on coal to produce one RMB of final output in every product category than China, except for coal-related products such as coal and coke. The largest difference in terms of coal consumption is 0.2 RMB of energy use per RMB of final output for electricity generation. In addition, the difference in refined petroleum, and crude petroleum and natural gas, are 0.03 and 0.09 more, respectively. However that is not the only energy sector where Shanxi Province does worse than China as a whole. In the nonenergy sectors, the largest differentials in the coal sector are in sawmills and furniture, building materials, and other industries. In terms of RMB of coal consumption per RMB of final output, the difference for the three sectors are 0.06, 0.08, and 0.03, respectively. In the electricity sector, the largest difference is the minus 0.0153 RMB of electricity per RMB of final output in the chemical industries and the plus 0.0169 RMB of electricity use per RMB of final output. The other significant sectors are the additional 0.04 and 0.02 RMB of coke consumption per RMB of final output in the primary metal and building materials sector, respectively. I will discuss these findings in greater depth later in this chapter and discuss its policy implications in Chapter 6.

Finally, the overall level of final demand is obviously different between Shanxi Province and China as a whole. Normally, when conducting SDA on a temporal level, this pattern would also be taken into consideration, which is the fact that final users may just buy more or less of everything and keep the mix of goods and services they purchase constant. However, this is not a relevant consideration in our case because we are comparing regions where there is a significant difference in the level of final demand. As such, when conducting spatial SDA, the level effect must be omitted from the final demand shifts.

Table 5.6 shows the energy effects of final-demand distribution and pattern changes between Shanxi Province and China. In this table, China is the base region, and Shanxi Province is the region under analysis. The table is presented in terms of percentages, that is, how much more does Shanxi Province consume above (or below) that of China, and what are the contributions each of distribution and pattern effects?

TABLE 5.6

PRIMARY ENERGY-USE DIFFERENCES BETWEEN SHANXI PROVINCE AND CHINA: FINAL-DEMAND SHIFT, DISTRIBUTION AND PATTERN CHANGES, 1992 (PERCENT DIFFERENCE WITH CHINA)

	Coal (percent)	Crude Petroleum & Natural Gas (percent)	Electricity (percent)	Refined Petroleum (percent)	Coke and Coal Gas (percent)	Total (percent)
Distribution Effect	-0.2	-0.1	0.0	0.2	0.6	0.5
Pattern Effect	5.1	-0.0	1.8	3.6	1.7	12.2
Total Effect	5.0	-0.2	1.8	3.9	2.3	12.8

Source: SSDA calculations from 1992 China and Shanxi Province Input-output Tables.

There are three factors that stand out from Table 5.5. First, and most important, is the fact that there is a difference in every final-demand category under consideration among all fuel types. The difference in total effects is greatest for coal, 5.0 percent, and negative for natural gas and crude petroleum at minus 0.1 percent. This is perfectly plausible given Shanxi Province's heavy reliance on coal. The second factor is the importance of the pattern effect in the overall final-demand-shift (total effect) between China and Shanxi Province. Over 90 percent of the final-demand shift can be explained by the fact that final consumers in Shanxi Province consume more of the products (segregated among the 33 sectors of the input-output table) that are more energy intensive than do the final users in China as a whole.

The third factor is the insignificant contribution of the distribution effect to the total effect. Altogether the distribution effect contributed only 0.5 percent to the energy consumption differences between Shanxi Province and China. This is essentially the result of the insignificant differences in the RMB of energy use per RMB of final demand (Table 5.1) between Shanxi Province and China.

In short, what Table 5.6 shows us is that in the absence of production-technology changes, which I will discuss next, final-demand differences between Shanxi Province and China were responsible for 12.8 percent of the differences in energy consumption in monetary values, Renminbi. In addition, almost all of this was due to the differences in the mix of goods and services within the individual demand sectors. Furthermore, because there are large differences in product energy intensities, these changes in the mix of goods and services purchased by final consumers did have an impact on the overall difference in energy consumption between Shanxi Province and China.

SOURCES OF FINAL DEMAND

The five final demand sectors that I have chosen for my analysis is a heterogeneous group, composed of peasant and non-peasant consumption, which combined comprise the total household consumption. Total institutional consumption is the final consumption of services by the society as a whole as well as the collective consumption of goods by enterprises and institutions. Gross fixed capital formation is the total value of the acquisitions, less disposals of new or existing tangible fixed assets. It includes capital repairs, renewal, and transformation of fixed assets as well as capital construction. Finally, changes in stocks are equal to the value of stocks required less the value of stocks disposed of during the accounting period (Input-Output Table of China, 1992). Total final demand is the sum of expenditures from all these sources along with imports and exports.

As I stated earlier, the distribution and pattern of final demand shifts are determined by how much each individual group of final consumers spends, and what goods and services they purchase. However, spending by different groups depends on widely different factors and may develop along divergent paths. For example, household consumption is closely related to disposable income, institutional consumption is constrained by government's (provincial and national) revenue and budget, and capital investment is affected by bank-lending policies. Given these differences, it is important to look at changes in spending from each demand source and quantify their individual impacts in the energy consumption of Shanxi Province and China.

As is apparent from Table 5.4, on the one hand, Shanxi Province's peasant households consumed fewer RMB in energy, industry and agriculture per RMB of final demand than their counterparts in China as a whole; on the other hand they spent slightly more on services and construction. There are two explanations for this. The first point to remember is that the units under discussion are in terms of RMB, and energy prices, in particular coal for which the majority of Shanxi Province households depend on extensively, is cheaper in Shanxi Province than in China. As such, although the overall RMB levels are lower than China as a whole, in terms of physical units, the reverse is true. This phenomenon will become more apparent when I discuss production technology and efficiency issues in the next section. The second reason for the discrepancy is the fact that per capita income in Shanxi Province is lower than in China as a whole, which explains the lower level of spending in the three main categories of agriculture, industry and energy, where the majority of consumption by peasants take place. The same pattern holds true in terms of non-peasant consumption, with the exception that non-peasant households in Shanxi Province consume more RMB of industrial goods per RMB of final demand than in China as a whole. In terms of institutional consumption, Shanxi Province's share of consumption in each of the five categories closely resembles that of China as a whole. Altogether the three sectors accounted for 40 percent of the GDP in Shanxi Province in 1992, amounting to 3.2 million RMB.

The overall expenditure on gross fixed capital formation amounted to over 1.8 million RMB in 1992, which was the largest final-demand sector under analysis. In addition, there was almost a 600,000 RMB in changes in stocks. The most significant difference in the consumption behavior between Shanxi Province and China is in the capital investment sectors, which is the sum of changes in stocks and gross fixed capital formation. The most glaring number is the 26 percent difference in gross capital formation in the transportation sector between Shanxi Province and China. What this says is that Shanxi Province spent one-fourth less in RMB per RMB of GDP in constructing and maintaining the transportation sector than China as a whole. This is significant, given Shanxi Province's limited railroad system and mountainous region. Indeed, this difference could partially explain the huge differentials in the energy-intensity levels in the transportation sector between Shanxi Province and China that I analyzed in Chapter 4. The second significant difference in capital investments expenditures between Shanxi Province and China is the almost 10 percent differential in the changes in stocks in the service sector between Shanxi Province and China. In other words, the value of services, that is, stocks required less the value of services-stocks disposed of during 1992, was 10 percent lower in Shanxi Province than in China. Again, this could partially explain the large difference in RMB spending by the household sector in the service sector in Shanxi Province.

EXPENDITURES OF DIFFERENT PRODUCT GROUPS

Although the differences in energy intensity among the final-demand sources can be an important source for explaining the energy-consumption differences between Shanxi Province and China, on the one hand, it is apparent from Table 5.1 that overall, these differences played an insignificant role in the final demand shifts. On the other hand, the decisions of final consumers, that is peasant and non-peasant households, institutional consumers, inventory controllers and investment-project managers, on how much to spend and what to purchase will determine the region's aggregate demand of final goods and services and the amount and composition of final products produced in the economy. Most products go through several stages of production. Final products are goods and services that are sold to final consumers at the end of the production chain. They are not, in the time period under consideration, used as inputs to produce other outputs. Intuitively, we can think of final products as the ultimate purpose or end result of economic production. The total value of all final goods and services produced domestically during a given period (in this case 1992) is exactly what we refer to as Gross Domestic Product.

For the purposes of our analysis, what is important is the energy impacts of the changes in consumption of different product groups. Table 5.5 shows the energy-use differences associated with changes in the purchase of the products in the 33-sectors under analysis between Shanxi Province and China. What is important to point out from Table 5.3, is the fact that only 0.03 RMB, or less than 4 percent, of energy use per RMB of final demand was due to increases in the direct purchase of energy products in Shanxi Province. The other 96 percent, or over 1 RMB of energy use per RMB of final demand, was caused indirectly by purchase of nonenergy goods and services which require energy to produce. In terms of fuels, the biggest difference was in coal consumption, which contributed 0.9 RMB of energy use, and crude petroleum and natural gas which was 0.6 RMB of energy use per RMB of final demand less in Shanxi Province than in China. The high differences in the use of coal and natural gas reflect the fact that coal is the dominant fuel for cooking and space heating in Shanxi Province as compared to China, and although gas (both natural, and coal-bed methane) use in the household sector has increased dramatically in China's urban households, the same cannot be said about the urban households in Shanxi Province. However, it is important to point out that coal and coke-oven gas, a byproduct of coke manufacturing, is becoming a household fuel in the urban areas of Shanxi Province and that transformation is realized in the 0.2 RMB of energy use per RMB of final demand difference in coke and coal gas energy sector (World Bank, 1997).

The major engine behind the energy-use growth from final-demand differences was the extra spending on electricity, crude petroleum and natural gas production, and the heavy industrial sectors. The extra spending on electricity alone contributed 0.16 RMB of energy use per RMB of final demand in Shanxi Province, almost all of which came from additional coal consumption. In the crude petroleum and natural gas sector, there was an additional 0.13 RMB of energy per RMB of final demand that was consumed in Shanxi Province, 70 percent of which came from additional coal consumption. In the industrial sectors,[3] Shanxi Province final consumers in Shanxi Province consumed an additional 0.81 RMB on energy, as a ratio of final demand than the final consumers in China as a whole. Of the 0.81 RMB, more than 0.45 RMB or almost 60 percent of the additional spending was on purchasing additional coal, and an additional 0.30 RMB on electricity and coke and coal products, both of which depend heavily on coal.

Our examination of the energy impacts of final-demand shifts presents only half of the energy dynamics between Shanxi Province and China. The other half is the changes in production technology, which may increase or decrease the amount of intermediate energy used to deliver one unit of final goods and services. Because final-demand shifts alone explain a small portion of the differences in energy intensity levels between Shanxi Province and China, production-technology differences must be responsible for a significant portion of the extra energy consumption in Shanxi Provinces. These are the two principal quantitative measures: changes in management practices, government rules, and regulations; but the methods of measuring these are not yet well-developed. We will quantify these energy savings and identify their sources in the next section.

ENERGY EFFECTS OF PRODUCTION-TECHNOLOGY CHANGES

In the last section, I showed that differences in the mix final customers consume of goods and services, contributed 12.2 percent of the differences between energy consumption in Shanxi Province and China. Only an additional 0.5 percent could be explained by the differences in the importance of the final demand sectors between Shanxi Province and China. The two effects influence energy consumption because of the fact that there are variations among the 33 product sectors in terms of the amount of energy they consume to satisfy one unit of final demand. However, it is apparent that there must be another mechanism involved that also contributes to the differences in the total energy consumption between China and Shanxi Province. That part can be explained by the differences in production-technology levels of Shanxi Province and China.

The concept of input-output economics is similar to that of a machine. At one end, energy and other inputs of productive sources are fed into the machine, where they are combined, processed, and transformed. From the other end, a flow of final goods and services

[3] Please see Appendix 5.A for the sectors that were included in the aggregate industrial classification.

emerges. As such, machines with different technologies may require different quantities and combinations of energy and other inputs to produce the same set of final goods and services. The amount of energy required in the production system, therefore, will change if there is a technological change, either due to a modification of the existing production machine, or due to a complete replacement of the old machine with a new one (Lin 1996). As I stated in Chapter 4, the primary factors behind improvements in energy efficiency in China have been and will continue to be the economies of scale, improvement in equipment and processes, and improvements in the fuel mix and industrial raw material inputs. It is important to point out, that within the framework of SSDA, we are unable to separate the contributions of the individual factors mentioned above. However, in Chapter 6, I will place production-technology changes into the general context of China's and Shanxi Province's economic development in 1992, to identify those macroeconomic factors that were primarily responsible for the production-technology changes.

In this study, I use the direct input or technical coefficients in the input-output accounts to describe production technology. The technical coefficients are obtained by dividing the entries in a column of the input-output transaction table, which represents the sector's inputs, by that sector's output. Each coefficient states the amount each particular input required by a particular sector to produce one unit of that sector's output. These direct-input coefficients, then, give quantitative description of the technique of production used by a sector (Carter, 1970; Polenske and Fournier, 1993). As such, a systematic tabulation of technologies of all sectors of an economy provides a concise and detailed description of the technological structure of the economy at a given time (Leontief, 1985). It is, however, important to point out that the technology inputs show the average technology of a sector. Furthermore, within a given sector, there may be a number of heterogeneous subsectors, producing different products and having different input structures. In general, what the direct inputs show is the average input structure of different subsectors, different technologies, and/or different products. We can reduce the heterogeneity of subsectors or products through the use of more detailed industrial classification. As long as we use the sector as an aggregate, however, there will always be supposed "technology" changes that are actually due to changes in the process mix and/or the changes in the output mix (Carter, 1970). In addition, because I use inputs measured in value, rather than physical units, some technology changes will only reflect price changes.

For the final SSDA analysis, I will take advantage of the total requirements coefficient table.[4] Each entry in Tables 5.D.1 and 5.D.2 shows the total purchases from the sector named on the left for each unit of delivery to final demand by the sector numbered across the top. In short, the total requirement table reports all the purchases generated by final users. This is important, because there is a significant difference in direct energy inputs, and direct and indirect energy inputs. The inclusion of indirect energy inputs is important because on a value basis, the direct use of energy inputs in production represents less than 10 percent of all inputs in China's economy (See Appendices 5.D).

DIFFERENCES IN DIRECT ENERGY INPUTS COEFFICIENTS

As is apparent from Table 5.7, there are significant differences in the direct energy-input requirements between Shanxi Province and China. There are three observations that can be made from this table. First, and most important, is the difference in coal requirements in terms of direct energy input between the two regions. In fact the only two sectors where the direct coal

[4] See 5.D for the 33-sector, 1992 total-requirement-coefficient tables for Shanxi Province and China.

requirement is smaller in Shanxi Province than in China are coal mining and coke production, and the difference in these two sectors are very small.

Furthermore among the energy sectors, the additional 0.237 units of direct coal utilization to produce one unit of electricity had the most significant impact on the 5-energy sectors combined. In the nonenergy sectors, the industrial sectors, such as sawmills (0.061) and primary metals (0.031), contributed a great deal to the overall differences in terms of coal inputs. Among the other energy inputs, the two that stand out are the coke inputs into the primary-metal sector (0.039), and the direct input of refined petroleum into the other-mining sector (0.056). At the same time, there are a number of sectors where there are no differences between the direct energy inputs between Shanxi Province and China. This is important, because it indicates that the policy makers in Shanxi Province need to concern themselves with only a few strategic economic sectors in order to reduce their energy-intensity levels and bring the overall levels to that of China as a whole.

Although Table 5.7 shows the difference in direct input in the 33 sectors, it does not adequately capture the difference in relative *importance* of the five energy sectors. In order to calculate this measure, I calculated the ratio of output in each of the five sectors per total output in China and Shanxi Province, and then calculated the ratio of their relative importance. Table 5.8 shows the results of my analysis. As is apparent from this table, the relative importance of coal is over 12 times greater in Shanxi Province than in China, while coke is over 10 times as great. The other three sectors' difference in relative importance is rather negligible compared to coke and coal, with electricity's relative importance being almost twice as great in Shanxi Province than in China. Table 5.9 shows the difference in relative importance of the direct energy input of the five energy sectors for the 5 energy and 28 nonenergy sectors between Shanxi Province and China.

TABLE 5.7

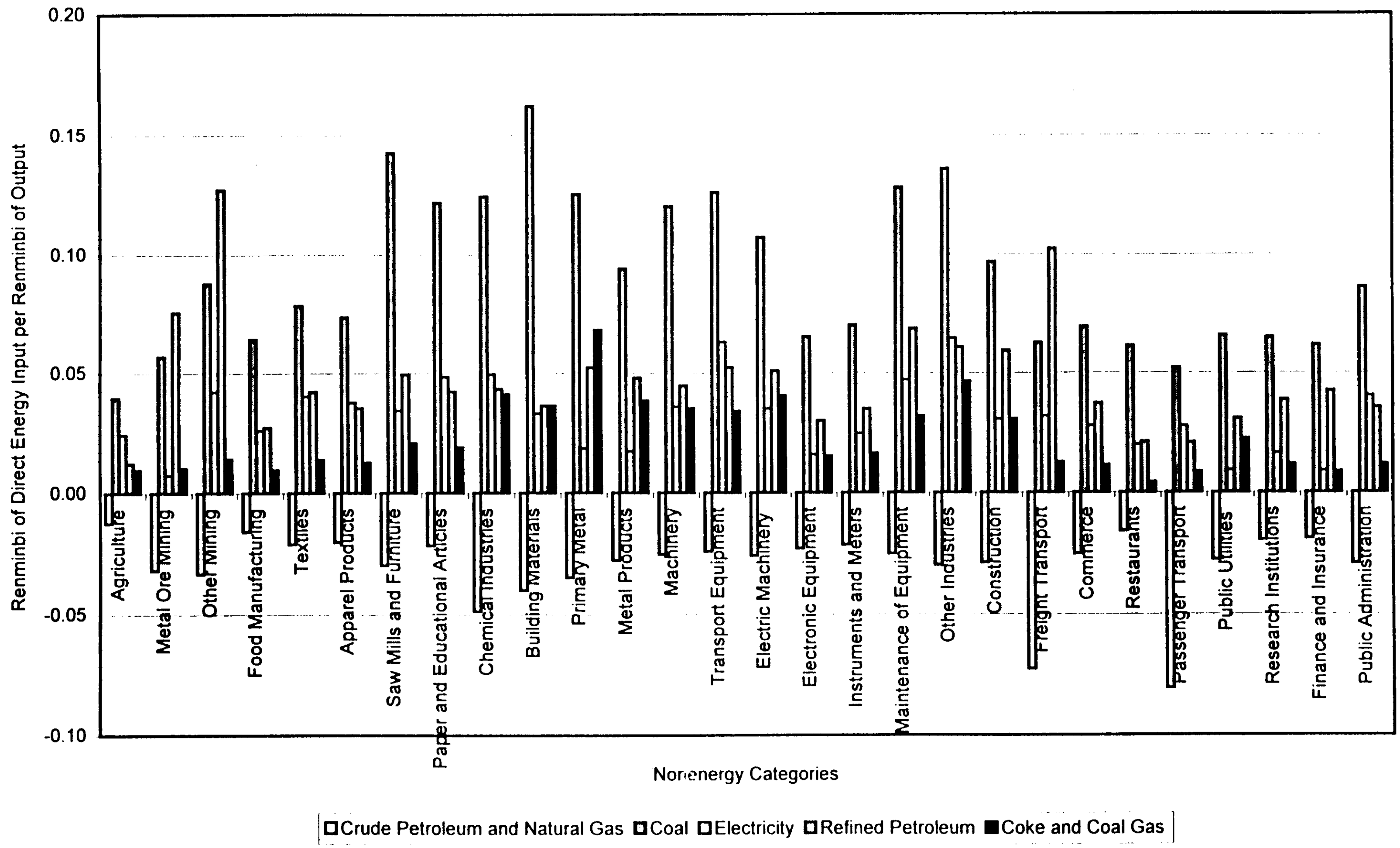
DIFFERENCES IN DIRECT ENERGY INPUT REQUIREMENTS, SHANXI PROVINCE AND CHINA, 1992

Energy Sectors	**Coal**	**Coke and Coal Gas**	**Crude Petroleum and NG**	**Refined Petroleum**	**Electricity**
Coal	-0.014	0.001	0.000	-0.003	-0.016
Crude Petroleum and NG	0.088	0.000	-0.016	0.015	0.041
Electricity	0.237	0.000	-0.038	-0.031	-0.011
Refined Petroleum	0.028	0.001	-0.521	0.280	0.069
Coke and Coal Gas	-0.007	0.007	-0.039	-0.012	-0.018
Nonenergy Sectors					
Agriculture	0.006	0.002	0.000	-0.002	0.011
Metal Ore Mining	0.002	0.001	0.000	0.033	0.001
Other Mining	0.012	0.004	0.000	0.056	0.017
Food Manufacturing	0.014	0.000	0.000	0.000	0.004
Textiles	0.014	0.000	0.000	0.003	0.016
Apparel Products	0.006	0.000	0.000	0.001	0.005
Sawmills & Furniture	0.061	0.000	0.000	0.001	0.006
Paper & Educational Articles	0.036	0.000	0.000	0.003	0.014
Chemical Industries	0.028	0.019	-0.015	-0.001	0.017
Building Materials	0.079	0.020	-0.003	-0.005	0.013
Primary Metal	0.031	0.039	-0.006	0.009	0.001
Metal Products	0.015	0.008	0.000	0.011	0.008
Machinery	0.028	0.002	-0.001	0.004	0.010
Transport Equipment	0.018	0.002	0.000	0.003	0.020
Electric Machinery	0.006	0.003	0.000	0.005	0.003
Electronic Equipment	0.004	0.000	-0.001	0.000	-0.001
Instruments and Meters	0.016	0.000	-0.001	0.009	0.015
Maintenance of Equipment	0.025	-0.001	-0.001	0.014	0.005
Other Industries	0.033	0.019	-0.003	0.009	0.028
Construction	0.006	0.000	0.000	0.014	0.007
Freight Transport	0.005	0.000	-0.002	0.024	0.002
Commerce	0.016	0.002	-0.001	0.009	0.010
Restaurants	0.021	-0.002	-0.003	-0.003	0.004
Passenger Transport	0.007	0.000	0.000	-0.033	0.008
Public Utilities	0.019	0.014	-0.001	0.000	-0.005
Research Institutions	0.017	0.002	-0.001	0.011	0.001
Finance and Insurance	0.021	0.000	0.000	0.015	-0.004
Public Administration	0.021	0.000	-0.002	-0.002	0.017

Source: SSDA calculations from 1992 China and Shanxi Province Input-output Tables.
NG: Natural Gas

FIGURE 5.2

DIFFERENCES IN DIRECT ENERGY-INPUT REQUIREMENTS IN NONENERGY SECTORS, SHANXI PROVINCE AND CHINA, 1992



Source: Table 5.7.

