MINERAL INDUSTRY AND CHINA'S REGIONAL DEVELOPMENT: AN EXPLORATORY ANALYSIS

BY

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A Thesis submitted to the Faculty of Graduate Studies in Partial Fulfilment of the Requirements for the Degree of Doctor of Philosophy.

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PREFACE

Throughout history mineral industry has been a determinant factor in the evolution of societies and civilization. In fact, few industries have imposed and experienced, such economic and political shocks as the mineral industry, especially since the oil crisis of the 1970s. It can be said that the development of mineral industry is a reflection of the way in which industry, government power and society as a whole is organized, and it is a reflection of the way in which the mineral industry is perceived. Minerals are seen as being vital to the economic growth of developing nations and future well-being of a mater manufacturing nation or region and as such the exploitation and the processing of those resources is deemed to be of paramount importance, and this has intensified the interest in research of resources. Unfortunately, the renaissance in the minerals activities in most parts of the developing countries during the last decade has gone out of fashion and only served to arouse very considerable interest in potential benefits to national economies and in environmental impacts, and much less in the consequences for regional development. Awareness of this neglect provided the initial stimulus for this thesis.

I am very grateful to Pro. D Todd, my supervisor, for his invaluable help and advice, with fully understanding and tremendous patience, throughout the preparation and writing of the thesis.

I would like to extent my deep appreciation to Dr. R.C. Tiwari, a professor in the Department of Geography, and Professor T.Henley, the assistant director of the Natural Resources Institute, for their useful suggestions and helps. I am also indebted to Dr. W. Norton, a professor and the former head of the Department of Geography, for his kindly encouragement and help during my study in the University of Manitoba.

ABSTRACT

Societal achievement in the world is dependent to a great extent on the development of mineral resources. The very obvious impact of minerals on Man's evolution can be traced in terms of Man's acquaintance with minerals--the Pre-stone Age, the Stone Age, the Bronze Age, the Iron Age, and the Atomic Age. Rapid growth in national economies, especially in large countries, is nowadays highly dependent on access to wide and ever-growing supplies of minerals at the lowest cost. Mineral industry, as a determinant factor in regional development, creates millions of jobs in the world, and mineral activity, including mining- related activities, provides the prerequisites for many production sequences and prepares the regions for achievement of the "take-off" point along their paths to fully-fledged development. Indeed, the importance of mineral activity can remain vital even for longer because of uneven distribution of mineral resources and changing demand of mineral products which together conspire to grant a region longstanding comparative advantages.

This thesis represents an exploratory research work to analysis the relative positive role of mineral activity in regional development, examining the interaction between economic growth and the development of mineral industry on the one hand and the role of mineral industry in the early stage of industrialization on the other. Examination of the contemporary role of mineral industry in regional development seemed to lead naturally to an analysis of its role in China, the largest developing country and one of the

world's leading mineral countries. The theory of intensive use of mineral product, input-output, factor analysis and cluster analysis are treated as a conceptual underpinning and a powerful tool to expose the significant relationships between of mineral industry and regional development.

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STUDY REGION, RELEVANT THEORIES AND OBJECTIVES

1.1 Introduction

Societal achievement in the world is dependent to a great extent on the development of mineral resources. The very obvious impact of minerals on Man's evolution can be traced in terms of Man's acquaintance with minerals--the Pre-stone Age, the Stone Age, the Bronze Age, the Iron Age, and the Atomic Age. Rapid growth in national economies, especially in large countries, is nowadays highly dependent on access to wide and ever-growing supplies of minerals at the lowest cost. Mineral industry, as a determinant factor in regional development, creates millions of jobs in the world, and mineral activity, including mining-related activities, provides the prerequisites for many production sequences and prepares the regions for achievement of the "take-off" point along their paths to fully-fledged development. Indeed, the importance of mineral activity can remain vital for even longer because of uneven distribution of mineral resources and changing demands for mineral products; factors which together conspire to grant a region longstanding comparative advantages.