TABLE 5.8
RELATIVE IMPORTANCE OF THE FIVE-ENERGY SECTORS, SHANXI PROVINCE OVER CHINA, 1992

	COAL	COKE AND COAL GAS	CP AND NG	REFINED PETROLEUM	ELECTRICITY
Shanxi Province	0.136	0.028	0.000	0.001	0.033
China	0.011	0.003	0.009	0.012	0.017
Ratio	**12.860**	**10.646**	**0.001**	**0.098**	**1.923**

Source: SSDA calculations from 1992 China and Shanxi Province Input-output Tables.
CP: Crude Petroleum; **NG:** Natural Gas.

TABLE 5.9
RELATIVE IMPORTANCE OF THE DIRECT INPUT OF THE FIVE-ENERGY SECTORS, SHANXI PROVINCE OVER CHINA, 1992

Energy Sector	Coal	Coke and Coal Gas	Crude Petroleum and NG	Refined Petroleum	Electricity
Coal	-0.177	0.010	0.000	0.000	-0.031
Crude Petroleum and NG	1.136	0.000	0.000	0.001	0.078
Electricity	3.048	-0.001	0.000	-0.003	-0.022
Refined Petroleum	0.365	0.006	-0.001	0.027	0.132
Coke and Coal Gas	-0.095	0.073	0.000	-0.001	-0.035
Agriculture	0.083	0.021	0.000	0.000	0.022
Metal Ore Mining	0.022	0.006	0.000	0.003	0.003
Other Mining	0.152	0.039	0.000	0.005	0.033
Food Manufacturing	0.181	-0.004	0.000	0.000	0.008
Textiles	0.178	0.001	0.000	0.000	0.030
Apparel Products	0.073	-0.003	0.000	0.000	0.009
Sawmills & Furniture	0.779	0.003	0.000	0.000	0.011
Paper & Educational Articles	0.458	-0.002	0.000	0.000	0.028
Chemical Industries	0.359	0.197	0.000	0.000	0.032
Building Materials	1.018	0.213	0.000	-0.001	0.026
Primary Metal	0.398	0.408	0.000	0.001	0.001
Metal Products	0.191	0.079	0.000	0.001	0.015
Machinery	0.366	0.023	0.000	0.000	0.019
Transport Equipment	0.230	0.019	0.000	0.000	0.039
Electric Machinery	0.082	0.036	0.000	0.000	0.006
Electronic Equipment	0.057	-0.005	0.000	0.000	-0.002
Instruments and Meters	0.201	-0.004	0.000	0.001	0.029
Maintenance of Equipment	0.324	-0.014	0.000	0.001	0.010
Other Industries	0.424	0.196	0.000	0.001	0.054
Construction	0.076	0.002	0.000	0.001	0.014
Freight Transport	0.065	0.000	0.000	0.002	0.003
Commerce	0.211	0.016	0.000	0.001	0.019
Restaurants	0.276	-0.020	0.000	0.000	0.007
Passenger Transport	0.091	0.000	0.000	-0.003	0.015
Public Utilities	0.240	0.151	0.000	0.000	-0.009
Research Institutions	0.218	0.016	0.000	0.001	0.003
Finance and Insurance	0.272	-0.003	0.000	0.001	-0.007
Public Administration	0.270	-0.004	0.000	0.000	0.032

Source: SSDA calculations from 1992 China and Shanxi Province Input-output Table.
NG: Natural Gas.

There are three points that stand out from the above table. First and most important, is the overall importance of the coal and coke sectors. Altogether, coal input is over 4 times as great in Shanxi Province for the 5 energy sectors, and over 8 times as great for the 28 nonenergy sectors. Second, the coal input in electricity generation is over 4 times as great in Shanxi Province as in China, by far the most difference of any of the 33 sectors, for any of the energy sources. The third point is that there is insignificant difference in terms of importance for the three remaining energy sources.

DIFFERENCES IN DIRECT AND INDIRECT (TOTAL) ENERGY INPUTS COEFFICIENTS

The input-output model used in this study is an open model. The main reason for choosing an open, rather than a partially closed, input-output model is that in China's economy, we cannot assume that the direct relationship between labor income and household consumption and between capital depreciation and gross capital formation is linear and has fixed proportions. In the open model, primary inputs, such as labor and capital depreciation, are not included in the calculation of intermediate energy input requirements. Instead, the energy consumption of workers and capital-investment projects are included as part of final demand. This failure to include primary inputs in the endogenous portion of the production technology results in an underestimation of the energy embodied in products. The magnitude of the underestimation, however, should be small because about 85 percent of the energy is used as intermediate inputs in China in the 1980s.

Table 5.10 shows the differences in direct and indirect energy inputs between Shanxi Province and China. There are four observations that can be made from this table. First is the significant differential between the differences in direct energy input (Table 5.6) and direct and indirect energy inputs between Shanxi Province and China (Table 5.7).[5] In the five energy sectors this difference is 85 percent greater when one takes into account the indirect inputs, the majority of which comes from the coal sector (41 percent). The difference in the nonenergy sectors is very large. In the coal sector alone, the difference is over 190 percent, and, in the refined petroleum sector, it is over twice as much. Altogether, the nonenergy sectoral difference is over 340 percent, and energy and nonenergy combined is over 430 percent greater. What this suggests is the magnificent importance of indirect energy inputs per unit of output.

The second point that stands out is once again the differentials in direct and indirect coal input per unit of output between Shanxi Province and China. In the five energy sectors alone, Shanxi Province consumes 75 percent more coal in terms of direct and indirect input than China, and combined with the 28 nonenergy sectors, that number jumps to over 330 percent, or over three times as much. This same trend holds true for the electricity, refined petroleum, and coke and coal products, where the direct and indirect energy input in Shanxi Province is over three and half times greater than that of China.

The third point that stands out is the differences among individual energy and nonenergy sectors. The industrial sectors show the largest differences, highlighted by the building materials and sawmills and furniture sectors. At the same time, there is a significant difference between Shanxi Province and China in the amount of refined petroleum used by the transportation sectors, such as freight transport. It is also important to note that overall, there is one magnitude of difference between the difference in direct and indirect coal input and any of the other fuel inputs. Finally, it is important to point out the similarity between the two regions in terms of crude oil and natural gas inputs. Just as is the case with direct energy inputs, Shanxi Province

[5] See Table 5.E.1 in Appendix 5.E for the actual differences between direct and direct and indirect input differences between Shanxi Province and China.

has lower direct and indirect crude petroleum and natural gas inputs than China. That difference is fairly negligible, less than 17 percent, in the five energy sectors, but much larger, more than 77 percent, in the 28 nonenergy sectors. Among the energy sectors, the most impressive is the amount of direct and indirect energy input into the refined petroleum sector (0.460), and among the nonenergy sectors, in the building materials sectors (0.162).

TABLE 5.10

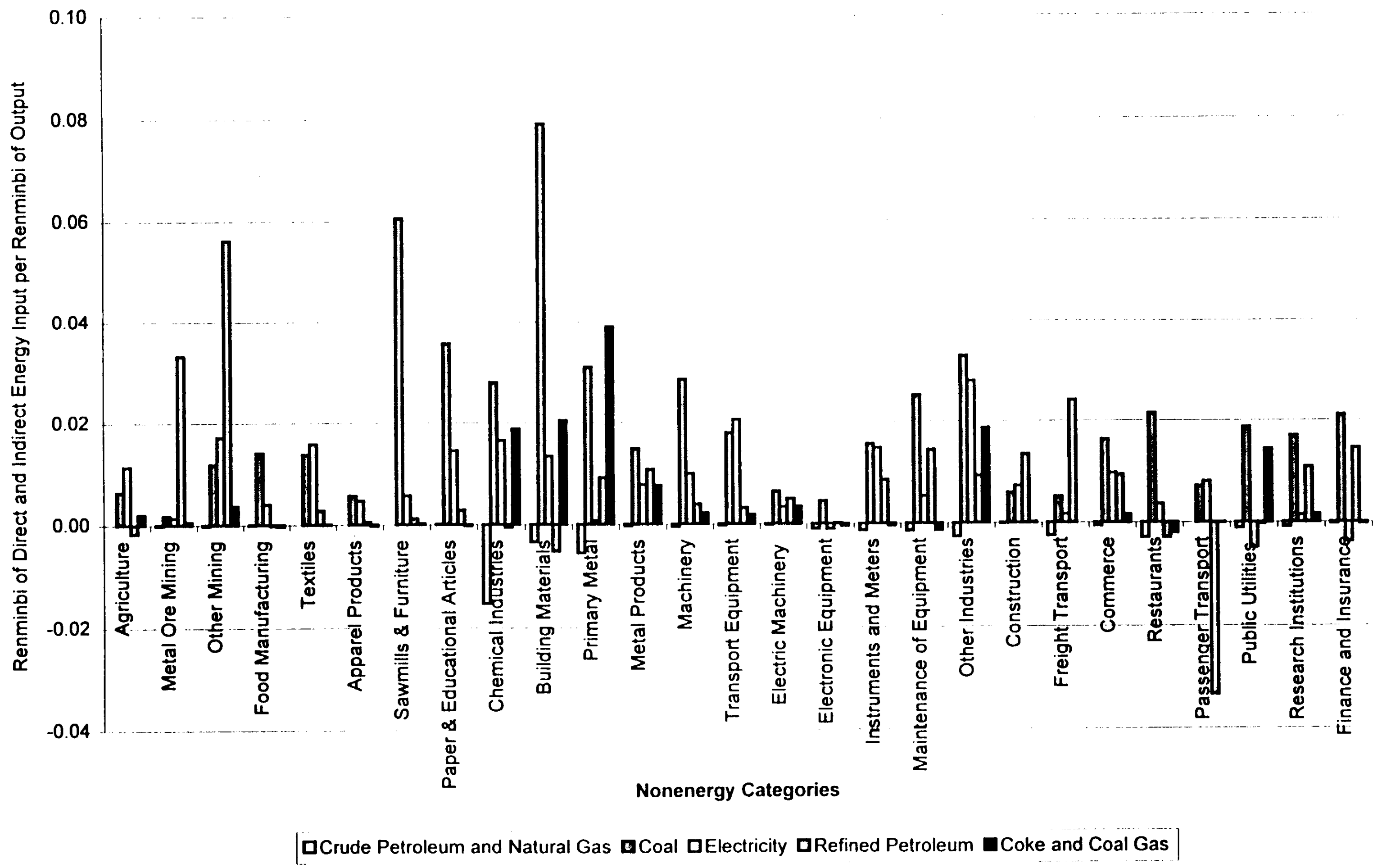
DIFFERENCES IN DIRECT AND INDIRECT ENERGY INPUT REQUIREMENTS, SHANXI PROVINCE AND CHINA, 1992

Energy Sector	Coal	Coke and Coal Gas	Crude and Natural	Refined Petroleum	Electricity
Coal	0.044	0.016	-0.030	0.023	-0.003
Crude Petroleum and Natural Gas	0.211	0.027	-0.034	0.090	0.100
Electricity	0.277	0.009	-0.079	-0.004	0.005
Refined Petroleum	0.161	0.026	-0.558	0.460	0.132
Coke and Coal Gas	0.052	0.024	-0.081	0.028	-0.006
Nonenergy Sectors					
Agriculture	0.040	0.010	-0.012	0.012	0.024
Metal Ore Mining	0.057	0.010	-0.032	0.076	0.007
Other Mining	0.088	0.014	-0.033	0.127	0.042
Food Manufacturing	0.064	0.010	-0.016	0.027	0.026
Textiles	0.079	0.014	-0.021	0.042	0.040
Apparel Products	0.074	0.013	-0.020	0.035	0.038
Sawmills & Furniture	0.143	0.021	-0.030	0.050	0.034
Paper & Educational Articles	0.122	0.019	-0.022	0.042	0.048
Chemical Industries	0.124	0.041	-0.049	0.043	0.050
Building Materials	0.162	0.037	-0.040	0.037	0.033
Primary Metal	0.125	0.068	-0.035	0.052	0.019
Metal Products	0.094	0.038	-0.028	0.048	0.017
Machinery	0.120	0.035	-0.025	0.045	0.036
Transport Equipment	0.126	0.034	-0.024	0.052	0.063
Electric Machinery	0.107	0.041	-0.026	0.051	0.035
Electronic Equipment	0.065	0.015	-0.023	0.030	0.016
Instruments and Meters	0.070	0.016	-0.021	0.035	0.025
Maintenance of Equipment	0.128	0.032	-0.025	0.068	0.047
Other Industries	0.136	0.046	-0.030	0.061	0.065
Construction	0.097	0.031	-0.029	0.059	0.031
Freight Transport	0.063	0.013	-0.073	0.102	0.032
Commerce	0.069	0.011	-0.025	0.037	0.028
Restaurants	0.061	0.004	-0.016	0.021	0.020
Passenger Transport	0.052	0.009	-0.081	0.021	0.028
Public Utilities	0.066	0.023	-0.028	0.031	0.009
Research Institutions	0.065	0.012	-0.019	0.039	0.016
Finance and Insurance	0.062	0.009	-0.019	0.043	0.009
Public Administration	0.086	0.012	-0.029	0.035	0.040

Source: SSDA calculations from 1992 China and Shanxi Province Input-output Tables.

FIGURE 5.3

DIFFERENCES IN DIRECT AND INDIRECT ENERGY INPUTS INTO NONENERGY SECTORS SHANXI PROVINCE AND CHINA, 1992



Source: Table 5.6.

Similarly, Table 5.11 shows the relative importance of the five-energy sectors in direct and indirect input into the 5 energy and 28 nonenergy sectors. There are two points that stand out in this table. First, coal retains its overall difference in overall importance between Shanxi Province, and China. Second, unlike direct energy inputs, there are significant differences in all five energy sectors between Shanxi Province, and China.

TABLE 5.11
RELATIVE IMPORTNACE OF THE DIRECT AND INDIRECT INPUT OF THE FIVE-ENERGY SECTORS, SHANXI PROVINCE OVER CHINA, 1992

Energy Sector	Coal	Coke and Coal Gas	CP and NG	Refined Petroleum	Electricity
Coal	0.56701	0.21083	-0.38328	0.29823	-0.03810
Crude Petroleum & NG	2.70788	0.35232	-0.43691	1.15858	1.29015
Electricity	3.56779	0.11988	-1.01747	-0.05515	0.06586
Refined Petroleum	2.06720	0.33905	-7.17428	5.91733	1.69458
Coke and Coal Gas	0.66837	0.30736	-1.04060	0.35650	-0.07982
Agriculture	0.50922	0.12383	-0.15895	0.15993	0.31325
Metal Ore Mining	0.73172	0.13172	-0.40790	0.97138	0.09594
Other Mining	1.12990	0.18372	-0.42798	1.63433	0.54263
Food Manufacturing	0.82519	0.12445	-0.20358	0.35056	0.33677
Textiles	1.01143	0.17909	-0.27073	0.54346	0.51878
Apparel Products	0.94568	0.16338	-0.25931	0.45504	0.48558
Sawmills & Furniture	1.83488	0.26795	-0.38217	0.63675	0.44315
Paper & Educational Articles	1.56720	0.24603	-0.27703	0.54429	0.62325
Chemical Industries	1.59945	0.53015	-0.62742	0.55775	0.63727
Building Materials	2.08694	0.46986	-0.51534	0.46958	0.42612
Primary Metal	1.61163	0.87409	-0.44678	0.67379	0.23917
Metal Products	1.21084	0.49417	-0.35819	0.61784	0.22486
Machinery	1.54595	0.45445	-0.32450	0.57474	0.46238
Transport Equipment	1.62314	0.43957	-0.30899	0.67356	0.80986
Electric Machinery	1.37984	0.52272	-0.33247	0.65436	0.45324
Electronic Equipment	0.83747	0.19665	-0.29391	0.38821	0.20572
Instruments and Meters	0.89895	0.21183	-0.27472	0.45028	0.31954
Maintenance of Equipment	1.64732	0.41388	-0.32175	0.87988	0.60575
Other Industries	1.74796	0.59764	-0.38209	0.78165	0.83081
Construction	1.24623	0.39637	-0.36914	0.76317	0.39454
Freight Transport	0.80427	0.16403	-0.93442	1.31710	0.41103
Commerce	0.88895	0.14778	-0.32340	0.47956	0.35930
Restaurants	0.78750	0.05445	-0.20317	0.27222	0.25954
Passenger Transport	0.66873	0.11158	-1.03632	0.26982	0.35716
Public Utilities	0.84481	0.28990	-0.35403	0.39790	0.11770
Research Institutions	0.83408	0.15164	-0.24985	0.49822	0.21165
Finance and Insurance	0.79454	0.11221	-0.24286	0.54680	0.11695
Public Administration	1.10862	0.15343	-0.37498	0.45633	0.51831

Source: SSDA calculations from 1992 China and Shanxi Province Input-output Tables.
NG: Natural Gas.

FACTORS INFLUENCING THE PRODUCTION TECHNOLOGY

There are five overlapping factors that can cause the actual technology of a given industry to be different. First, there can be differences in the types and quality of goods and services that are produced. As an example, a shift from less to more energy-intensive products will lead to a decline in direct and indirect energy input coefficients. Second, differences in production facilities, such as the introduction of a new facility line, a modification of existing facilities, or retirement of obsolete equipment, in one region can have profound effects on its energy consumption compared to another region. Third, changes in management practices and operations of production facilities, can improve direct and indirect energy input coefficient, through such practices as improving operations of energy intensive equipment and through better energy housekeeping. Fourth, differences in the quality of inputs can make a significant difference in energy consumption. Energy can be saved, by better matching coal quality to the input specifications of a furnace or boiler or by switching from low-quality coal to high-quality coal.

Fifth, changes in capacity utilization and scale of production is of significance. We can divide input uses in production activities into two categories: those that vary with level of output and those that remain relatively constant when output changes. Within the limit of capacity, higher capacity utilization or output level reduces fixed inputs per unit of output, and therefore reduces input requirements. An obvious example is the transportation sector. Fuel consumption per passenger or unit of freight, generally decreases as more passengers travel in a given vehicle.

So why is there is such a significant difference in the technology-input structures between Shanxi Province and China? The answer lies in the degree to which China's policies interacted with the realities of Shanxi Province's macro-economic needs and situations. The first has to do with Shanxi Province's role as being the largest energy producer in China, producing over 25 percent of the coal in China. As is evident from Table 5.11, the relative importance of direct and indirect inputs into the 5 energy sectors were 10 times greater than in China as a whole, as such there are no incentives to save energy, while at the same there is a tendency to adopt energy-intensive technologies.

In addition, during the 1980s, a severe energy shortage in China led to a major shift in energy policy, from a policy of complete devotion to increasing supply to one of placing equal emphasis on supply expansion and energy conservation, with priority given to conservation efforts in the short run (Tomitate, 1989; Smil, 1988). Starting in 1981, energy-conservation targets were incorporated into the Five-Year Social Economic Development Plan as well as into annual plans. They included targets for the amount of energy to be saved, limits on energy consumption in the production sectors, and energy-saving targets (Wang, 1990). Overall, the energy-conservation program has been highly successful and has resulted in large energy savings (World Bank, 1985). In some cases, however, the government conservation programs and plans were more not as successful. They may not necessarily have been implemented at all, or as originally designed, at the local and enterprise level. This was especially true in Shanxi Province, where the availability of abundant and cheap coal, and the Province's reliance on coal for majority of their industrial processes, made it much easier to ignore the directives of the national government. This is an illustration of the Chinese saying, "where the mountain is high, the emperor is far away," meaning that the central government only has limited control over local affairs.

Improvement in energy efficiency was also a by-product of China's economic reform and reflected the improvement in macroeconomic performance in the 1980s. Between 1949 and

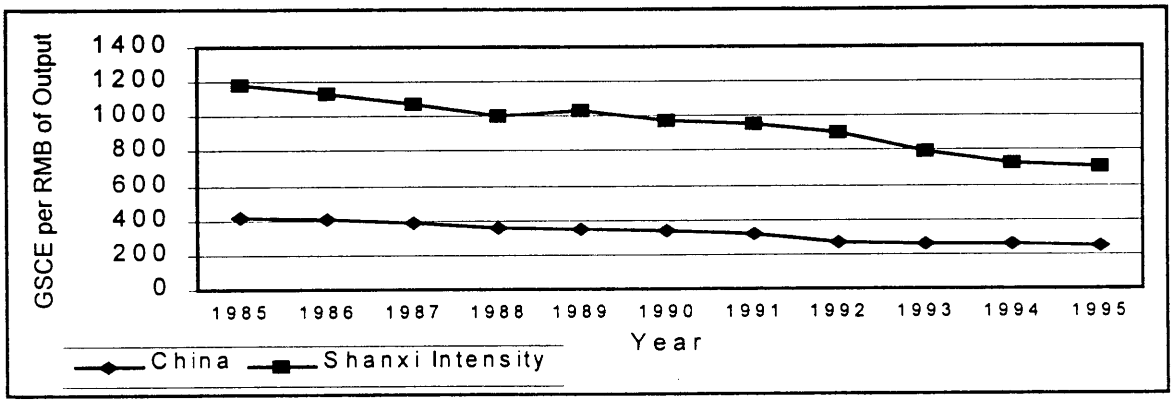
1977, China's economic development strategy followed the Soviet growth model, which emphasized high output growth and development of heavy industry. This strategy did result in high output growth, but at very high resource costs. The growth achieved was accompanied by great wastes and inefficiencies so that more and more investment and resources were required to attain a given increase in national income. Li et al. (1993) found that all the output growth in China from 1953 to 1978 came from increases in factor inputs; factor productivity actually went down during this period. Chen et al. (1988) and Perkins (1986) reach a similar conclusion. In addition, managers of firms in this overly centralized economic system ignored supply and demand conditions and failed to produce what was needed. Some goods were overproduced and stockpiled, while others, especially consumer goods, were in chronic shortage (Naughton, 1987).

Since 1978, China has initiated a series of reform measures in the hopes that such measures would raise economic efficiency and rate of productivity growth of its economy (Barnett and Clough, 1986; Lampton, 1987; Reynolds, 1988; World Bank, 1985, 1990). The reform started in rural areas in 1978 with the piecemeal dissolution of collective agriculture through the introduction of household-land-contract or agricultural responsibility system. It penetrated into the urban economy in the mid-1980s in three basic forms: (1) greater decision-making autonomy for enterprises, in production and, to a lesser extent, in investment; (2) reinstitution of financial incentives for enterprises and individuals; and (3) expansion of the role of markets in the allocation of industrial goods and the corresponding reduction in the role of planning and administrative allocation (Byrd, 1991, 1992). The basic objective of the reform was to marketize China's economy, that is to shift from a centrally planned economy, in which planning and administrative directives guided the allocation of resources, to an eclectic, market-oriented, socialist commodity economy, in which resource allocation was determined largely by interactions in the market among autonomous, competitive, and profit-oriented economic agents. Although, Shanxi Province benefited from the above measures to increase output and decrease energy intensity (see Chapter 3), their starting energy intensity was so much greater than China as a whole, that the reforms merely kept Shanxi Province's energy intensity levels at a much greater level than China's. Furthermore, because of Shanxi Province's position as the leading producer of energy, particularly coal, it meant that energy-intensive industries, such as coal mining and coke manufacturing have continued to play a significant role in the output levels of Shanxi Province.

Another critical difference between Shanxi Province and China has been in the development of Township and Village Enterprises (TVE) which have become a major producer of industrial goods, comprising over 40 percent of the total output in 1997. The same holds true for Shanxi Province. The difference lies in the dominance of some of the most polluting and energy-intensive industries in Shanxi Province as compared with China. The two most prevalent are brick-making and cokemaking. In general these TVEs tend to be more energy intensive, and polluting than similar SOEs. Given the preponderance of these industries in Shanxi Province compared to China, this trend toward more energy-intensive TVEs has hampered the means by which Shanxi Province could reduce its energy-intensity levels to that of the nation (Figure 5.4).

Finally, improvements in energy efficiency was an enterprise's rational response to energy-price increases in China in the 1980s. For years, energy had been underpriced in China in order to promote industrial development. In the early 1980s, coal prices, for example, were about 60 percent of the long-run marginal cost of coal production (World Bank, 1985). The greatly underpriced energy overconsumption provided no incentives for energy-efficiency improvements. Energy was consumed as if its value to the country was much lower than it really was. Processes were designed, machinery and appliances built, and buildings constructed that used more energy than was justified, considering its real value in other uses. Low prices also caused people to operate those facilities in ways that used more energy than they would have if managers had taken account of energy's true value.

FIGURE 5.4
ENERGY INTENSITY OF CHINA AND SHANXI PROVINCE'S MATERIAL-PRODUCTION SECTORS (TOTAL), 1986-1995 (GSCE PER 1980 RMB OF OUTPUT)



Source: The Gross Domestic Product of China, 1952-1995, pp. 192-199; China Provincial Statistics, 1949-1989, pp. 66-67; China Energy Statistical Yearbook, 1991, pp. 205-206; China Energy Annual Review, 1996, and 1994; China Statistical Yearbook, 1997, p. 216; Shanxi Province Statistical Yearbook, 1997.
RMB: Renminbi, the Chinese currency=0.125 U.S. Dollar; **GSCE:** Grams of Standard Coal Equivalent.

This problem of irrational energy pricing was mitigated, to some degree, by price reforms in the energy sector, mainly in the coal industry, in the early 1980s (Byrd, 1987). Altogether in the 1980s the government raised the price of coal by 10 to 25 percent, and more fundamentally, a dual price system was introduced into the energy sector in 1983-1984 (Byrd, 1987). Under this system, goods were exchanged at two different prices: a state-set price, for the amount produced under central planning, and a higher free-market price, for above-plan output. The State also removed price controls on locally produced coal, which accounted for an increasing share of total coal production (Byrd, 1987; World Bank, 1985). Although China's energy-price increases in the 1980s provided some incentives for energy-efficiency improvements, these incentives remained low because energy prices remained low despite the price hikes. Most fuels continued to be allocated through state planning, and the share of market-allocated energy was too small to affect the overall energy price structure. As such, due to low energy prices, energy expenditures made up a very small share of the total production costs, and therefore managers in most enterprises did not view cutting energy costs as a top priority. This situation was exasperated in Shanxi Province because for the reasons I have mentioned elsewhere: Shanxi Province's heavy reliance on coal as a energy input; its position as the primary coal producer in the country; and the fact that the fastest growing production sectors were also some of the most energy-intensive sectors.

CONCLUSION

In this Chapter, I show the specific factors behind energy-intensity levels between Shanxi Province and China. The results of SSDA shows that the primary factor is the differential in direct and indirect energy, especially coal inputs, in the 33 sectors under observation. However, shifts in the final demand contributed 12 percent to the overall difference, the majority of which was due to the fact that the 5 final-demand sectors under consideration consumed more energy-intensive products. A negligible percentage can be attributed to the fact that composition in these five sectors was different between Shanxi Province and China. I also discuss some of the possible reasons behind these energy-intensity differentials, almost all of which can explain the reductions in energy-intensity levels in both China and Shanxi Province, while also giving a clue as to why there is such a difference between the two regions. Among the reasons cited were: energy-conservation programs, energy-pricing systems, and macroeconomic performance.

I will discuss these findings as well as those from Chapter 4 in more detail in the next chapter. I also give explicit examples of what Shanxi Province is currently doing about energy which will have a profound effect on their energy-intensity levels, along with some policy options that could further bring their energy-intensity level closer to that of China.

CHAPTER 6

POLICY RECOMMENDATIONS AND OPTIONS

In order to understand the policy options available to Shanxi Province officials, we first need to understand the future paths of development, along with its associated problems, in China. There is no single predetermined route for China's future economic development. The external environment will without doubt play an important part in shaping the Chinese economy, and the handling of the reform process will be a critical factor on the domestic front. But equally, or perhaps more importantly, China faces an impressive range of structural challenges whose resolution will have a significant bearing on the size, profile, and functioning of the Chinese economy 15 to 20 years hence. Broadly speaking, these structural challenges fall into four groups: infrastructural; technological and organizational; environmental, and institutional.

Infrastructural deficiencies are likely to be important stumbling blocks to China's economic development. It is estimated that bottlenecks in transport already cost around one percent of the GDP, and little improvement is foreseen given that between the 1980's and early 1990s investment in transport infrastructure declined from 1.7 to 1.0 percent of GDP. Similarly, demands on energy production will rise substantially. Electricity generation, for example, could grow by 6 to 7 percent per year up to 2010. In terms of financial infrastructure, the difficulty is that while China has emerged as a major player on global financial markets, its domestic capital markets, banking sector and financial services are underdeveloped. (Minematsu, Shin, Hisae Sakata, Xiao-ping Zheng, Junichi Yamada, 1997)

The volume of capital inputs is unlikely to pose a problem in the coming years, provided that saving rates remain high. Currently they are about 2.5 trillion RMB (China Statistical Yearbook, 1998); but if China is to move up the specialization ladder, away from simple labor-intensive products towards more sophisticated high-quality goods involving a wide range of advanced technologies and industries, considerable investment in human resources is likely to be required over the next ten to twenty years to secure the necessary indigenous scientific and technological foundations, the broad skill base, and the organizational know-how. Similarly, China will face the task of feeding 1.2 to 1.4 billion people, whose nutritional behavior will, in all probability, change dramatically as incomes rise. Thus, in the agricultural sector as well, considerable efforts will be required on all three fronts—technological, educational, and organizational.

Even at rates of growth slower than those currently recorded, China faces serious environmental problems. Most of the costs of pollution are borne by the Chinese themselves: for example, only about 20 percent of industrial waste and 15 percent of sewage flowing into China's rivers is treated. There is a considerable cross-regional pollution, mainly due to the heavy reliance on coal and to the related carbon and sulfur emissions. The Chinese government has made substantial efforts since the early 1980s to reduce environmental damage. Investment in pollution prevention and control increases from virtually nil to about 1 percent of national income towards the end 1980s. Given the prospect of continuing population pressures, rapid industrialization, a tripling of power generation (from 150 GW in 1991 to 430 GW in 2010), and a doubling of car ownership by the end of the century, China's environmental challenge will pervade every sector of the economy. (Junfeng, Li, Todd M. Johnson, Zhou Changyi, Robert P. Taylor, Liu Zhiping, and Jiang Zhongxiao, 1995)

Finally, there are institutional challenges to be confronted. For example, the current legal framework is not well adapted to a rapidly expanding, increasingly market-based, and internationalized economy. Corruption is widespread. Continuing reform of state-owned enterprises implies that social functions and responsibilities they hitherto assumed will need replacing by alternative approaches to health, education, pensions, housing and unemployment. Moreover, considerable effort will need to go into maintaining an appropriate balance between the powers and resources of the center and the provinces. Many of the latter have, during the reform years, increased their ability to determine their own economic strategies, often quite independently of the views and wishes of central. (Michalski, Miller, and Stevens, 1996)

FUTURE ENERGY DEMAND ALTERNATIVES IN CHINA

As I have mentioned before, Shanxi Province produces over 20 percent of the total energy in China, mostly coal. As such, in order to understand the options that are available to Shanxi Province officials, we need to examine future demand and supply scenarios for China as a whole. In 1996, the World Bank examined the future energy demand scenarios in China, and reached the following conclusion.[1]

Baseline case

The baseline case (Table 6.1) is intended to show how energy demand might evolve under "business-as-usual" conditions. Energy is priced at economic cost, implying some relatively modest adjustments from current pricing policy, but no large new energy taxes are imposed. Major gains in economic efficiency are achieved through the implementation of the economic reform program in general, and enterprise and capital market reform in particular, which affects the structure of the economy and the behavior of the enterprises. The country's

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[1] Junfeng, Li, Todd M. Johnson, Zhou Changyi, Robert P. Taylor, Liu Zhiping, and Jiang Zhongxiao. 1995. *Energy Demand in China: Overview Report*, pp. 42-46. World Bank.

efforts to improve technical energy efficiency levels continue as during the 1980s and early 1990s, realizing significant benefits.

TABLE 6.1

TOTAL ENERGY DEMAND: BASELINE CASE

	1990	2000	2010	2020
Total Primary Energy Use (Mtce)	987	1,561	2,377	3,301
• Coal (million tons)	1,051	1,574	2,376	3,100
• Oil and gas (million toe)	112	182	285	442
• Natural gas (10^9 cubic meter)	15	29	67	114
• Power (TWh)	126	362	508	871
Total final energy use (Mtce)	987	1,561	2,377	3,301
• Coal (million tons)	902	1,135	1,503	1,791
• Oil and gas (million toe)	101	170	274	433
• Natural gas (10^9 cubic meter)	15	27	62	107
• Power (TWh)	623	1,302	2,429	3,845
Per capita use (kgce)	863	1,201	1,698	2,276
• Coal (kilograms)	702	873	1,073	1,236
• Oil (kgoe)	89	130	196	299
• Natural gas (cubic meter)	13	21	44	74
• Power (kWh)	545	1,002	1,735	2,651

Source: China Statistical Yearbook; The World Bank Joint Study Program.
Mtce: Million Tons of Coal Equivalent; **toe:** Tons of Oil Equivalent; **TWh:** (TeraWatt Hour); **tce:** Tons of Coal Equivalent; **kgoe:** Kilograms of Oil Equivalent; **kWh:** KiloWatt Hour

The broad structure of GDP changes in the baseline case, with a large increase in the share of the service sector, and a large decrease in the state of agriculture. The share of industry, a critical determinant of a country's energy intensity, rises slightly from its current high level of 44 percent to 45 percent in 2000, then falls to 41 percent in 2010, and 37 percent in 2020. Growth in industrial output must continue to be strong, in order to provide the wide range of material goods that will be demanded by the population as per capita income moves to the middle income range. The absence of a steady and strong increase in the share of industry in economic output, however, marks an important break with past trends.

The relative share of different industrial sectors in industrial output also changes markedly in the baseline case. Growth is relatively modest in the coal, oil, ferrous and non-ferrous metal, chemical fertilizer, and cement industries; the share of these industries in total output all fall markedly. Growth is especially strong in the machinery and electronics industry; the share of this industry is projected to increase from about 17 percent net industrial output in 1990 to about 26 percent in 2020. Growth in light industry, cement, non-cement building materials, and chemicals other than fertilizers also exceeds the average for industry as a whole.

The baseline case is by no means a simple extrapolation based on the current economy; the baseline case results in further major declines in energy intensity. If the rapid economic growth of the baseline case is assumed with an energy/GDP elasticity of 1.0 (that is energy use grows as fast as economic output), China's energy demand would reach about 10 billion Tons of Coal Equivalent (tce) by 2020, which is roughly equivalent to total world energy use in 1990. This situation is shown in Table 6.2, referred to as the "no further change" case. Such an extrapolation also implies that per capita commercial energy use in China would be no more than 7.5 tce in 2020, which is three times the world average level in 1990, and higher than the OECD average level of 7.4 tce in 1990. Clearly, an economic growth pattern that represents a rapidly growing extension of the current economy is not feasible. Without major economic and energy efficiency gains, primarily through economic system reform, rapid economic growth over the medium term is not viable.

TABLE 6.2

TOTAL ENERGY DEMAND: NO FURTHER CHANGE CASE

	1990	2000	2010	2020
Primary Energy Use (Mtce)	987	2,446	5,281	9,913
• Coal (million tons)	1,051	2,610	5,636	10,579
• Oil (mtoe)	113	278	601	1,128
• Gas (bcm)	15	38	82	153
• Power (TWh)	126	313	676	1,269
Per Capita Energy Use (kgce)	863	1,882	3,772	6,837

Source: China Statistical Yearbook; The World Bank Joint Study Program.
Mtce: Million Tons of Coal Equivalent; **mtoe:** Million Tons of Oil Equivalent; **TWh:** (TeraWatt hours); **bcm:** Billion Cubic Meters; **kgce:** Kilograms of coal Equivalent

Slower-Growth Case

In the slower growth case (Table 6.3), GDP grows by one percentage point less per year than in the baseline case during the 1990s, and 1.5 percent less per year during 2001-2020. Total GDP in 2020 reaches only US$2.5 trillion (1990 prices), which is about 35 percent less than in the baseline scenario. Assumptions concerning economic structural change and population growth are the same as the baseline case.

TABLE 6.3

TOTAL ENERGY DEMAND: SLOWER GROWTH CASE

	1990	2000	2010	2020
Primary Energy Use (Mtce)	987	1,535	2,226	2,879
• Coal (million tons)	1,051	1,551	2,226	2,671
• Oil (mtoe)	113	176	257	370
• Gas (bcm)	15	28	63	104
• Power (TWh)	126	362	508	871
Per capita energy use (kgce)	863	1,180	1,590	1,985

Source: China Statistical Yearbook; The World Bank Joint Study Program.
Mtce: Million Tons of Coal Equivalent; **mtoe:** Million Tons of Oil Equivalent; **TWh:** TeraWatt hour; **bcm:** Billion Cubic Meters; **kgce:** Kilograms of Coal Equivalent

Although total GDP is over 30 percent less in 2020 compared to the high-growth case, energy consumption is only 10 percent less. When the economy grows more slowly, the transformation of the economy proceeds at a slower pace, and per unit energy consumption falls at a slower pace. There also is less capital investment in newer, more energy efficient plants and equipment.

High Efficiency Case

The high efficiency case is designed to assess the potential impact of a more aggressive effort to achieve advanced levels of technical energy efficiency. Compared with the baseline case, the high efficiency case assumes that advanced international levels of energy efficiency in selected key industrial sectors are achieved in China more rapidly. More effective adoption of high efficiency energy-using industrial equipment also is assumed. In the baseline case, China does not fully meet international efficiency levels in a number of industries because of difficulties in achieving economies of scale. This constraint is largely lifted in the high efficiency case. Other key assumptions, on economic growth, population growth and structural growth remain the same as the baseline case.