This thesis mainly represents an exploratory undertaking to analyse the positive aspects of mineral activity in regional development, examining the role of mineral industry in the early stage of industrialization on the one hand and the interaction between regional development and mineral activity on the other. Examination of the contemporary role of mineral industry in regional development seemed to lead naturally to an analysis of its role in China, the largest developing country and one of the world's leading mineral producers.

1.2 The China Context: A Brief Look

Before the mid-twentieth century, China was characterized by dualism; that is, its economy could be said to revolve around a small modern sector based on foreign capital and technology and a large traditional agricultural sector accounting for 90 percent of its population and 70 percent of its domestic products. Progress in industrialization in China did not occur until the new republic was founded in 1949, and since then billions of yuan in capital investment and millions of workers were devoted to industrial construction, particularly heavy industry. With an annual growth rate of 17 per cent as opposed to the 13 per cent of the industry at large and accounting for 7 per cent of National Income during the period between 1949 and 1990, mineral industry was to be the leading sector in this effort. If one compares China's present economic structure and spatial development level with the situation prevailing at the outset of such transformation some forty years ago, it comes as no surprise to conclude that the progress in mineral-based industrialization in the country is both undeniable and impressive (see Table 1-1, Table 1-2 and Figure 1-1). However, in explaining the economic and spatial consequences of mineral-based industrialization, one must rely on the developed body of regional growth theories.

Table 1-1 Sectoral Contributions to National Income, China, 1949-92 (selected years, %)

Sector	1949	1952	1965	1980	1989	1992
Agriculture	68.4	57.7	46.2	36.0	31.9	29.2
Industry	12.6	19.5	36.4	48.9	47.4	49.4
Construction	0.3	3.6	3.8	5.0	5.9	7.4
Transportation	3.4	4.1	4.2	3.4	4.1	4.8
Commerce	15.4	17.2	9.4	6.7	10.7	9.1
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: China Statistics Bureau (1993) China's Statistics Yearbook, 1993.

Table 1-2 China's Urban Population and City-Size Categories, 1940-90 (selected years)

Item	1949	1980	1985	1990
Urban population (millions)	57.7	191.4	250.9	301.9
% of total population	10.6	19.4	24.5	26.4
City-size category				
Super city (> 2 million)	1	-	8	9
Huge city (2-1 million)	5	-	14	22
Large city (1-0.5 million)	10	-	30	28
Medium-sized city (0.5-0.2 million)	19	-	94	117
Small city (<0.2 million)	34	-	178	291
Total	**69**	**223**	**324**	**467**

Source: **China's Statistics Bureau (1991)** China's Urban Statistics Yearbook, 1991.
Chen Xiang Ming (1991) 'China's City Hierarchy, Urban Policy and Spatial Development in the 1980s', Urban Studies, Vol. 28, No.3, pp.341-367.

1.3 Relevant Theories

Three cogent theories underpin the approach adopted in this study; namely, Material Intensive-Use Theory (IU), Export-Base Theory and Centre-Periphery Theory. It is appropriate that some idea of their scope be given at this juncture.

Material Intensive-Use Theory. Fundamental to a discussion

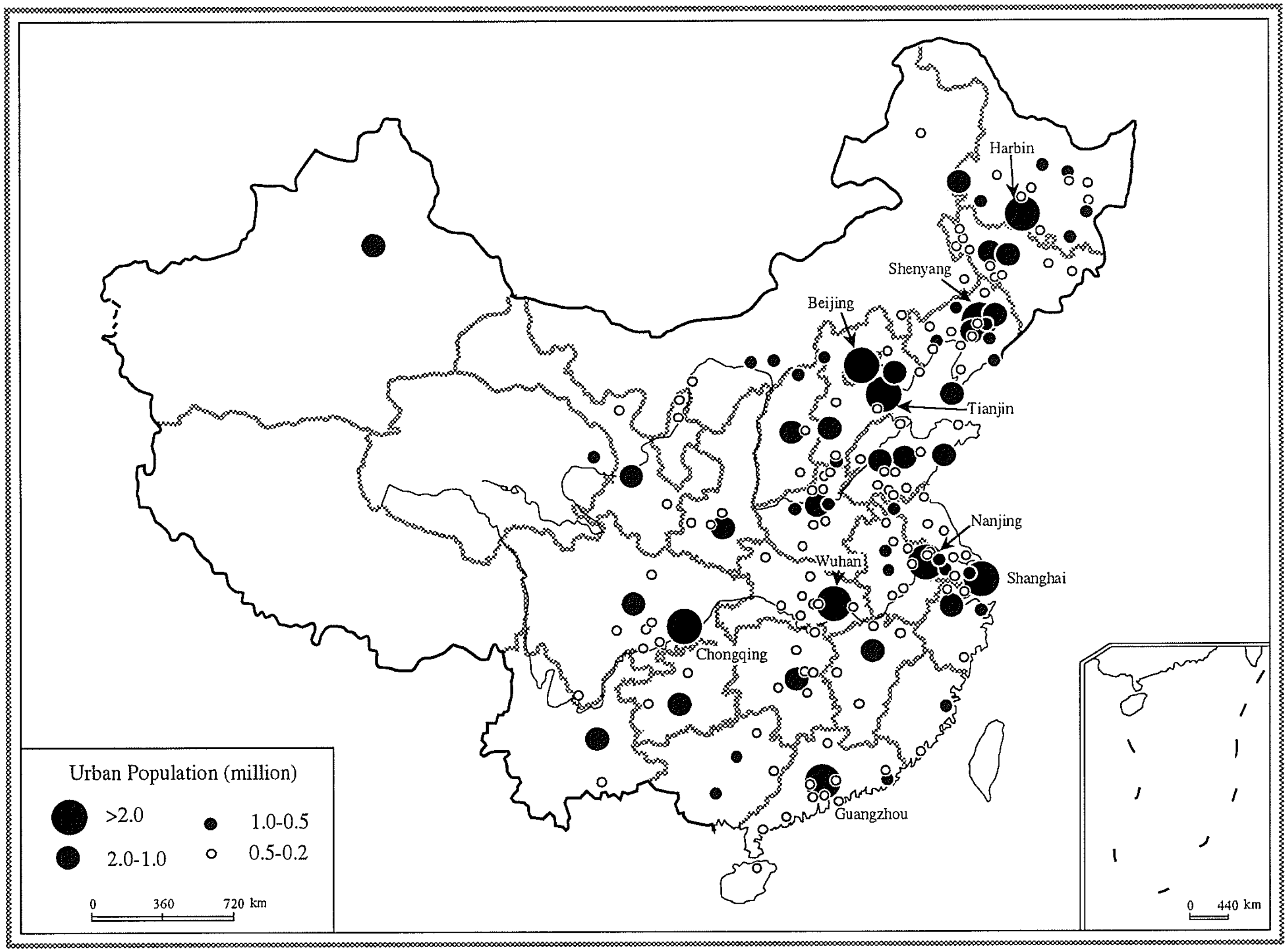


Figure 1-1. Major Industrial Cities in China, 1990

of minerals and regional development is an understanding of the nature of change in modern economies. The characteristics of industrialization become apparent when viewed in relation to various classifications of modern economies as defined, for example, by Rostow (1960) in terms of his four principal stages of industrialization. The first stage is dominated by agriculture with a minor industrial development. The second stage or the early stage of industrialization is characterized by very important industrial development. During this stage an economy is building up infrastructural facilities, heavy industries such as coal and oil, steel, metal fabricating, heavy engineering, chemicals, pulp and paper, etc.; and emphasizing the export of raw materials. Critically, it is also engaged in the allocation of appropriate technologies to the particular mix of resource-oriented activities. It is an era of import replacement or substitution, usually conducted behind high tariff barriers. This is followed by a mass-consumption stage (mainly represented by a great increase in the usage of new kinds of metals rather than in the volumes of metals being consumed), referred to as the late stage of industrialization. It represents a period in which there is a strong drive towards automation and in which industries associated with the automobile industry are established (including, note, the vital electronics sector). Finally, there is a post-industrial stage in which the emphasis is on a search for quality. There is growth in certain kinds of services associated with this objective, such as those of private and public health, education and travel.