TABLE 6.4

TOTAL ENERGY DEMAND: HIGH EFICIENCY CASE

	1990	2000	2010	2020
Primary Energy Use (Mtce)	987	1,474	2,136	2,841
• Coal (million tons)	1,051	1,467	2,078	2,530
• Oil (mtoe)	113	174	267	410
• Gas (bcm)	15	29	65	110
• Power (TWh)	126	362	508	871
Per capita energy use (kgce)	863	1,134	1,526	1,960

Source: China Statistical Yearbook; The World Bank Joint Study Program.
Mtce: Million Tons of Coal Equivalent; **mtoe:** Million Tons of Oil Equivalent; **TWh:** (TeraWatt hour); **bcm:** Billion Cubic Meters; **kgce:** Kilograms of coal Equivalent.

FACTORS INFLUENCING FUTURE ENERGY DEMAND

As it is apparent from the above alternatives, for China to support the growth of its economy, energy consumption will need to increase substantially in China over the next 30 years. The energy demand elasticity of the economy is projected to stay in the range of 0.5 to 0.6, similar to the situation in the 1980s. Under the baseline scenario, China will surpass the United States as the largest energy consuming country in the world around 2010.

The energy demand is affected by both the level and pace of economic development. Economies at high levels of development generally need less energy to generate each unit of economic output due to high share of services and low share of energy-intensive primary industries in GDP. The speed of development also affects energy demand. In China, energy efficiency is likely to improve more rapidly with a moderate to high rate of economic growth as compared to slow rate; that is, the energy demand elasticity will be higher when economic growth is slower.

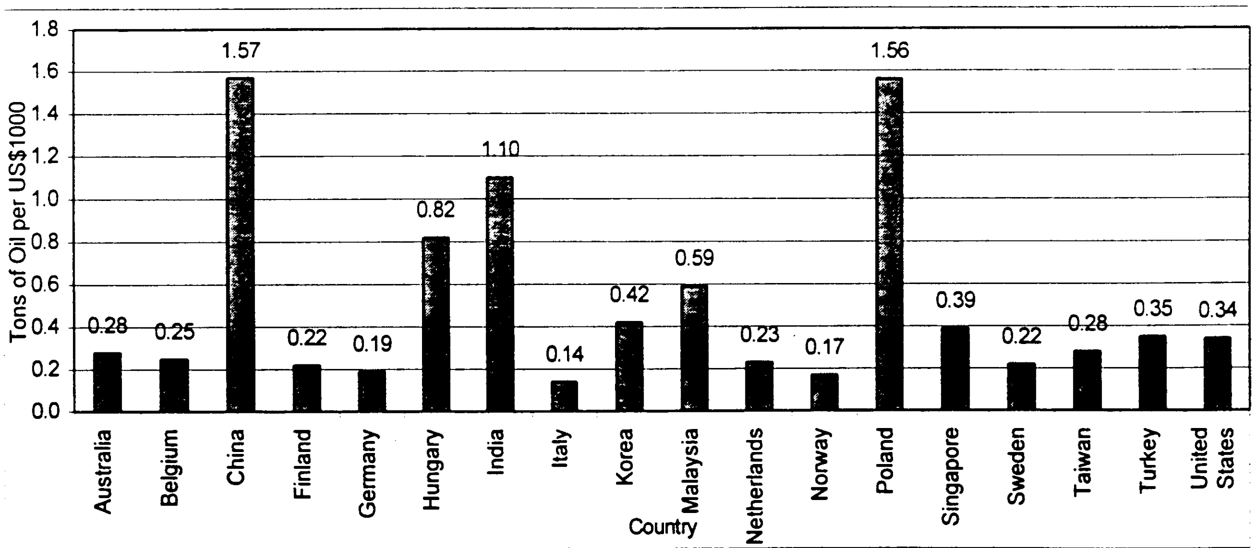
In addition, changes in broad macroeconomic structure, the relative share of agriculture, industry, and services, is not expected to have a significant impact on China's energy demand over the coming 25 years. Although agriculture's share of GDP will decline and that of services will increase, both the light and heavy industrial sectors are expected to maintain their approximate shares to satisfy the consumer demand. Under the baseline case, the overall level of energy efficiency as well as total energy demand will depend critically on the efficiency of new capital stock since the Chinese economy would be 10 times as large in the year 2020 as it was in 1990.

The efficiency of the production processes is an important factor affecting overall energy demand. However, optimizing resource allocation and utilization and efficiently organizing production have been found to be the key to reducing future energy demand. Sustained energy-conservation programs are important, but the most important energy conservation measures will be achieved through the modernization and reform of China's economy.

The high-efficiency case is a realistic possibility because of China's current energy-intensity levels compared to other developed and emerging countries. Figure 6.1 shows the energy-intensity levels of selected group of countries, and, as is apparent, China's energy-intensity level is ten times as great as that of Italy, and five times larger than that of the United States. The energy-intensity is lower in industrialized countries because, (a) energy efficiency in each individual sector is better than in developing countries, and (b) the economy is dominated by energy-efficient industries.

FIGURE 6.1

ENERGY-INTENSITY LEVELS IN SELECT COUNTRIES, 1996 (TONS OF OIL PER 1000 $US GROSS DOMESTIC PRODUCT)



Source: International Energy Agency, data of 1996. Available: http://www.iea.org/stats/files/glance.htm
Organization for Economic Cooperation and Development (OECD), data of 1997. Available: http://193.51.65.78/publications/figures/1997/
World Factbook 1997, Central Intelligence Agency (CIA), data of 1996. Available: http://www.odci.gov/cia/publications/factbook/country-frame.html
TOE: Tonnes of Oil Equivalent; **US$:** 1990 U.S. Dollar; **GDP:** Gross Domestic Product;

This implies that the first task for China is to continue to improve end-energy use efficiency. More specifically, they need to find out why energy-efficient technologies are not used as much in high energy-intensity provinces, such as Shanxi Province, as in China as a whole.

In China, energy prices are subsidized to keep them considerably below costs. In these circumstances, it is likely that an energy-intensive industrial structure will be sought, which is particularly true in Shanxi Province. As a result, the *physical* energy unit per unit of output will be higher than otherwise; however, this does not necessarily imply that energy *expenditures* per unit of output will also be higher. What matters is the investment decision in energy expenditures, not the quantity of energy used. A high energy/GDP ratio reflects an energy-inefficient outcome, but given low energy prices, it makes good business sense to have high-energy intensity. This is why the inefficient outcome is sustainable.

In order to achieve a lower ratio for energy/GDP in developing countries, energy prices should be rationalized. But this is easier said than done. Energy prices in developing countries reflect a complex mixture of economic, social, and political interdependencies. The task then is to determine means of inducing the adoption of energy-efficient technologies in a situation of low energy prices. Market competition and energy-efficiency regulations play a critical role.

Experience in Korean manufacturing industries indicates that the more industries are subject to competition, especially export competition, the higher the energy efficiency in those industries. Energy-efficiency standards are also effective and complement market competition. Industries are, however, generally reluctant to see the tightening of efficiency standards. As such, in order to realize an energy-efficient growth strategy, the following conditions must be satisfied: no energy price subsidies, market competition, and, energy-efficiency regulations (Lee, 1997).

THE ROLE OF ENVIRONMENTAL PROTECTION IN CHINA

Environmental regulations were first promulgated in China in the 1950s and 1960s, however, environmental protection did not become a major issue on the national agenda until after the United Nations Conference on Human Environment (UNCHE), held in Stockholm in 1972. The Environmental Protection Leading Group of the State Council was formed soon thereafter, in May 1974 (Qu, 1991).

A legal basis for environmental protection was established by Article II of the Constitution of the People's Republic of China, in 1978. Article II declares that "the State protects the environment and natural resources and prevents and eliminates pollution and other hazards to the public" (Qu, 1991). The Environmental Protection Law (EPL) of the People's Republic of China (PRC) and a series of related decrees were promulgated in 1979. The EPL requires that discharges comply with environmental standards and that environmental impact assessment be conducted for all environmental standards and that environmental impact assessment be conducted for all new construction projects.

Other provisions of the 1979 Environmental Protection Law established environmental protection bureaus and offices from the national to the local level, encouraged environmental research and education, allowed assessment of fines against polluters and tax advantages for those who employ pollution control measures, and gave the State Council, the highest organ of China's state administration, authority to formulate rules and regulations pertaining to environmental protection. (Sinkule, and Ortolano, 1995)

During the 1980s, attention to environmental management increased, and environmental concerns were given a higher priority on the national agenda. In 1981, the State Council issued the Decision for Strengthening Environmental Protection during the National Economic

Readjustment, a document which stressed that environmental protection should be viewed as part of economic development (Qu 1991, p.219).

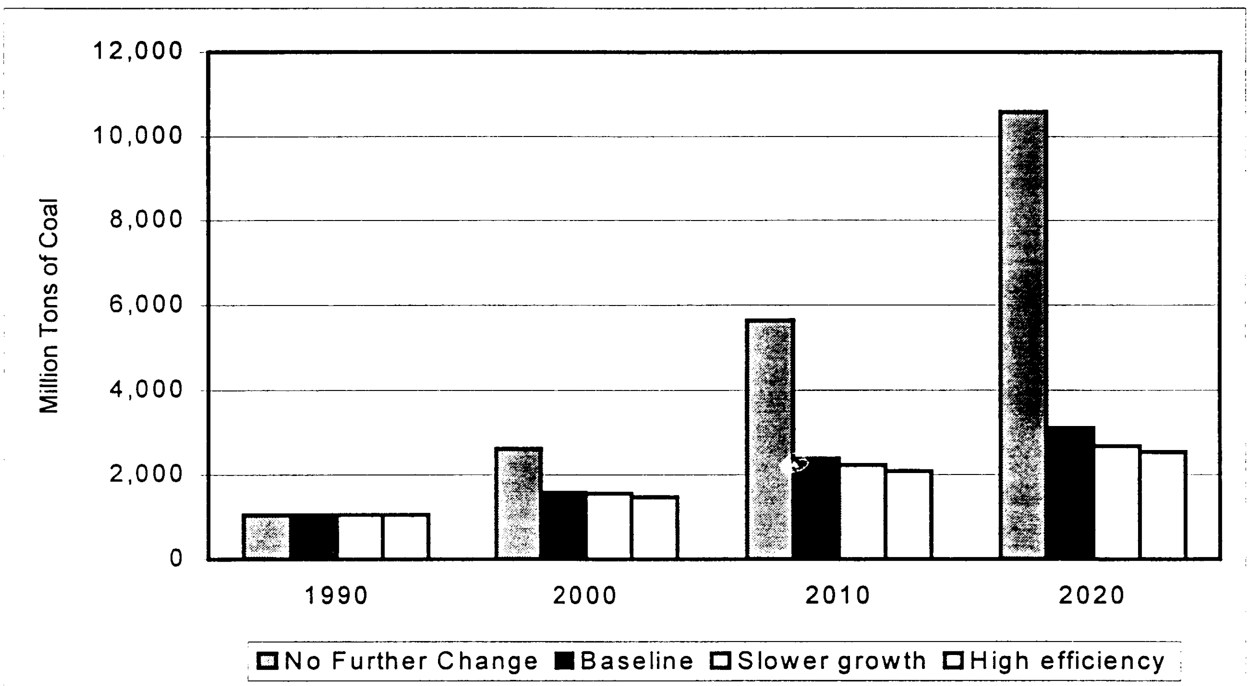
Several major environmental laws, regulations, and guidelines were issued during the 1980s. The principal differences between the Environmental Protection Laws of 1979 and 1989 have been summarized by Yu and Ma (1992). In comparison to the 1979 version, the 1989 Environmental Protection Law: (1) Expanded the authorities and responsibilities of environmental protection agencies at all levels of government; (2) Made environmental protection an explicit responsibility of each level of government; (3) Provided a statutory basis for each of the following programs: the discharge permit system, the environmental responsibility system, and annual assessment of environmental quality in cities, limited time treatment orders and centralized pollution control; and (4) Added criminal, civil, and administrative sanctions to improve the ability of environmental agencies to enforce environmental requirements (Sinkule, Barbara, J. and Leonard Ortolano, 1995).

THE ROLE OF COAL

The connection between China's future energy consumption and Shanxi Province, lies in the pivotal role of coal as the engine of China's development. As of 1998, coal supplied 75 percent of all the primary energy production in China, with Shanxi Province producing 25 percent of that amount (see Chapter 3). The same holds true in the World Bank's scenarios described above. Although China has intentions of building 50 nuclear power plants within the next 25 years, and completing of the Three Gorges Dam, both of which will increase the output of electricity from other sources, coal will continue to be the primary fuel in China. In fact, in two of the four cases, the Baseline and No Further Change, the share of coal as a percentage of all primary energy consumption increases. Figure 6.2 shows the coal consumption in each of the four cases for the years 1990, 2000, 2010 and 2020.

FIGURE 6.2

COAL CONSUMPTION UNDER FOUR CASES, 1990, 2000, 2010, 2020 (MILLION TONS OF COAL)



Source: Junfeng, Li, Todd M. Johnson, Zhou Changyi, Robert P. Taylor, Liu Zhiping, and Jiang Zhongxiao. 1995. *Energy Demand in China: Overview Report.* World Bank.

There are three patterns that can be detected from the above chart. The first and most important is that even under the most optimistic circumstances, coal consumption will double in China by the year 2020. At the same time, if the worst case unfolds, that is the current path in the no-further-change case, coal consumption will be ten times greater in 2020 than it was in 1990. The third pattern is that for other three cases, there is little difference between the amount of coal that is consumed. In other words, China can follow a number of alternatives that will result in significant decline in the rate of increase in coal consumption, as long as it does not follow the current path of development. It is extremely important to note that the current path of development has resulted in a significant decline in energy-intensity levels already; yet, this pattern does not appear to be a sustainable path of development for China.

China's coal-consumption alternatives will have significant consequences for Shanxi Province, if it continues to produce 25 percent of China's coal, and if its energy-intensity levels continue to be 1.7 times greater in coal production than that of China. In fact, under the no-further-change scenario, Shanxi Province will consume 47 times the amount of energy (in RMB) than it did in 1992; however, because Shanxi Province depends on energy production for so much of its growth, it has few options for substituting coal production with other industries. As such, Shanxi Province needs to devise plans that would allow it to remain flexible regardless of China's future development path. The single most important way in which Shanxi Province can achieve this flexibility is through expanding their options of delivering coal through a variety of means and forms. Shanxi Province officials have started a number of projects that tackles this issue. In the next section, I will give an overview of the current projects in Shanxi Province.

Transporting Coal through Electric Wires

Over the past 15 years, the province has built and upgraded about 60 thermal electric power plants, fueled by locally produced coal, bringing its electric-power generating capacity to 8,800 Mega Watts (MW). Shanxi Province generated 55 billion kilowatt-hours (kWh) in 1998, up 1.2 percent over 1997, and transmitted 11.4 billion kWh of electricity to Hebei Province, Beijing and Tianjin municipalities. In addition, Shanxi Province is planning to invest 70 billion RMB to expand 10 main power plants by 2001. Plants will be built to supply the provinces of

Shandong and eastern Juangsu, as well as Tianjin, through a 700 kilometers high-voltage power transmission line. The 1.35 billion-dollar project will be jointly funded by Chinese investors and the American Energy Sources Service from the United States. The move is part of a strategy of generating electricity at the sites of coal deposits and distributing energy to industrial coastal areas, versus the more expensive approach used to date of transporting coal by road and rail. This is due to the fact that, despite the upgrading of rail lines, Shanxi Province has had 40 to 70 million metric tons of coal stockpiled every year since 1990, and the coal mines operate at 25 percent below capacity because of inadequate railway transport (Power in Asia, 1995; Asia Pulse, 1999; Singapore Business Times, 1998).

Highway, Railway and Coal-Slurry Pipeline Transportation of Coal

Since 1996, 22 highway-construction joint ventures have been set up in Shanxi Province, the investment coming from the United States, South Korea, Australia and Hong Kong, which has reached 347 million dollars, with 184 million dollars of investment in 1998 alone. Furthermore the State Council has approved a 2 billion dollar, 590 kilometer railway line between Shanxi Province and Hebei Province, to be completed in 2001. The line is meant to bring the coal from Shanxi Province to Huanghua Port, in Hebei Province, which is a 400 million dollar port that will be completed by 2003 (Singapore Business Times, 1996; Cbnet, 1999).

In addition, China is planning to build an 890 million dollar coal-slurry pipeline from the coal mines of Shanxi Province to the Shandong peninsula. The pipeline project includes a 720-mile underground pipeline, a 150 million dollar coal-cleaning plant, and port facilities. The pipeline will be the longest worldwide for transporting liquefied coal, and is due to start operating in the year 2000. The China Pipeline Holdings Ltd., the holding company of pipeline project, will be jointly formed by an international consortium led by Custom Coals of Pittsburgh, Pennsylvania, which will own 47 percent of the project. The Chinese government will own the rest through its China Coal Construction and Development Corporation. The Consortium's interest will transfer to the Chinese government in 50 years. The pipeline is designed to carry 15 million metric tons of clean coal slurry from Shanxi Province to power plants in Shandong peninsula (Wall Street Journal, 1994; Singapore Business Times, 1997).

MACRO-LEVEL DEVELOPMENT OPTIONS

In Chapter 5, I showed where the greatest differentials in energy-efficiency levels exist between Shanxi Province and China. As such, on the sectoral level, it is important for Shanxi Province officials to close the gap among the sectors that have the largest gaps. Technology and knowledge transfer among the various provinces and central government is critical for reducing this gap. In addition, I have shown that transportation bottlenecks and inefficiencies play a critical role in contributing to the large-energy intensity differentials, and earlier I showed what Shanxi Province is doing to alleviate some of the inadequacies of the Province's transportation system.

Although sectoral changes and improvements will be critical to improving the overall energy-intensity levels in Shanxi Province, it is imperative to look at the macroeconomic development in Shanxi Province. The macroeconomic elements include institutions such as financing, labor, infrastructure and the business environment. Because one of my recommendations in this paper has been the idea of transferring knowledge among the 30 provinces, it is just as important to look at regional economic development, and provide a viewpoint from which to analyze and evaluate future regional development strategies. There are ten factors in three categories for the development of Shanxi Province that requires consideration, which are listed below.

1. Reform-related
   - Establishment and promotion of market systems, including but not limited to, price-system reform, and improvement of the united market.
   - Reform of SOEs, by introducing the contract and stock system, and restructuring of companies with large fiscal deficits.
   - Development of non-state-owned industries, by providing guidance for TVEs, along with foreign-affiliated and personal businesses.
   - Development of strategies within regions, by creating regional strategies, and clarifying and improving the relationship between the central, and regional governments.
2. Pertaining to openness
   - Strengthening foreign trade, by promoting exports.
   - Open-door policy for the regions, by creating a healthy environment for foreign capital investment.
3. Pertaining to input elements
   - Improving the financing policy by promoting investment, and securing investment funds.
   - Improving the quality of the workforce, by promoting education, and scientific research, and emphasizing human resources.
   - Preparation of the economic infrastructure, by developing traffic, telecommunication, energy, and urban functions.
   - Preserving the environment, by rational development of natural resources, processing household and industrial waste water, and improving the living environment.

These factors cover both the facets of system and of input elements. They show a means to solve the issues facing Shanxi Province, by looking at some of the success stories of other provinces in China. Concepts that these factors reveal to us concerning regional development strategy include the following:

1. Transitions to the market economy on the regional level: Through the successful experience of the coastal areas, reform and openness policies are the most critical conditions for the market economy. Especially in Shanxi Province, one of the reasons for the current economic slump is that reform and openness policies in the Southeast coastal regions were not applied there from the start. However, whether the market economy transition experiences of the Southeast can be repeated in Shanxi Province is a critical issue for the development of those areas.