Services and leisure-type industries become the leading sector of economic growth.

This classification of economic growth is supported by the concept of a U-shaped mineral-intensive use or intensity-of-use (I-U) pattern first advocated by Malenbaum in 1973. In analyzing long-run trends in the mineral demand of the United States, Malenbaum observed that the intensity of mineral use is a function of the level of economic development as reflected by a country's per capita income. The exact nature or specification of this relationship is determined empirically, and generally varies among countries and materials. In his work titled "World Demand for Raw Materials in 1985 and 2000" (1978), Malenbaum argued that regularities in the historical patterns of demand for many metal and energy materials permitted the description of a life-cycle of material-intensity of use. In other words, the material-intensity of use is presumed to follow an inverted U. Such a cycle consists of three phases: growth (including introduction), maturity and decline. At early stages of industrialization, countries increase their mineral-intensive use (IU) as growth occurs and per capita income rises. The growth stage of IU, therefore, involves freeing of resources from agriculture for the construction of industrial plants, homes, roads and railways, motor vehicles, and other material-intensive products. However, as per capita income continues to rise, demand shifts towards services, which are less material-intensive, and this sector expands at the expense of the construction and manufacturing sectors. In this shift, consumer

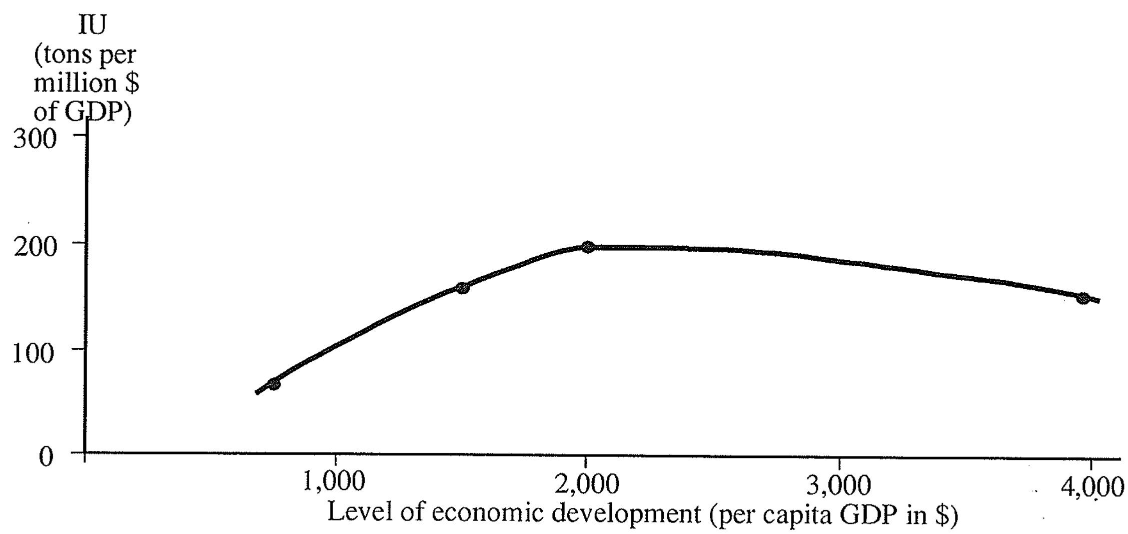


Figure 1-2 Relationship between Intensity of Steel Use and Per Capita Income in the United States, 1888-1967