2. Incorporating regional economies into the global economy: The rapid economic growth in the coastal regions is being fueled by trade expansion and the incorporation of foreign capital. By further freeing Shanxi Province's economy and incorporating it into the world's economy, not only could the world's resources, technologies, and markets be accessible, but Shanxi Province's economy would receive a boost. The ability to receive direct investment from foreign countries should be granted especially to urban areas of medium or larger scale. This, and implementing open-door policies that have effectively been applied in the coastal regions, would doubtless give an opportunity for more economic growth.

3. Clarifying the roles of central and Shanxi Province government: The relationship between the central and regional governments is an important factor in regional development; yet the roles each will bear must be clarified. Once Shanxi Province's financial power grows through reform and openness policies, the central government's control will weaken. As such it is important to strengthen the capacity of the central government to adjust regional economies by,

(1) converting government function and role, through the *gradual* withdrawal of government from administrative function as the market economy makes a transition, and (2) by strengthening central financing.

4. Eliminating regional disparity and implementing a regional development strategy that emphasizes building infrastructure and environmental preservation: Growing regional disparities, the delay in improving infrastructure, and a worsening environment are key issues in modern China's regional development. The same level of reform and openness seen in the coastal regions should be put into effect in inland regions as well, and the focus of regional development should be shifted gradually inland. Funding and infrastructure improvements in these regions is vitally important. In addition, classification of the position of environmental preservation should be made clear in the context of regional development, as one of the issues is an urgent improvement and enhancement of the legal system. As such, implementation of a regional, rather than provincial, development strategy, which will clearly solve this issue is required.

CONCLUSION

The above factors—further economic reform, decreasing regional disparities, clarifying the roles of Shanxi Province and Central governments, and further incorporating Shanxi Province's economy into the global economy—are critical for the future development of Shanxi Province. However, what is even more important for Shanxi Province officials is to make strategic decisions that take into account the scarcity of resources, environmental limitations, particularly in terms of air pollution and severe water resources, and employment issues. Shanxi Province will continue to be the coal center of China, given its 230 billion metric tons of proven reserves, which is one-third of all the proven reserves in China (Power in Asia, 1995).

Furthermore, coal will continue to play a major role in China's energy future, even with the increasing role of nuclear and hydropower energy sources. Even more important, Shanxi Province will continue to rely on coal, and coal products, including electricity, for much needed income and investment opportunities. Therefore, coal consumption, production, and energy-intensity levels in Shanxi Province will most likely continue to be above China's levels. As such, it is imperative that Shanxi Province tackles the specific economic sectors where there is the greatest room for improvement, invests in improving its transportation infrastructure, and creates more value from its main resource by utilizing coal's byproducts and the services that coal provides more thoroughly and efficiently.

CHAPTER 7

SUMMARY AND CONCLUSION

Energy plays a critical role in modern society. It is a necessity in our daily life, helping to cook our food, light our houses, power our appliances, keep us warm in the winter, and cool in the summer, and fuel our vehicles. Energy is also a fundamental input to the economy. It is essential for growing crops, mining ores, manufacturing products, transporting material input, and output, constructing facilities, and delivering services (Office of Technology Assessment (OTA), 1990). The consumption of energy, however, has costs as well. These include the capital, labor, and natural resources devoted to obtaining energy, which, therefore, are not available for other purposes, and the growing negative environmental, and sociopolitical impacts of energy supply and use (Holdren, 1992).

There was a belief among energy analysts (e.g., Holdren, 1992) that because the costs of supplying and consuming energy were increasing in the 1970s, that the world would embark on a transition to costlier energy. Although, the big jump in the price of fossil fuels sparked the move toward energy conservation worldwide, the overall price of oil is now at one of its lowest levels ever. In addition, there does not appear to be a crisis in terms of running out of fossil fuels. With improvements in extraction technology, and better methods to discover new sources of fossil fuels, the world has now as much proven reserves of fossil fuels as it did in the 1970s. As such, the driving force behind energy conservation is no longer energy prices. However, there are at least two reasons why energy-efficiency improvements will continue. The first is the fact that the environment's assimilative capacity to absorb pollution is diminishing. In the area of energy consumption, this is most visible in the problem of climate change. Although there is still a great deal of uncertainty regarding the reality of this change, and its magnitude, we do know for certain that the carbon dioxide (CO_2) levels in the atmosphere have increased from 250 parts per million (ppm) to 330 ppm since the beginning of the industrial age (Intergovernmental Panel on Climate Change (IPCC), Working Group I, 1995). In addition, the average global temperature has been increasing steadily during the past twenty years, with 1998 being the warmest year on record (National Oceanic and Atmospheric Agency (NOAA), 1999). What this implies is that there may eventually be firm restrictions on the amount of CO_2 that is emitted by individual countries, which may be accomplished through the introduction of a carbon tax, or fines.

The second driver behind continued energy-efficiency improvements is the globalization of trade and commerce. The increase in the level of competition is making it imperative for companies to reduce their production costs as much as possible, in order to be able to compete on the global level. This can be done in two ways: for the governments to subsidize energy prices, or to decrease energy inputs per unit of output. In almost every case where energy prices are subsidized, there are fewer incentives for industries to improve their technologies and processes. In short, what matters is the investment decision in energy expenditures, not the quantity of energy use. A high energy/GDP ratio reflects an energy-inefficient outcome, but given low energy prices, it makes good business sense to have high-energy intensity. This is why inefficiencies persist (Lee, 1997).

As I showed in this study, energy-efficiency improvements have been the primary factor behind decreasing energy-intensity levels in both China and Shanxi Province, albeit in different sectors. In Shanxi Province, the sector most responsible for decreasing energy-intensity levels was the transportation sector, while in China it was the heavy-industrial sector. Although there have been dramatic improvements in energy-intensity levels in both, there remains significant room for improvement when compared with other countries. As I showed in Chapter 6, China's energy consumption per GDP was 10 times greater than that of Italy and five times greater than that of the United States. Even more dramatic though, are the differences in energy-intensity levels between Shanxi Province and China. In almost every sector that I analyzed in Chapter 5, Shanxi Province spent more Renminbi of energy, particularly coal, than China, in some cases, by a factor of two.

Although there is a great deal of potential for improving the energy-intensity levels in China and Shanxi Province, it is difficult to determine how much of this potential will be or can be actually realized, and how soon. The reason is that there are many economic, institutional, informational, and technological barriers to energy efficiency. Energy conservation, often viewed as an easy "soft path," is, in fact, a difficult and complex path. It involves all sectors of the economy and requires a strong societal commitment (Polenske and Lin, 1993). Assessing past energy-conservation experiences will help us understand how far energy efficiency can be pushed, and where the push needs to be the hardest (Schipper and Meyers, 1992). In this study, understanding the economic sectors in Shanxi Province that need the most level of improvement as compared to China, allows us to concentrate our efforts on the sectors that need the most help.

SUMMARY OF RESEARCH FINDINGS

Before summarizing our findings, we need to reiterate two caveats associated with our efforts to analyze the differences in energy-intensity levels between Shanxi Province and China. First, although we were using the official input-output tables, and data from State Statistical Bureau, the quality of the data can at times be questioned. Therefore, the numbers we present here should be interpreted as an indication of a general pattern of energy-use differences, rather than as an exact estimate of different contributing components. Second, we conducted the Spatial Structural Decomposition Analysis (SSDA), at an aggregated 33 economic sectors. Although, we felt that this level of aggregation gave us general patterns, it may nonetheless be too high of an aggregation to capture some important changes in specific industries and specific production processes. We must take this into consideration when we discuss changes in production technology and final-demand pattern and distribution.

With that caveat in mind, Tables 7.1, and 7.2 show the results of the shift-share analysis from Chapter 4, which was included in Appendix 4.B, and Table 7.3 shows the summary results of the structural decomposition analysis from Chapter 5.

TABLE 7.1

SHIFT-SHARE ANALYSIS OF TOTAL ENERGY-INTENSITY IN CHINA'S MATERIAL PRODUCTION SECTOR, 1986-1995

GRAMS OF STANDARD COAL EQUIVALENT PER CONSTANT 1980 RMB OF OUTPUT

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
ACTUAL ENERGY INTENSITY	**414.2**	**382.7**	**352.9**	**351.5**	**335.7**	**315.4**	**272.6**	**257.8**	**255.6**	**246.7**
INDUSTRIAL MIX	**6.9**	**0.4**	**7.6**	**17.8**	**-7.7**	**4.9**	**24.1**	**-7.4**	**3.6**	**2.3**
EFFICIENCY SHIFT	**-14.0**	**-32.0**	**-37.3**	**-19.2**	**-8.1**	**-25.1**	**-66.9**	**-7.5**	**-5.8**	**-11.2**
CONSTANT SHARE	**421.2**	**406.4**	**382.7**	**352.9**	**351.5**	**335.7**	**315.4**	**272.6**	**257.8**	**255.6**
DISCREPANCY	**0.0**	**7.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Source: Shift-Share Analysis Calculations.
RMB: Renminbi, Chinese currency = 0.125 $US.

TABLE 7.2

SHIFT-SHARE ANALYSIS OF TOTAL ENERGY-INTENSITY IN SHANXI PROVINCE'S MATERIAL PRODUCTION SECTOR, 1986-1995

GRAMS OF STANDARD COAL EQUIVALENT PER CONSTANT 1980 RMB OF OUTPUT

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
ACTUAL ENERGY INTENSITY	**1129.82**	**1075.36**	**1005.56**	**1036.98**	**976.45**	**955.43**	**904.00**	**795.00**	**721.11**	**704.32**
INDUSTRIAL MIX	**13.66**	**-37.30**	**-12.13**	**10.27**	**2.97**	**43.07**	**18.86**	**24.01**	**4.09**	**1.46**
EFFICIENCY SHIFT	**-67.73**	**-17.15**	**-57.67**	**21.15**	**-63.50**	**-64.08**	**-70.30**	**-133.00**	**-77.97**	**-18.25**
CONSTANT SHARE	**1183.89**	**1129.82**	**1075.36**	**1005.56**	**1036.98**	**976.45**	**955.43**	**904.00**	**795.00**	**721.11**
DISCREPANCY	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Source: Shift-Share Analysis Calculations.
RMB: Renminbi, Chinese currency = 0.125 $US.

TABLE 7.3

SPATIAL STRUCTURAL DECOMPOSITION ANALYSIS OF CHINA AND SHANXI PROVINCE ENERGY-USE DIFFERENCES (%)

Source	Percent
Final Demand Shift	
• Changes in Distribution Effect	0.5
• Changes in Pattern Effect	12.2
Production Technology Change	
• Changes in Energy Sectors	89.1
• Changes in Nonenergy Sectors	455.7

Source: SSDA calculations from 1992 China and Shanxi Province Input-output Tables.

There is an important point to remember when analyzing the above tables, and that is the fact that in this case, SSA and SSDA are examining different things. SSA is measuring energy-intensity changes across time in *physical* energy units, in this case, grams of standard coal per 1980 constant RMB. The SSDA is examining the underlying factors behind energy-intensity levels in terms of RMB of energy input, per RMB of final demand in case of final-demand shifts, and RMB of energy input per RMB final output in terms of technological changes. Although the actual values are very different, both analysis show the same trends, differences in energy efficiency is the primary reason behind discrepancies in energy-intensity levels between Shanxi Province and China.

To summarize, Tables 7.1 and 7.2 show the significant differences in overall energy-intensity levels between Shanxi Province and China. Although both showed significant improvements during this ten-year period, Shanxi Province consistently had energy intensity levels 3 times as great as that of China as a whole. Furthermore, in almost every year, in both regions, the primary reason behind improvements in decreasing energy intensity was a shift in energy efficiency, due to the growth of the economy, and the introduction of new technologies.

Furthermore, as I showed in Chapter 4, the sector most responsible for this shift was the heavy-industrial sector in China, and the transportation sector in Shanxi Province.

Table 7.3 shows the summary results of SSDA. The same trend is visible here. In 1992, only 12.8 percent of the differences in RMB of energy input could be attributed to changes in final demand, almost all of which could be attributed to the fact that final users in Shanxi Province consumed products from more energy-intensive economic sectors. Less than half a percent of the final demand shift can be attributed to the different rate of growth of the five final demand sectors between Shanxi Province and China; however, the final-demand shift played an insignificant role in the overall difference between them. Production technology differences in the five energy sectors accounted for almost ninety percent of the difference, while the differences in the 28 nonenergy sectors accounted for over 450 percent of the 545 percent of total differences. In short, production-technology difference easily dwarfed the contribution of the final-demand shifts.

In closing, we believe that it would be important to undertake further research in regional energy-intensity disparities not only among the various provinces in China, but also between China, and other industrialized, and emerging countries, in particular, India. China and India combined, represent a third of the population of the planet, and India is prime for economic growth that could rival that of China's. However, given India's rapid population growth, which is expected to surpass that of China within twenty years, along with modest economic growth, energy consumption in India will likely increase an even more rapid pace. Therefore, it is imperative that we understand the factors behind those energy-intensity levels. We just hope that our study has improved the empirical and methodological foundation upon which to conduct further research and that it will contribute to the formation and implementation of a sustainable energy strategy in Shanxi Province, and China as a whole.

APPENDIX 1.A

CHINA AT A GLANCE

CHINA AT A GLANCE

Poverty and Social Statistics: China, East Asia and Pacific, and Lower-Middle Income Countries

1997	China	East Asia and Pacific	Lower-Middle Income
Population (millions)	1,227.2	1,753	2,282
GDP per capita, ($ U.S.)	860	970	1,230
GDP, (billion $ U.S.)	1,055.4	1,707	2,818
Average Annual Growth, 1991-1997			
Population (%)	1.1	1.3	1.2
Labor force (%)	1.1	1.4	1.3
Most Recent Estimate, 1991-1997			
Poverty (% below national PL)	7	NA	NA
Urban population (% of population)	32	32	42
Life expectancy at birth (years)	70	68	69
Infant Mortality (per 1,000 LB)	32	38	36
Child malnutrition (% of children under 5)	16	16	NA
Access to safe water (% of population)	90	84	84
Illiteracy (% of population age 15+)	19	17	19
Gross primary enrollment (% of school-age pop.)	120	118	114
Male	121	120	116
Female	120	119	113

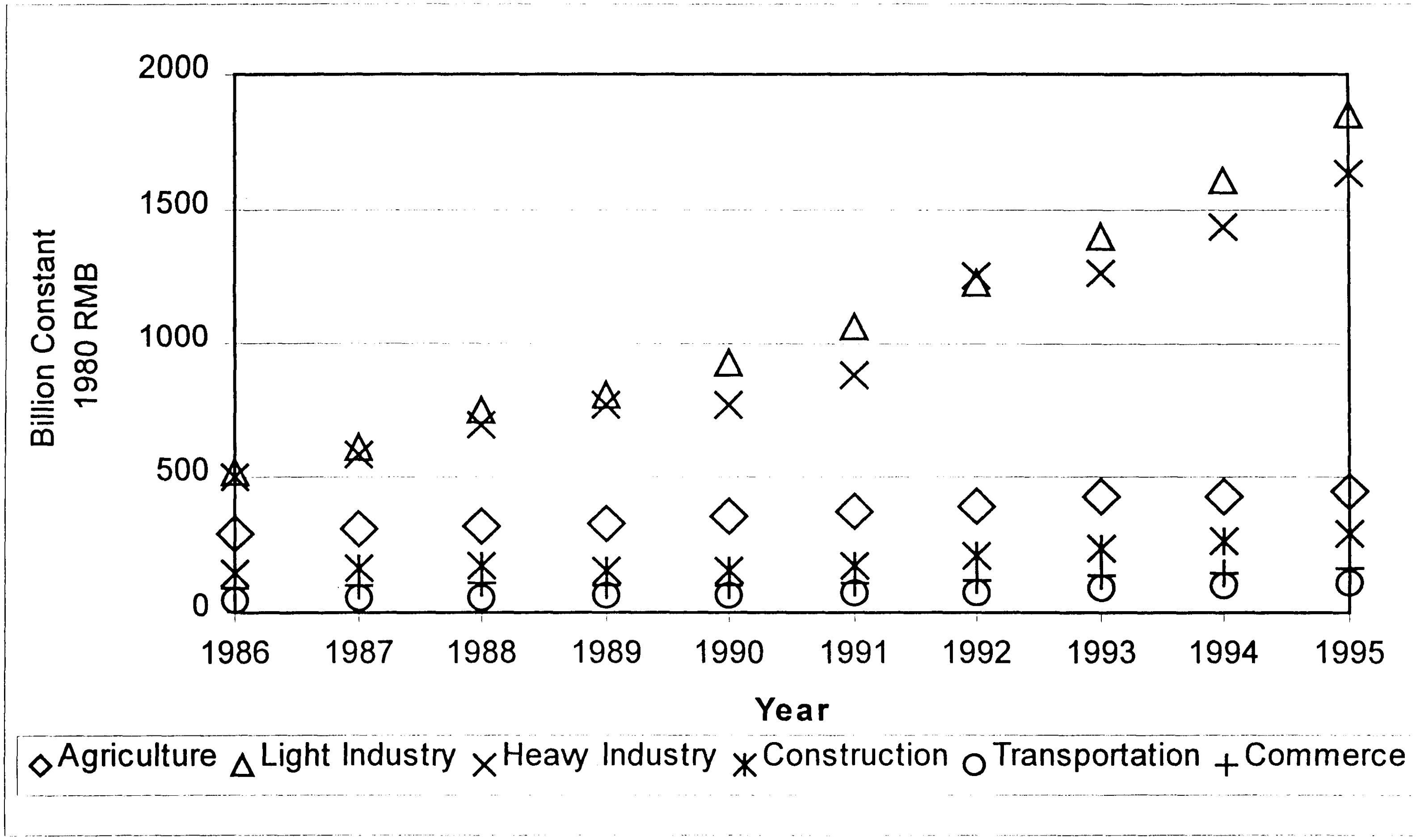
Source: The World Bank Development Economics Database, *1997*.
GDP: Gross Domestic Product; **pop.:** population;
NA: Not Available.

APPENDIX 3.A

TOTAL AND COMPOSITION OF GROSS OUTPUT
SHANXI PROVINCE AND CHINA

FIGURE 3.A.1

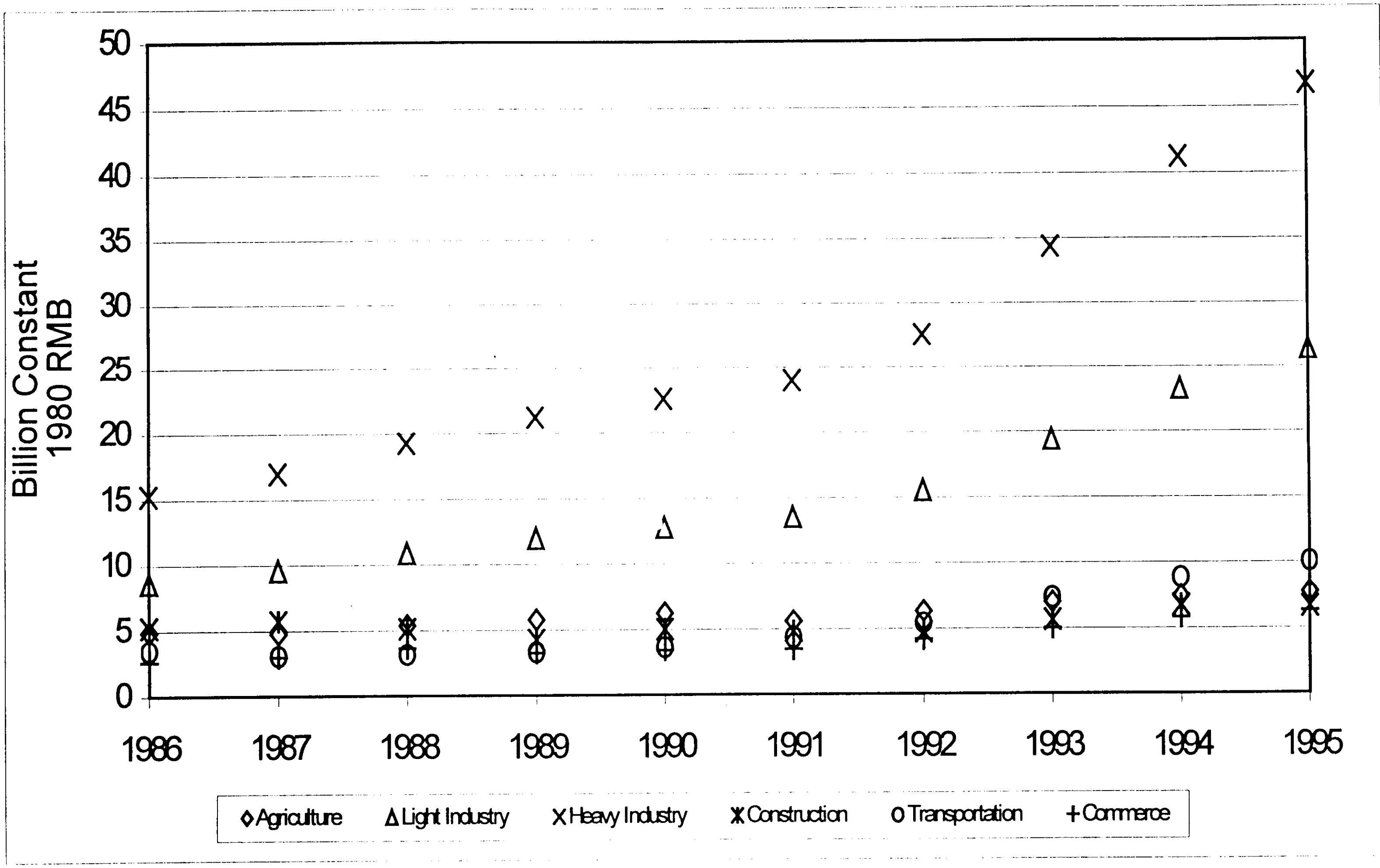
GROSS OUTPUT OF MATERIAL-PRODUCTION SECTORS, CHINA, 1986-1995 (BILLION CONSTANT 1980 RMB)



Source: China Energy Databook, 1996, Jonathan E. Sinton et. al. Editors. p. X-15. China Statistical Yearbook, 1989, p. 39.
RMB: Renminbi, the Chinese currency, which is about 0.125 U.S. Dollar.

FIGURE 3.A.2

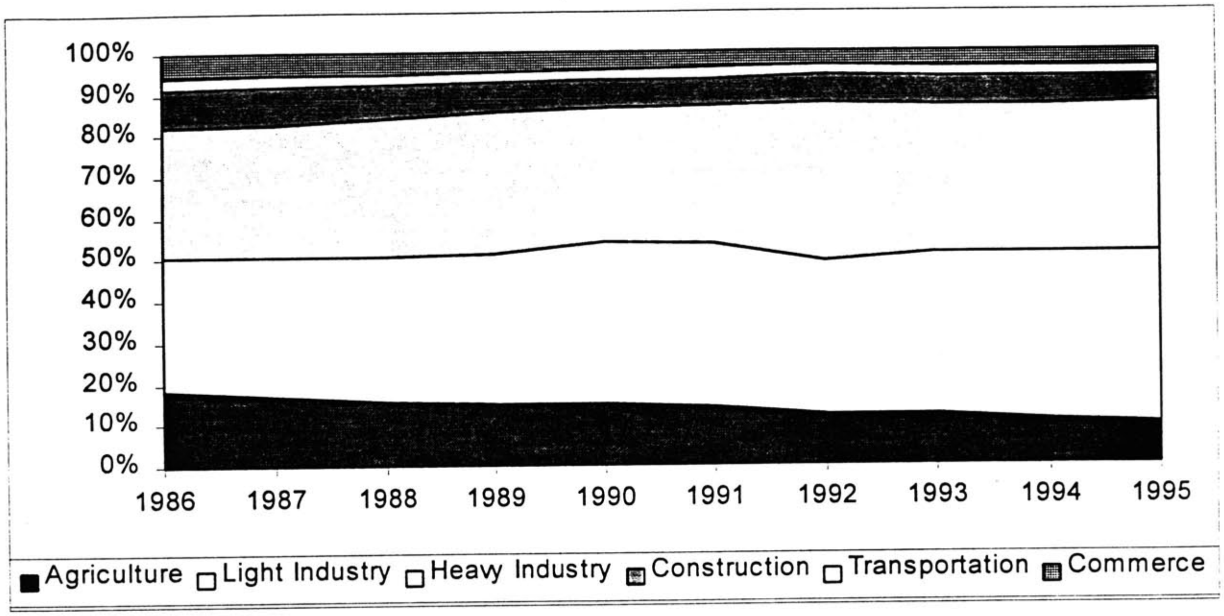
GROSS OUTPUT OF MATERIAL PRODUCTION SECTORS, SHANXI PROVINCE (BILLION CONSTANT 1980 RMB)



Source: Gross Domestic Product of China, 1952-1995, pp. 192-199; China Provincial Statistics, 1949-1989, pp. 66-67.
RMB: Renminbi, the Chinese currency, which is about 0.125 U.S. Dollar.

FIGURE 3.A.3

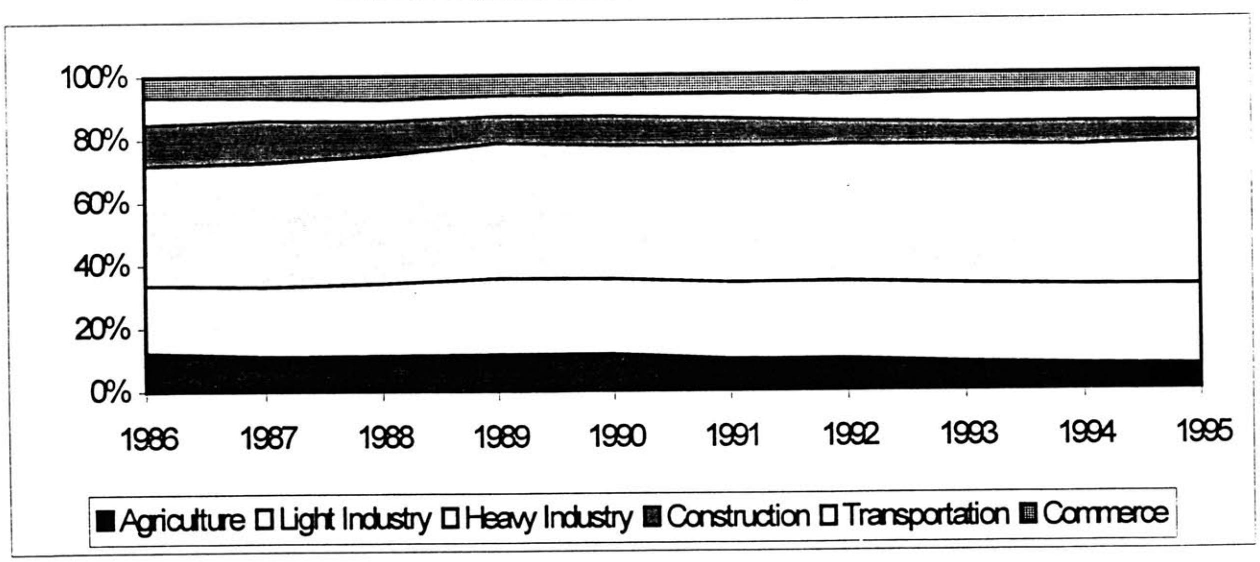
COMPOSITION OF GROSS OUTPUT OF THE MATERIAL-PRODUCTION SECTORS, CHINA, 1986-1995



Source: China Energy Databook, 1996, Jonathan E. Sinton et al. Editors, p. X-15; China Statistical Yearbook, 1989, p. 39.

FIGURE 3.A.4

COMPOSITION OF GROSS OUTPUT OF THE MATERIAL-PRODUCTION SECTORS, SHANXI PROVINCE, 1986-1995



Source: The Gross Domestic Product of China, 1952-1995, pp. 192-199; China Provincial Statistics, 1949-1989, pp. 66-67.

TABLE 3.A.1
THE GROWTH RATE OF THE OUTPUT AND ENERGY CONSUMPTION OF THE MATERIALS-PRODUCTION SECTORS, CHINA, 1986-1995

	1986		1987		1988		1989		1990		1991		1992		1993		1994		1995	
	Output	Energy	Output	Energy	Output	Energy	Output	Energy	Output	Energy	Output	Energy	Output	Energy	Output	Energy	Output	Energy	Output	Energy
Ag.	3	5	6	5	4	5	3	1	8	2	4	5	6	-2	8	5	1	7	4	8
LI	13	7	19	14	22	7	7	2	15	1	15	2	15	11	15	7	15	13	15	11
HI	10	6	17	7	19	7	10	6	0	2	15	7	43	6	0	2	14	12	14	9
Const.	14	-6	10	3	7	-8	-12	10	0	-5	10	5	25	9	14	-5	8	2	11	-1
Trans.	11	8	11	3	13	5	11	4	5	1	6	5	8	6	17	4	11	7	10	4
Comm.	11	8	10	10	9	19	-6	12	-4	3	8	2	8	12	21	34	8	-3	10	9
Total	10	6	14	7	16	7	5	5	7	2	12	6	23	6	9	3	12	11	13	9

TABLE 3.A.2
THE GROWTH RATE OF THE OUTPUT AND ENERGY CONSUMPTION OF THE MATERIALS-PRODUCTION SECTORS, SHANXI PROVINCE, 1986-1995

	1986		1987		1988		1989		1990		1991		1992		1993		1994		1995	
	Output	Energy	Output	Energy	Output	Energy	Output	Energy	Output	Energy	Output	Energy	Output	Energy	Output	Energy	Output	Energy	Output	Energy
Ag.	8	-6	-3	-7	13	-6	7	6	8	-13	-11	0	14	-5	10	14	6	6	4	12
LI	8	-1	11	1	13	1	10	3	6	-8	8	10	15	12	25	-4	20	4	13	2
HI	9	8	7	6	15	6	11	15	6	0	6	-2	13	8	27	11	19	6	15	8
Const.	1	-20	9	-7	-11	-17	-17	-5	18	-6	-4	11	-1	7	19	35	19	27	-2	28
Trans.	12	1	-12	6	3	4	4	-3	10	12	20	4	24	8	36	-2	20	3	14	1
Comm.	19	75	13	37	22	33	33	62	6	7	1	1	21	30	20	29	16	18	9	20
Total	6	1	7	2	10	3	3	8	8	2	4	2	14	8	23	9	18	7	11	9

Source: China Energy Databook, 1996, Jonathan E. Sinton et al. Editors, p. X-15; China Statistical Yearbook, 1989, p. 39; The Gross Domestic Product of China, 1952-1995, pp. 192-199; China Provincial Statistics, 1949-1989, pp. 66-67.

Ag.: Agriculture; **LI:** Light Industry; **HI:** Heavy Industry; **Const.**: Construction; **Trans.**: Transportation; **Comm.**: Commerce.

TABLE 3.A.3

THE GROWTH RATE OF THE OUTPUT AND ENERGY CONSUMPTION OF MATERIAL PRODUCTION SECTORS, CHINA AND SHANXI PROVINCE, 1986-1995

	China (1986-1995)		Shanxi Province (1986-1995)	
	Output (percent)	Energy Consumption (percent)	Output (percent)	Energy Consumption (percent)
Agriculture	52	30	45	-2
Light Industry	258	90	231	19
Heavy Industry	228	73	211	88
Construction	96	9	28	23
Transportation	141	47	223	38
Commerce	83	145	187	1229
Total	182	71	174	63

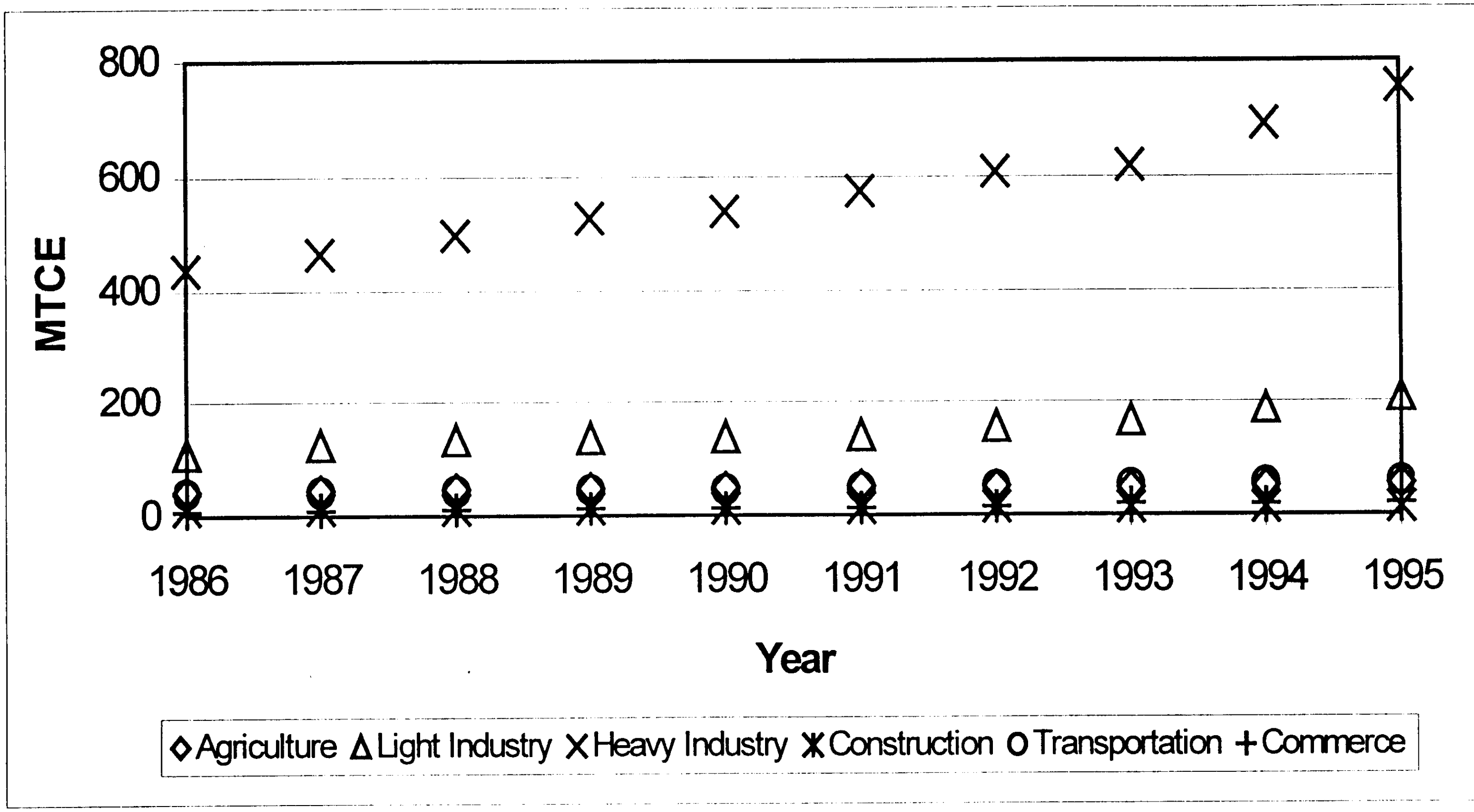
Source: China Energy Databook, 1996, Jonathan E. Sinton et al. Editors, p. X-15; China Statistical Yearbook, 1989, p. 39; The Gross Domestic Product of China, 1952-1995, pp. 192-199; China Provincial Statistics, 1949-1989, pp. 66-67.

APPENDIX 3.B

ENERGY CONSUMPTION TRENDS
SHANXI PROVINCE AND CHINA

FIGURE 3.B.1

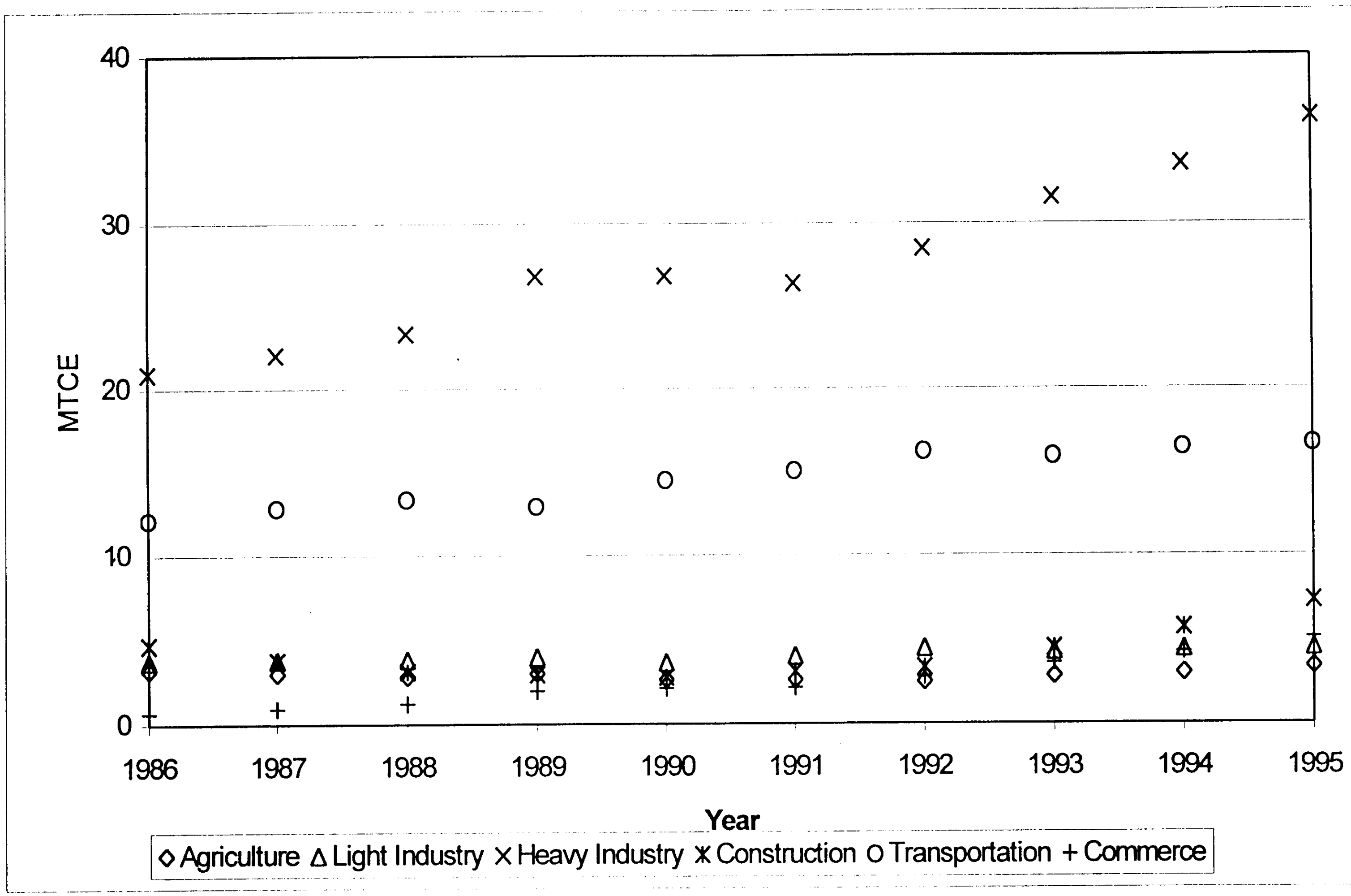
ENERGY CONSUMPTION OF THE MATERIAL PRODUCTION SECTORS, CHINA, 1986-1995 (MILLION TONS OF COAL EQUIVALENT (MTCE))



Source: China Energy Statistical Yearbook, 1991, pp. 205-206; China Energy Annual Review, 1996, p. 95; Polenske, Karen R. and Xiannuan Lin, *Conserving Energy to Reduce Carbon Dioxide Emissions in China*, p. 253; China Statistical Yearbook, 1997, p. 216; China Energy Annual Review, 1994, p. 131.
MTCE: Million Tons of Coal Equivalent.