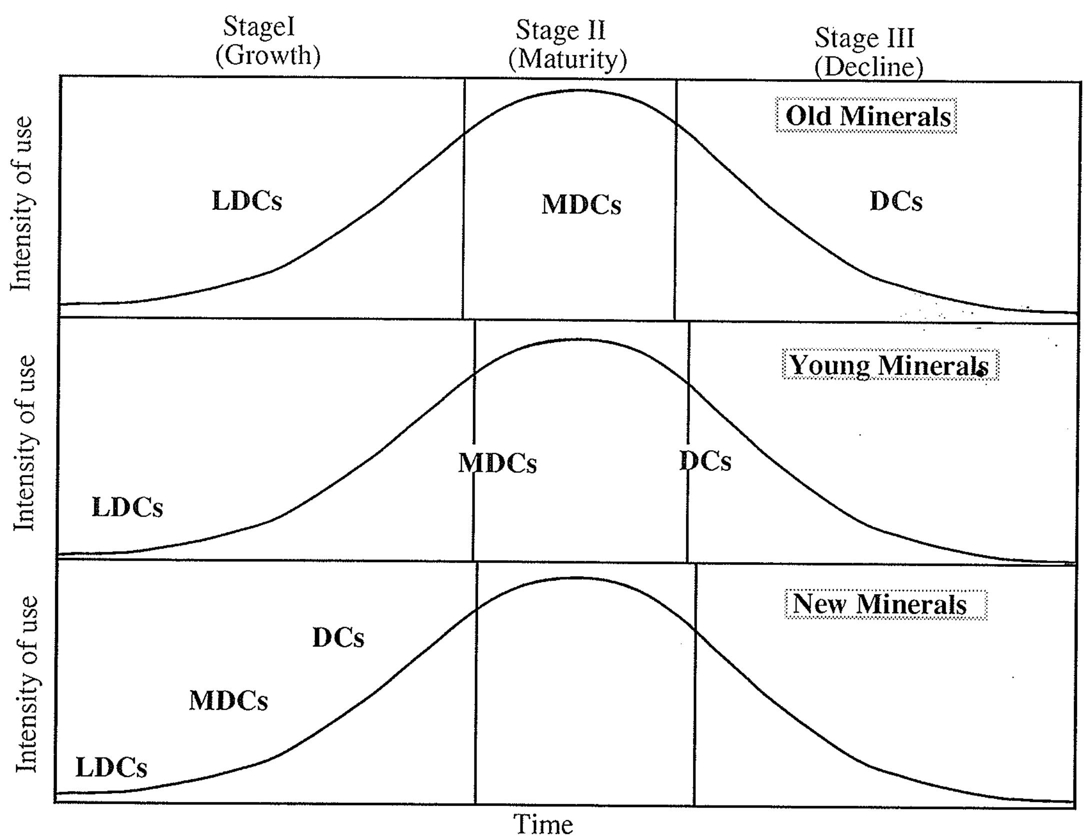


Figure 1-3 Theoretical Life-Cycle Curve of Mineral Consumption for Groups of Countries (After Clark and Jeon)

demand leads first to a slowing and eventually to a reversal in the upward rise in intensity of mineral use as per capita income advances, and the pattern of IU starts to enter a decline stage. Between the growth and decline stages, however, there is a transfer period, known as the maturity stage, in which the material-intensive use remains relatively stable. This is the basic rationale for the inverted U-shaped behavioural relationship that exists between intensity of metal use and per capita income. Furthermore, Malenbaum argued that this three-stage assumption of the material-intensive use hypothesis can be proved by the cases of less-developed countries (LDCs), middle-developed countries (MDCs) and developed countries (DCs). The particular stage of minerals demand exhibited by a country depends on the type of mineral considered and its stage of economic development.

Clark and Jeon (1990) developed this concept, and they argued that individual minerals can be categorized into three basic groups according to their time of introduction and widespread acceptance in the world's mineral market (Figure 1-3). Categories and examples of representative metals and energy materials are as follows:

1. old minerals--copper, iron ore, lead, tin, zinc and coal;
2. young minerals--aluminum, chromium, manganese, molybdenum, nickel, vanadium, and crude oil as well as natural gas; and
3. new minerals--cobalt, germanium, platinum, rare earths, titanium and uranium.

In general, minerals classified as old are those which are extensively employed in the early stage of industrialization. The young minerals are commonly utilized when industrial diversification occurs and technology has advanced. New minerals are used primarily by developed countries that enjoy a high level of technological development and diversification. Table 1-3 provides an example to illustrate the patterns of intensity of use in the world between 1951 and 1975.

Table 1-3 Intensity of Use of Iron Ore, Aluminum and Cobalt, 1951-1975

Region	Iron Ore 1951-55	Iron Ore 1961-65	Iron Ore 1971-75	Primary Aluminum 1951-55	Primary Aluminum 1961-65	Primary Aluminum 1971-75	Cobalt 1951-55	Cobalt 1961-65	Cobalt 1971-75
	(1000 metric tons per billion $ GDP, 1971 prices)			(metric tons per billion $ GDP, 1971 prices)					
1. W. Europe	104.4	126.9	101.0	1565	2283	3056	6.4	9.5	6.5
2. Japan	67.0	267.3	204.5	866	2258	4863	5.9	14.7	15.3
3. U.S.A.	106.9	92.9	76.1	2174	3002	3911	7.9	6.5	6.5
4. Former U.S.S.R	137.1	172.5	157.1	1363	2106	2413	2.0	2.4	3.2
5. E. Europe	71.9	117.7	115.7	876	2247	2647	5.0	6.3	5.9
6. Africa	46.4	57.9	53.2	37	163	559	13.2	12.0	9.9
7. Asia	27.9	46.2	49.8	140	764	1462	0.1	0.6	1.3
8. World	95.0	121.8	109.1	1478	2239	3097	5.6	6.0	5.9

Source: 1. United Nations "Statistical Yearbook" (various issues).
2. United Nations "Demographic Yearbook" (various years).
3. "Metal statistics" Metallgesellschaft AG, Germany (various years).

National consumption of iron ore (a typical old mineral) is influenced by a country's level of national income, the living standard of its people and the structure of its economy. The changing levels and composition of demand for the total of final goods and services thus exercise a dominant force upon the level and pattern of intensity-use of this material. It is not surprising, therefore, that the data embodied in Table 1-3 conform closely with the general observations above, which were based on relationships that emerged from the range of raw minerals' studies. The world's developed nations had in early years expanded their use of iron ore for modern transportation, industry and construction, and then usage declined rapidly. Intensities for this mineral in Europe and Japan were moderate in the early 1950s, but peaked in the period of 1961-65 mainly on account of the effects of post-war economic recovery and prosperity. A movement to less intensive use began after 1970, however, when higher GDP per capita (over US$2,000) was achieved. Because of a higher level of GDP per capita (over US$3,000) prevailing even before the 1950s, the intensity of use of iron ore in the United States exhibits a trend of continuing decline for all these periods. By way of contrast, intensities in Africa and Asia are rising, albeit from a very low base. They reflect the early expanding of economic growth based on the lower level of GDP per capita (around US$100). Most developing nations are increasingly involved in infrastructural projects--railways and other transportation and communications systems, dams for irrigation and power, to say nothing of electric utilities. All this contributes to national output that is more iron-intensive and steel-intensive.

The record for the intensity-of-use (I-U) of primary aluminum, one of the key young minerals, is unequivocal. There is no evidence of an absolute decline anywhere, although the growth rates of I-U have become persistently lower in the main consumption regions. For example, during the period between 1965 and 1975 the growth rate of aluminum consumption in the USA registered only 30 per cent in comparison with 91 per cent recorded in Asia. There remains an impressive and widening technical scope for the substitution of aluminum for iron ore, nickel, tin, and zinc in metal production, and for steel and copper in respect of metal final goods, such as the expanding role of aluminum in electrical transmission equipment. Construction and transportation equipment (automobiles particularly) and an expanding array of consumer goods have become even greater users of aluminum in most part of the world. The rapid growth in I-U in developing countries combines a high income effect as the economies develop (or at least industrialize), supplemented with what is generally a positive substitution effect.

As a result of its special qualities in making steel for high-temperature products ("superalloys" for jet engines and rotor blades), cobalt serves important non-steel uses associated with the magnetic and chemical properties of the metal. Extensive investment in technological research has contributed to this demand, particularly with respect to the combination of cobalt with aluminum and nickel in the permanent magnet, Alnico. On the other hand, cobalt has increasingly suffered from substitution, in some measure by nickel but mostly by the growth in importance of ceramic magnets. Since the late 1950s, technological change has, on the whole, served to make competing materials progressively less costly than cobalt. The I-U patterns for cobalt in Table 1-3 correspond closely with the pattern discerned with respect to iron ore and aluminum. Since about 80 percent of all cobalt was produced in Africa during this period, data for this continent reflect inventory adjustment difficulties rather then trends in economic development. For Japan, high intensities are interpreted principally as a consequence of the country's exports of goods containing cobalt, such as office equipment.