FIGURE 3.B.2

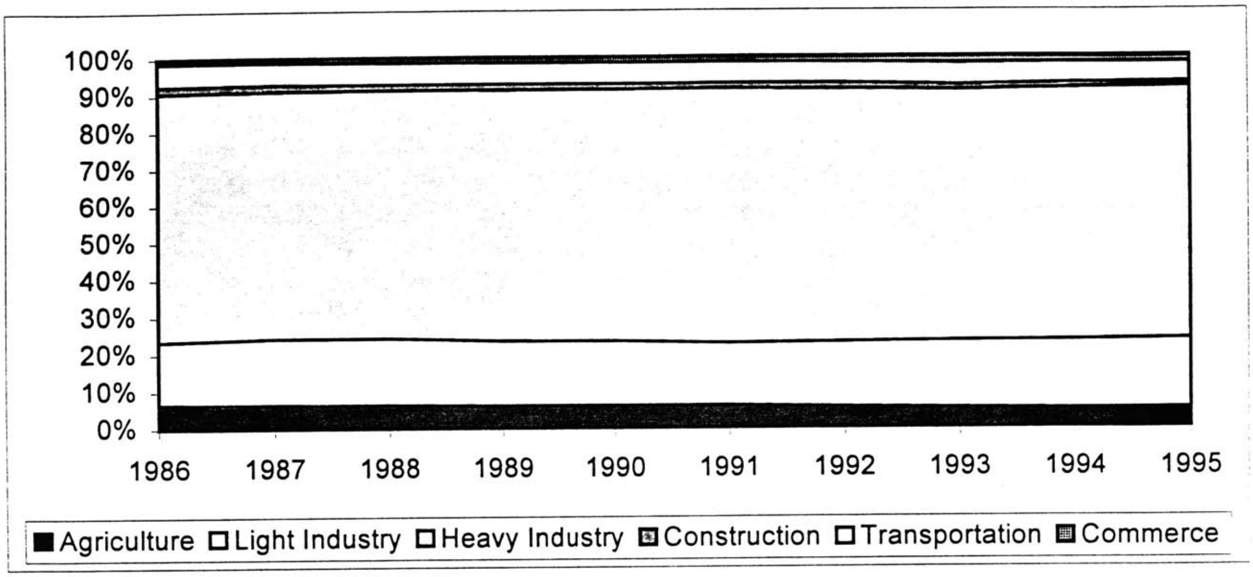
ENERGY CONSUMPTION OF THE MATERIAL PRODUCTION SECTORS, SHANXI PROVINCE, 1986-1995 (MILLION TONS OF COAL EQUIVALENT (MTCE))



Source: Shanxi Province Statistical Yearbook, 1993 Edition, p. 444; Shanxi Province Statistical Yearbook, 1997 Edition, p. 120.
MTCE: Million Tons of Coal Equivalent.

FIGURE 3.B.3

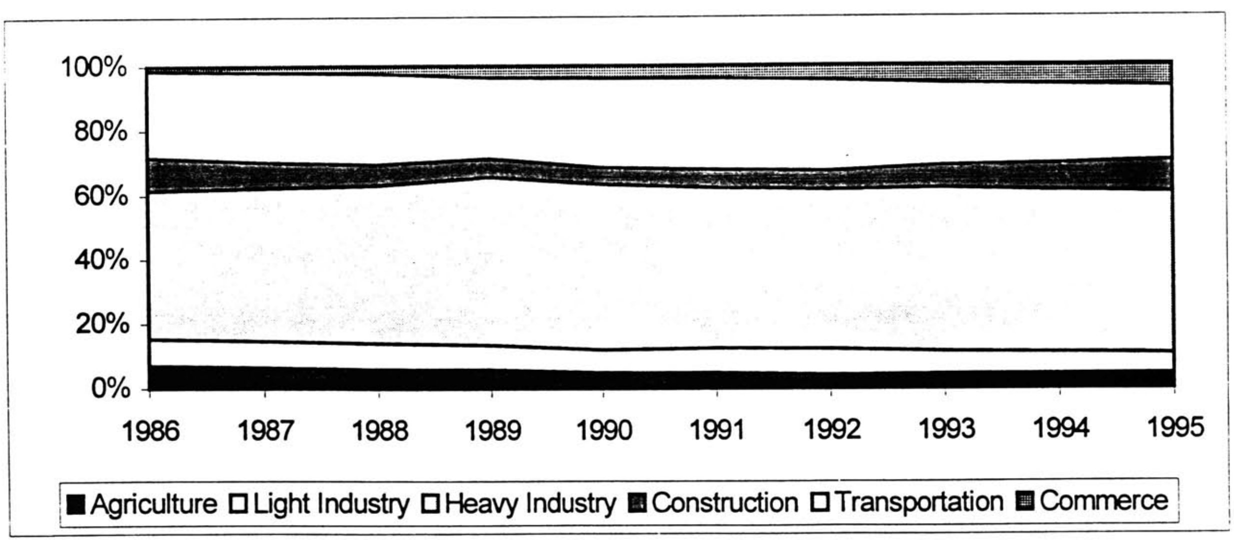
COMPOSITION OF ENERGY CONSUMPTION OF MATERIAL PRODUCTION SECTORS, CHINA, 1986-1995



Source: China Energy Statistical Yearbook, 1991, pp. 205-206; China Energy Annual Review, 1996, p. 95; Polenske, Karen R. and Xiannuan Lin, *Conserving Energy to Reduce Carbon Dioxide Emissions in China*, p. 253; China Statistical Yearbook, 1997, p. 216; China Energy Annual Review, 1994, p. 131.

FIGURE 3.B.4

COMPOSITION OF ENERGY CONSUMPTION OF MATERIAL PRODUCTION SECTORS, SHANXI PROVINCE, 1986-1995



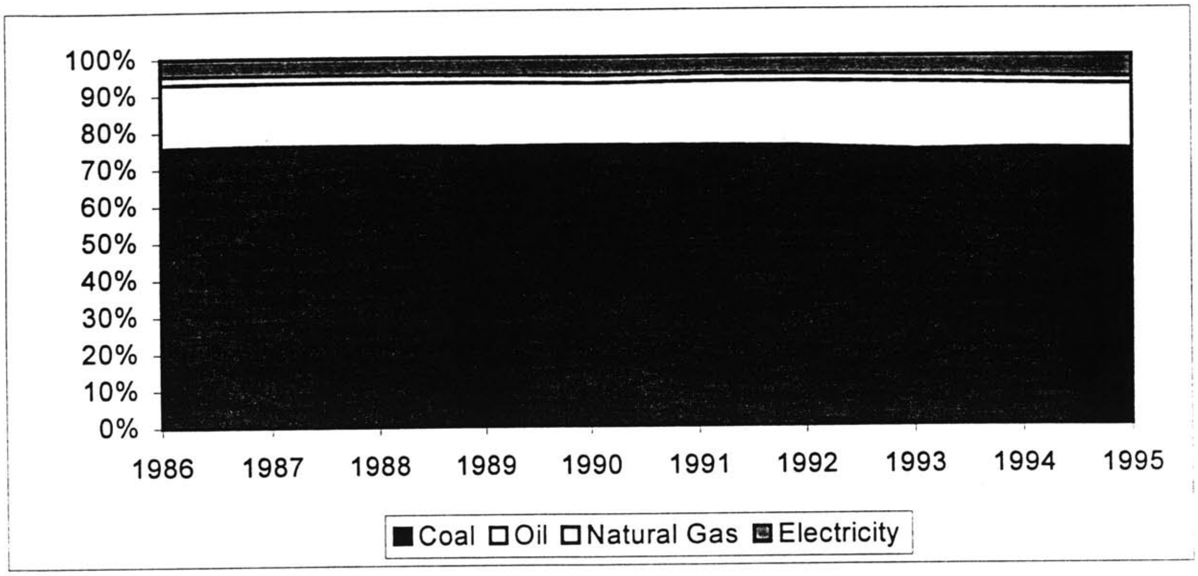
Sources: Shanxi Province Statistical Yearbook, 1993 Edition, p. 444; Shanxi Province Statistical Yearbook, 1997 Edition, p. 120.

APPENDIX 3.C

ENERGY CONSUMPTION BY ENERGY SOURCE
SHANXI PROVINCE AND CHINA

FIGURE 3.C.1

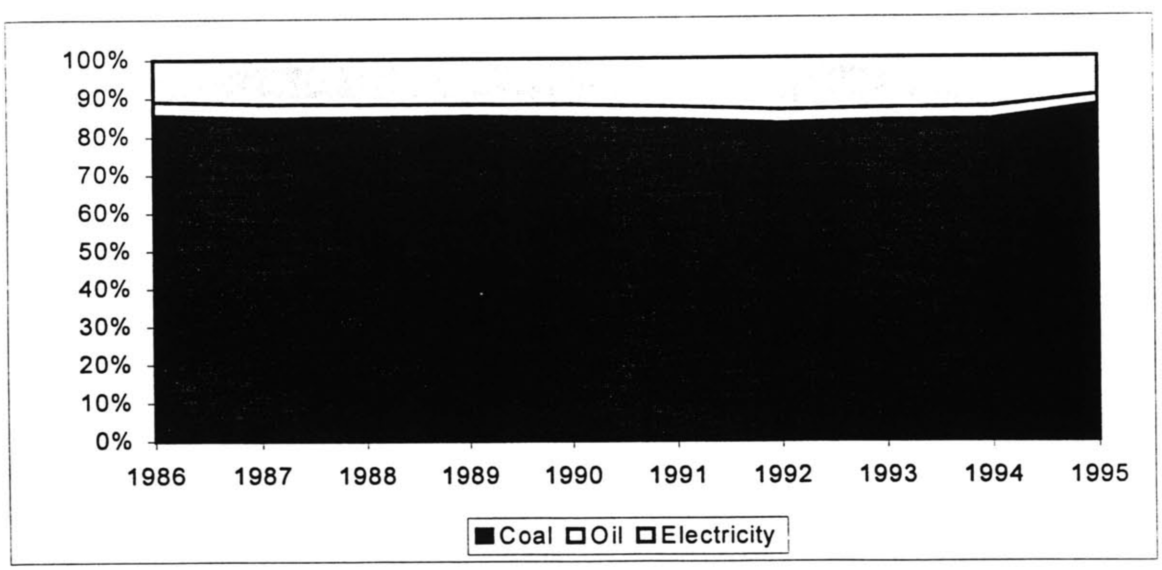
SHARES OF ENERGY CONSUMPTION, BY ENERGY SOURCE, CHINA, 1986-1995



Source: China Statistical Yearbook, 1997, p. 215; China Energy Databook, 1996 Edition, Ernest Orlando Lawrence Berkley National Laboratory, University of California-Berkley, Sinton et al. Editors.

FIGURE 3.C.2

SHARES OF ENERGY CONSUMPTION BY ENERGY SOURCE, SHANXI PROVINCE, 1986-1995



Source: Shanxi Province Statistical Yearbook, 1997, p. 125-126.

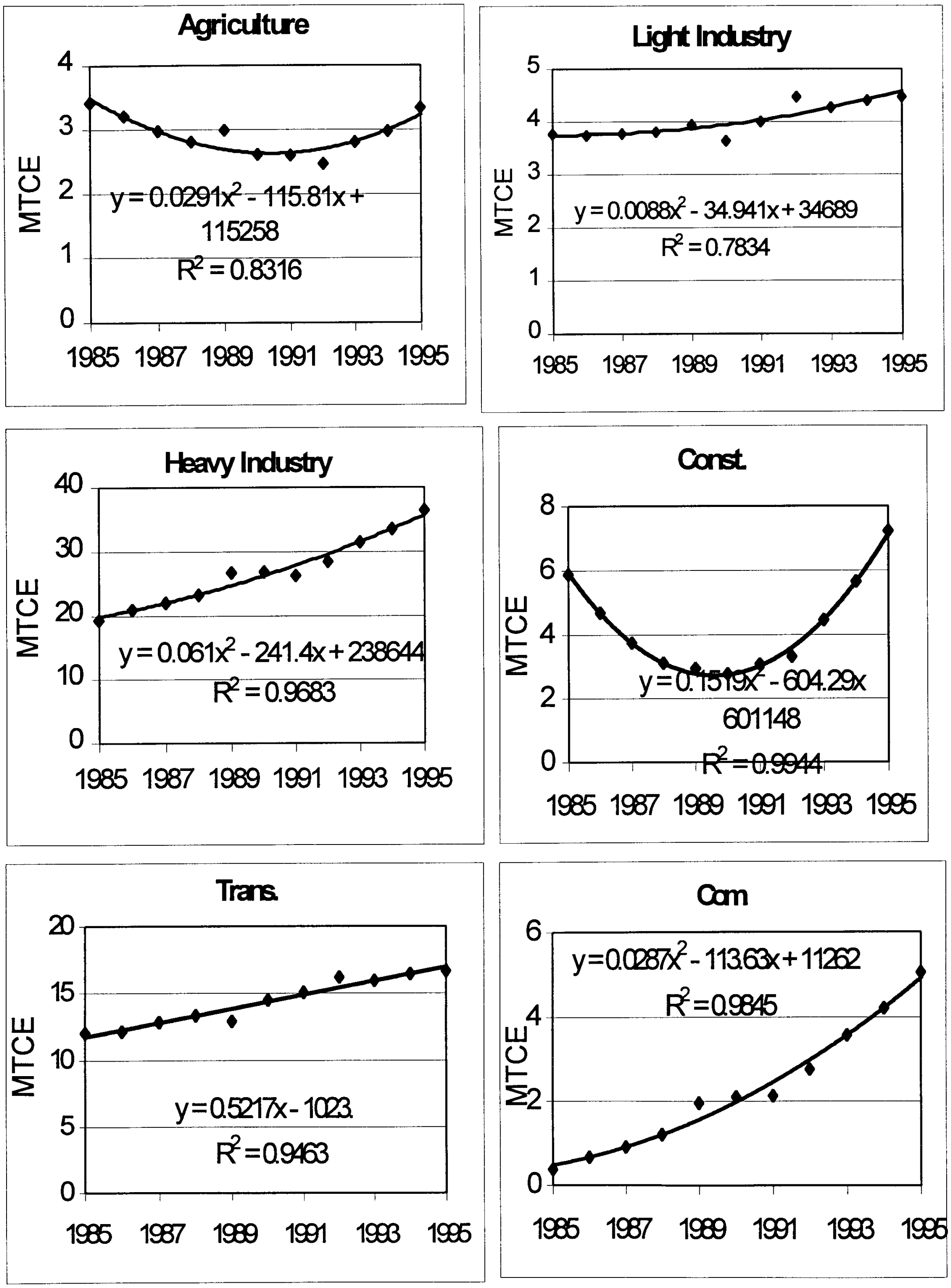
APPENDIX 4.A

DATA REGRESSION CHARTS FOR SHANXI PROVINCE AND CHINA

REGRESSION-ANALYSIS TOOL

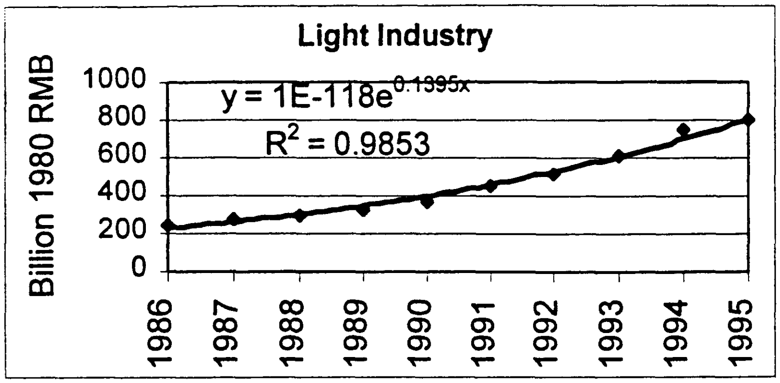
I used a "least squares" regression method to fit a line through a set of observations. In this case I have analyzed how a single dependent variable, energy consumption, is affected by the values of one or more independent variables, in this case fitting in the blanks in certain years. I have used the R-squared measurement to determine the accuracy of the regression analysis. In this case, the closer R-squared is to the value of 1, the more accurate is the regression analysis.

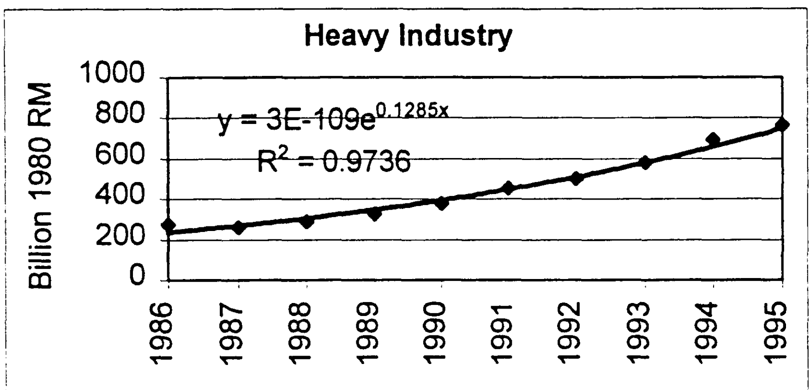
SHANXI PROVINCE DATA-REGRESSION CHARTS



Source: Shanxi Province Statistical Yearbook, 1993, p. 444; 1997, p. 120.
MTCE: Million Tons of Coal Equivalent; **Com.:** Commerce; **Trans.:** Transportation; **Const.:** Construction.

CHINA DATA-REGRESSION CHARTS





Source: The Gross Domestic Product of China, 1952-1995.
RMB: Renminbi, the Chinese currency, which is about 0.125 U.S. Dollar.

APPENDIX 4.B

SHIFT-SHARE ANALYSIS TABLES FOR ENERGY-INTENSITY AND TOTAL ENERGY CONSUMPTION, CHINA AND SHANXI PROVINCE, 1986-1995

Table 4.B.1: Shift-Share Analysis of Total Energy Consumption in China's Material Production Sector, 1986-1995
(Million Tons of Standard Coal Equivalent)

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Total Consumption	647.2	695.6	743.2	780.1	794.3	838.2	891.7	916.1	1017.8	1109.1
Industrial Mix	10.9	0.8	16.0	39.5	-18.3	13.0	78.7	-26.3	14.4	10.3
Efficiency Shift	-21.9	-58.1	-78.6	-42.5	-19.3	-66.8	-218.8	-26.6	-22.9	-50.4
Constant Share	658.2	752.9	805.8	783.2	831.9	891.9	1031.8	968.9	1026.4	1149.2
Discrepancy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: Shift-Share Analysis Calculations.

Table 4.B.2: Shift-Share Analysis of Total Energy Consumption in Shanxi Province's Material Production Sector, 1986-1995
(Million Tons of Standard Coal Equivalent)

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Total Consumption	45.34	46.28	47.61	51.51	52.35	53.18	57.61	62.56	67.23	73.11
Industrial Mix	0.55	-1.61	-0.57	0.51	0.16	2.40	1.20	1.89	0.38	0.15
Efficiency Change	-2.72	-0.74	-2.73	1.05	-3.40	-3.57	-4.48	-10.47	-7.27	-1.89
Constant Share	47.51	48.62	50.91	49.95	55.60	54.35	60.89	71.14	74.11	74.85
Discrepancy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: Shift-Share Analysis Calculations.

Table 4.B.3: Shift-share Analysis of Energy Intensity in China's Material Production Sector, 1986-1995
(Grams of Standard Coal Equivalent per Constant 1980 RMB of Output)

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Actual Energy Intensity	414.2	382.7	352.9	351.5	335.7	315.4	272.6	257.8	255.6	246.7
Industrial Mix	6.9	0.4	7.6	17.8	-7.7	4.9	24.1	-7.4	3.6	2.3
Efficiency Shift	-14.0	-32.0	-37.3	-19.2	-8.1	-25.1	-66.9	-7.5	-5.8	-11.2
Constant Share	421.2	406.4	382.7	352.9	351.5	335.7	315.4	272.6	257.8	255.6
Discrepancy	0.0	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: Shift-Share Analysis Calculations.

Table 4.B.4: Shift-Share Analysis of Energy Intensity of the Material Production Sector in Shanxi Province, 1986-1995
(Grams of Standard Coal Equivalent per Constant 1980 RMB of Output)

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Actual Energy Intensity	1129.8	1075.4	1005.6	1037.0	976.4	955.4	904.0	795.0	721.1	704.3
Industrial Mix	13.7	-37.3	-12.1	10.3	3.0	43.1	18.9	24.0	4.1	1.5
Efficiency Shift	-67.7	-17.2	-57.7	21.1	-63.5	-64.1	-70.3	-133.0	-78.0	-18.2
Constant Share	1183.9	1129.8	1075.4	1005.6	1037.0	976.4	955.4	904.0	795.0	721.1
Discrepancy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: Shift-Share Analysis Calculations.

APPENDIX 5.A

CONCEPTS AND DEFINITIONS OF THE 1992 INPUT-OUTPUT TABLES

1. Total consumption of households is the domestic consumption of goods and services by resident households. It includes the consumption of goods or services required by individual households through social transfers in kind received from government and collective units. It excludes direct purchases abroad by resident households and direct purchases in the domestic market by non-resident households. In this table, the two are divided into peasant (rural) and non-peasant consumption (urban).
2. Total institutional consumption is the final consumption of services by the society as a whole as well as the collective consumption of goods by enterprises and institutions.
3. Gross capital formation is the total value of the acquisitions less disposals of new or existing tangible fixed assets during the accounting period. It includes capital repairs, renewal and transformation of fixed assets as well as capital construction.
4. Changes in stocks are equal to the value of stocks required less the value of stocks disposal of during the accounting period.
5. The 1992 input-output table of China is valued at producer's prices.

Source: 1992 Input-Output Table of China, p. 9; 1992 Input-Output table of Shanxi Province, p. 9.

Aggregate-Sectors Definitions:

Energy: Coal Mining, Crude Petroleum and Natural Gas, Electricity, Refined Petroleum, and Coke and Coal Gas

Agriculture: Agriculture

Industry: Metal Ore Mining; Other Mining; Food Manufacturing; Manufacture of Textiles; Manufacture of Wearing Apparel, Leather and Products and Fur; Sawmills and Manufacture of Furniture; Manufacture of Paper, Cultural and Educational Articles; Chemical Industries; Manufacture of Building Materials and Other Non-Metallic Mineral Products; Primary Metal Manufacturing; Manufacture of Metal Products; Manufacture of Machinery; Manufacture of Transport Equipment; Manufacture of Electric Machinery and Instrument; Manufacture of Electronic and Communication Equipment; Manufacture of Instruments, Meters and Other Measuring Equipment; Maintenance and Repair of Machinery and Equipment; Industries not Elsewhere Classified

Transport: Freight Transport and Communications; Passenger Transport

Construction: Construction

Services: Commerce; Restaurants; Public Utilities and Services to Households; Cultural, Education, Health and Scientific Research Institutions; Finance and Insurance; Public Administration

APPENDIX 5.B

ENERGY REQUIREMENTS OF FINAL-DEMAND SECTORS IN CHINA AND SHANXI PROVINCE, 1992

Table 5.B.1: Energy Requirements of Final-Demand Sectors in China, 1992
(RMB of energy-use per RMB of Final Demand)

Sector	Coal	Coke and Coal Gas	Crude Petroleum and Natural Gas	Refined Petroleum	Electricity
Peasant Consumption	0.0091	0.0024	0.0000	0.0009	0.0078
Non-peasant Consumption	0.0019	0.0059	0.0001	0.0013	0.0097
Institutional Consumption	0.0000	0.0000	0.0000	0.0000	0.0000
Gross Fixed Capital Formation	0.0000	0.0000	0.0000	0.0000	0.0000
Changes in Stock	0.0231	0.0078	0.0207	-0.0072	0.0000

Source: SSDA calculations from 1992 China and Shanxi Province Input-output Table.
RMB: Renminbi, the Chinese Currency which is about 0.125 U.S. Dollar.

Table 5.B.2: Energy Requirements of Final-Demand Sectors in Shanxi Province, 1992
(RMB of energy-use per RMB of Final Demand)

Sector	Coal	Coke and Coal Gas	Crude Petroleum and Natural Gas	Refined Petroleum	Electricity
Peasant Consumption	0.0238	0.0008	0.0000	0.0016	0.0037
Non-peasant Consumption	0.0109	0.0046	0.0000	0.0024	0.0065
Institutional Consumption	0.0000	0.0003	0.0000	0.0008	0.0014
Gross Fixed Capital Formation	0.0000	0.0000	0.0000	0.0000	0.0000
Changes in Stock	0.0068	0.1069	-0.0004	0.0296	0.0000

Source: SSDA calculations from 1992 Shanxi Province Input-output Table.
RMB: Renminbi, the Chinese Currency which is about 0.125 U.S. Dollar.

APPENDIX 5.C

FINAL DEMAND ENERGY REQUIREMENTS BY SECTOR, CHINA AND SHANXI PROVINCE, 1992

Table 5.C.1: Direct Energy Requirement, China, 1992
(RMB of energy-use per RMB of Final Demand)

Energy Sectors	Coal	Coke and Coal Gas	CP and NG	Refined Petroleum	Electricity
Coal	0.0347	0.0002	0.0000	0.0173	0.0644
Crude Petroleum and NG	0.0009	0.0000	0.0161	0.0089	0.0366
Electricity	0.1428	0.0002	0.0377	0.0446	0.0223
Refined Petroleum	0.0008	0.0000	0.5212	0.0223	0.0014
Coke and Coal Gas	0.3381	0.0224	0.0392	0.0251	0.0485
Nonenergy Sectors					
Agriculture	0.0008	0.0001	0.0000	0.0057	0.0021
Metal Ore Mining	0.0096	0.0016	0.0001	0.0158	0.0727
Other Mining	0.0085	0.0001	0.0002	0.0213	0.0749
Food Manufacturing	0.0037	0.0005	0.0000	0.0034	0.0079
Textiles	0.0043	0.0001	0.0000	0.0026	0.0104
Apparel Products	0.0013	0.0002	0.0000	0.0019	0.0015
Sawmills & Furniture	0.0064	0.0004	0.0000	0.0109	0.0208
Paper & Educational Articles	0.0035	0.0004	0.0001	0.0030	0.0181
Chemical Industries	0.0085	0.0018	0.0153	0.0106	0.0359
Building Materials	0.0267	0.0055	0.0033	0.0228	0.0624
Primary Metal	0.0244	0.0152	0.0055	0.0062	0.0443
Metal Products	0.0020	0.0023	0.0003	0.0031	0.0196
Machinery	0.0018	0.0028	0.0005	0.0045	0.0159
Transport Equipment	0.0013	0.0006	0.0003	0.0045	0.0029
Electric Machinery	0.0009	0.0004	0.0002	0.0030	0.0098
Electronic Equipment	0.0006	0.0005	0.0010	0.0018	0.0076
Instruments and Meters	0.0019	0.0012	0.0013	0.0024	0.0015
Maintenance of Equipment	0.0051	0.0079	0.0014	0.0048	0.0200
Other Industries	0.0052	0.0034	0.0026	0.0067	0.0091
Construction	0.0006	0.0001	0.0000	0.0081	0.0007
Freight Transport	0.0073	0.0002	0.0025	0.1070	0.0113
Commerce	0.0018	0.0005	0.0008	0.0088	0.0029
Restaurants	0.0023	0.0020	0.0029	0.0029	0.0044
Passenger Transport	0.0059	0.0002	0.0000	0.1268	0.0043
Public Utilities	0.0047	0.0008	0.0011	0.0225	0.0264
Research Institutions	0.0031	0.0004	0.0008	0.0047	0.0165
Finance and Insurance	0.0015	0.0003	0.0003	0.0057	0.0146
Public Administration	0.0038	0.0004	0.0025	0.0144	0.0166

Source: SSDA calculations from 1992 China and Shanxi Province Input-output Table.
RMB: Renminbi, the Chinese Currency which is about 0.125 U.S. Dollar; **NG:** Natural Gas;
CP: Crude Petroleum.

Table 5.C.2: Direct Energy Requirement, Shanxi Province, 1992
(RMB of energy-use per RMB of Final Output)

Product	Coal	Coke and Coal Gas	CP and NG	Refined Petroleum	Electricity
Coal	0.0210	0.0011	0.0001	0.0139	0.0483
Crude Petroleum and NG	0.0893	0.0000	0.0000	0.0238	0.0774
Electricity	0.3799	0.0001	0.0000	0.0137	0.0109
Refined Petroleum	0.0292	0.0006	0.0000	0.3018	0.0700
Coke and Coal Gas	0.3307	0.0294	0.0000	0.0128	0.0304
Nonenergy Sectors					
Agriculture	0.0072	0.0021	0.0000	0.0040	0.0135
Metal Ore Mining	0.0113	0.0022	0.0000	0.0491	0.0740
Other Mining	0.0204	0.0038	0.0000	0.0775	0.0920
Food Manufacturing	0.0178	0.0002	0.0000	0.0032	0.0119
Textiles	0.0181	0.0002	0.0000	0.0054	0.0262
Apparel Products	0.0070	0.0000	0.0000	0.0024	0.0062
Sawmills & Furniture	0.0670	0.0007	0.0000	0.0121	0.0264
Paper & Educational Articles	0.0391	0.0002	0.0003	0.0059	0.0326
Chemical Industries	0.0364	0.0206	0.0000	0.0101	0.0524
Building Materials	0.1058	0.0259	0.0000	0.0176	0.0758
Primary Metal	0.0553	0.0541	0.0000	0.0154	0.0450
Metal Products	0.0169	0.0098	0.0000	0.0138	0.0273
Machinery	0.0302	0.0050	0.0000	0.0084	0.0258
Transport Equipment	0.0192	0.0024	0.0000	0.0076	0.0233
Electric Machinery	0.0073	0.0038	0.0000	0.0080	0.0131
Electronic Equipment	0.0051	0.0000	0.0000	0.0020	0.0066
Instruments and Meters	0.0176	0.0008	0.0000	0.0110	0.0164
Maintenance of Equipment	0.0303	0.0066	0.0000	0.0192	0.0253
Other Industries	0.0382	0.0221	0.0000	0.0160	0.0371
Construction	0.0065	0.0002	0.0000	0.0217	0.0080
Freight Transport	0.0124	0.0002	0.0000	0.1311	0.0130
Commerce	0.0182	0.0020	0.0002	0.0182	0.0126
Restaurants	0.0237	0.0000	0.0000	0.0000	0.0080
Passenger Transport	0.0130	0.0001	0.0000	0.0934	0.0123
Public Utilities	0.0234	0.0152	0.0000	0.0222	0.0215
Research Institutions	0.0200	0.0020	0.0000	0.0156	0.0179
Finance and Insurance	0.0226	0.0001	0.0000	0.0202	0.0109
Public Administration	0.0248	0.0000	0.0000	0.0121	0.0335

Source: SSDA calculations from 1992 China and Shanxi Province Input-output Table.
RMB: Renminbi, the Chinese Currency which is about 0.125 U.S. Dollar; **NG:** Natural Gas;
CP: Crude Petroleum.

APPENDIX 5.D

DIRECT AND INDIRECT ENERGY INPUT COEFFICIENTS, CHINA AND SHANXI PROVINCE, 1992

Table 5.D.1: Direct and Indirect Energy Input Coefficients, China, 1992
(RMB of Input per RMB of Output)

Energy Sector	Coal	Coke and Coal Gas	Crude Petroleum and Natural Gas	Refined Petroleum	Electricity
Coal	1.06256	0.00436	0.02994	0.04199	0.10142
Crude Petroleum & NG	0.01810	0.00312	1.03405	0.02411	0.06062
Electricity	0.16404	0.00279	0.07918	0.06816	1.05640
Refined Petroleum	0.01470	0.00247	0.55793	1.04538	0.04158
Coke and Coal Gas	0.38470	1.02655	0.08099	0.06136	0.10653
Agriculture	0.00799	0.00131	0.01242	0.01646	0.01708
Metal Ore Mining	0.03965	0.00546	0.03175	0.04290	0.11682
Other Mining	0.03604	0.00355	0.03331	0.04632	0.11102
Food Manufacturing	0.01566	0.00247	0.01589	0.02154	0.02993
Textiles	0.02242	0.00263	0.02110	0.02576	0.04501
Apparel Products	0.01825	0.00287	0.02022	0.02556	0.03562
Sawmills & Furniture	0.03267	0.00535	0.02977	0.04010	0.06854
Paper & Educational Articles	0.02404	0.00388	0.02195	0.02709	0.05521
Chemical Industries	0.03437	0.00530	0.04884	0.03869	0.08131
Building Materials	0.05949	0.00988	0.04012	0.05197	0.10694
Primary Metal	0.06834	0.02487	0.03480	0.03587	0.10254
Metal Products	0.04231	0.01420	0.02790	0.03233	0.08112
Machinery	0.03208	0.01128	0.02528	0.03088	0.06525
Transport Equipment	0.02536	0.00733	0.02409	0.03019	0.04657
Electric Machinery	0.03235	0.00927	0.02591	0.03031	0.06335
Electronic Equipment	0.02182	0.00535	0.02292	0.02671	0.04877
Instruments and Meters	0.02344	0.00687	0.02140	0.02539	0.04084
Maintenance of Equipment	0.03310	0.01449	0.02507	0.02989	0.06176
Other Industries	0.03032	0.00889	0.02977	0.03395	0.05304
Construction	0.03121	0.00734	0.02875	0.03942	0.05703
Freight Transport	0.01968	0.00251	0.07270	0.12466	0.03425
Commerce	0.01526	0.00306	0.02537	0.03859	0.02828
Restaurants	0.01332	0.00375	0.01585	0.01802	0.02379
Passenger Transport	0.01702	0.00253	0.08062	0.14506	0.02661
Public Utilities	0.02067	0.00324	0.02757	0.04018	0.05107
Research Institutions	0.01813	0.00282	0.01948	0.02333	0.04376
Finance and Insurance	0.01546	0.00259	0.01893	0.02732	0.03976
Public Administration	0.01925	0.00300	0.02924	0.04194	0.04330

Source: SSDA calculations from 1992 China and Shanxi Province Input-output Table.

RMB: Renminbi, the Chinese Currency which is about 0.125 U.S. Dollar;

NG: Natural Gas.

Table 5.D.2: Direct and Indirect Energy Input Coefficients, Shanxi Province, 1992 (RMB of Input per RMB of Output)

Energy Sector	**Coal**	**Coke and Coal Gas**	**Crude Petroleum and Natural Gas**	**Refined Petroleum**	**Electricity**
Coal	1.10665	0.02075	0.00014	0.06518	0.09845
Crude Petroleum & NG	0.22867	0.03051	1.00008	0.11420	0.16095
Electricity	0.44148	0.01211	0.00006	0.06387	1.06152
Refined Petroleum	0.17545	0.02884	0.00006	1.50552	0.17335
Coke and Coal Gas	0.43668	1.05045	0.00007	0.08908	0.10032
Agriculture	0.04758	0.01094	0.00006	0.02890	0.04144
Metal Ore Mining	0.09655	0.01570	0.00003	0.11843	0.12428
Other Mining	0.12390	0.01783	0.00003	0.17340	0.15321
Food Manufacturing	0.07982	0.01215	0.00006	0.04880	0.05612
Textiles	0.10107	0.01655	0.00005	0.06802	0.08535
Apparel Products	0.09179	0.01557	0.00006	0.06094	0.07338
Sawmills & Furniture	0.17535	0.02619	0.00005	0.08962	0.10300
Paper & Educational Articles	0.14591	0.02302	0.00041	0.06942	0.10367
Chemical Industries	0.15875	0.04652	0.00005	0.08206	0.13087
Building Materials	0.22177	0.04641	0.00005	0.08848	0.14008
Primary Metal	0.19366	0.09284	0.00006	0.08826	0.12114
Metal Products	0.13647	0.05263	0.00004	0.08038	0.09860
Machinery	0.15229	0.04662	0.00005	0.07557	0.10121
Transport Equipment	0.15158	0.04151	0.00006	0.08257	0.10955
Electric Machinery	0.13964	0.04992	0.00005	0.08120	0.09860
Electronic Equipment	0.08694	0.02064	0.00007	0.05690	0.06477
Instruments and Meters	0.09335	0.02334	0.00004	0.06040	0.06569
Maintenance of Equipment	0.16119	0.04667	0.00005	0.09831	0.10886
Other Industries	0.16624	0.05537	0.00006	0.09474	0.11764
Construction	0.12812	0.03816	0.00004	0.09876	0.08771
Freight Transport	0.08222	0.01527	0.00004	0.22708	0.06622
Commerce	0.08439	0.01455	0.00022	0.07588	0.05622
Restaurants	0.07456	0.00799	0.00005	0.03918	0.04398
Passenger Transport	0.06902	0.01120	0.00003	0.16605	0.05439
Public Utilities	0.08637	0.02578	0.00004	0.07112	0.06022
Research Institutions	0.08298	0.01461	0.00005	0.06207	0.06022
Finance and Insurance	0.07724	0.01132	0.00005	0.06984	0.04886
Public Administration	0.10545	0.01493	0.00008	0.07743	0.08360

Source: SSDA calculations from 1992 China and Shanxi Province Input-output Table.
RMB: Renminbi, the Chinese Currency which is about 0.125 U.S. Dollar; **NG:** Natural Gas.

APPENDIX 5.E

DIFFERENCES BETWEEN SHANXI PROVINCE-CHINA DIFFERENTIALS IN DIRECT AND INDIRECT INPUTS AND DIRECT INPUTS

Table 5.E.1: Differences between the Shanxi Province-China Differentials in Direct and Indirect Inputs and Direct Inputs

Energy Sector	Coal	Coke and Coal Gas	Crude Petroleum and Natural Gas	Refined Petroleum	Electricity
Coal	0.0581	0.0154	-0.0298	0.0262	0.0130
Crude Petroleum and NG	0.1226	0.0274	-0.0180	0.0751	0.0593
Electricity	0.0404	0.0093	-0.0411	0.0267	0.0161
Refined Petroleum	0.1327	0.0254	-0.0369	0.1801	0.0628
Coke and Coal Gas	0.0590	0.0169	-0.0419	0.0397	0.0118
Agriculture	0.0336	0.0076	-0.0124	0.0144	0.0134
Metal Ore Mining	0.0549	0.0092	-0.0317	0.0425	0.0065
Other Mining	0.0759	0.0103	-0.0333	0.0711	0.0252
Food Manufacturing	0.0502	0.0097	-0.0158	0.0273	0.0222
Textiles	0.0646	0.0139	-0.0211	0.0393	0.0243
Apparel Products	0.0675	0.0127	-0.0202	0.0344	0.0328
Sawmills & Furniture	0.0817	0.0208	-0.0297	0.0485	0.0285
Paper & Educational Articl	0.0859	0.0191	-0.0215	0.0393	0.0345
Chemical Industries	0.0964	0.0222	-0.0338	0.0444	0.0326
Building Materials	0.0833	0.0165	-0.0371	0.0415	0.0201
Primary Metal	0.0943	0.0290	-0.0287	0.0434	0.0176
Metal Products	0.0792	0.0304	-0.0279	0.0370	0.0095
Machinery	0.0922	0.0333	-0.0242	0.0407	0.0260
Transport Equipment	0.1082	0.0322	-0.0240	0.0494	0.0430
Electric Machinery	0.1013	0.0376	-0.0259	0.0459	0.0322
Electronic Equipment	0.0611	0.0153	-0.0219	0.0302	0.0170
Instruments and Meters	0.0539	0.0165	-0.0204	0.0260	0.0098
Maintenance of Equipment	0.1031	0.0332	-0.0240	0.0544	0.0421
Other Industries	0.1029	0.0275	-0.0267	0.0518	0.0366
Construction	0.0909	0.0308	-0.0287	0.0453	0.0237
Freight Transport	0.0575	0.0128	-0.0707	0.0784	0.0300
Commerce	0.0531	0.0095	-0.0241	0.0283	0.0179
Restaurants	0.0402	0.0062	-0.0128	0.0242	0.0162
Passenger Transport	0.0450	0.0087	-0.0806	0.0540	0.0198
Public Utilities	0.0467	0.0085	-0.0265	0.0309	0.0142
Research Institutions	0.0479	0.0098	-0.0184	0.0277	0.0155
Finance and Insurance	0.0408	0.0087	-0.0189	0.0275	0.0131
Public Administration	0.0652	0.0119	-0.0272	0.0375	0.0233

Source: SSDA calculations from 1992 China and Shanxi Province Input-output Table.
RMB: Renminbi, the Chinese Currency which is about 0.125 U.S. Dollar;
NG: Natural Gas.

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