The IU concept has four significant implications for developing countries. First, it suggests that expanding mineral markets, both domestic and international, are a significant factor which enables LDCs to catch the benefits of industrialization. Second, it implies that the development of the old minerals should be accorded priority in the mineral strategy of LDCs rather than the young and the new minerals, on account not only of the fact that they need less capital and technology inputs which are relatively scarce in LDCs but also because of the pattern of their domestic market. In 1990, for example, LDCs consumed 148 million tonnes of pig iron, or about 26.6 per cent of the world's total. By way of contrast, the share of the consumption of aluminum for LDCs was only about 15 per cent of the world's total. Their pattern is

Table 1-4 Distribution of Minerals Consumption, Population and GNP in the World, 1990 (%)

Group	Pig Iron	Aluminum	Coal	Petroleum	Population	GNP*
LDCs	26.6	14.5	38.5	10.5	58.3	5.1
MDCs	27.7	19.0	26.4	38.8	26.2	16.2
DCs	45.7	66.5	35.1	50.7	15.5	78.7
the World	100.0	100.0	100.0	100.0	100.0	100.0

Note * GNP 1991.
Sources: **Metallgesellschaft Aktiengesellschaft**, Metal statistics 1991, Frankfurt am Main, Metallgesellschaft. AG.
The World Bank (1993) World Development Report 1993, Oxford University Press, Oxford.
United Nations (1992) Energy Statistics Yearbook, 1990, New York.

equally distinct with respect to energy consumption (see Table 1-4). Third, it suggests, therefore, that the first object of economic growth for developing countries is to build up a stable mineral-supply system in order to meet the demands of both domestic and international markets. Last, it hints at a fundamental relationship; namely, the larger the population of a developing country, the bigger the potential of domestic market and, accordingly, the greater the demand for mineral development.

Export-Base Theory Export-base theory or economic-base theory speaks in terms of a region's comparative advantages which lead to the sale of goods that, in turn, directly or indirectly provide resources to the commodity-exporting region. The inflow of resources, for its part, makes possible further development to the end that multiple gains are attributable ultimately to the original export (North, 1955). This export-base theory has origins in the trade theories of Ricardo and Mill, and the location theories of Hoyt. The stock of resources, both natural to the region as well as those obtained by it from trade, serves as a base for its economic growth.

The theory of the export base has often been presented in the literature as an alternative to the deterministic development stages theory in accounting for regional economic growth. As its name implies, it stresses the importance of export industries in the region's economy that grow up within a framework of a national or international division of labour and can therefore respond to profit maximizing opportunities, in which factors of production can be relatively mobile (North, 1955).

According to the export-base theory, provided there is an increase in demand, an increase in exports of surplus resources in a region can give rise to input requirements by exporting industry, requirements that take the form of factor services and intermediate products. In turn, this leads to income payments by the exporting industry and 'residentiary industries' supplying intermediate products and services for export production. The additional income received by local households is a catalyst for further growth, resulting in consumption expenditures on domestic goods and imports.

An increasing export production may engender three scenarios for promoting regional development. First, it can effect both the quantity and quality of the labour force by both an increasing skilled labour immigration into the host region and a greater requirement for more advanced technology. As a result, the diffusion of more advanced technology and skilled labour in the region is likely to influence strongly the education and technical training of the local labour force. If the export industry generates a more highly-educated and skilled work-force, then it may encourage technological change in the region either directly or indirectly (Baldwin, 1963). Second, it can absorb more investment from outside when the export product is a relatively important input in the national production process. Also induced capital formation in the region may take place in the investment-goods industries and services, which usually function in a forward (usually defined as a proportion of an industry's output used as an input by other industries) and backward (which exists when an industry purchases intermediate inputs from suppliers) linkage chain with the export product. Third, it can improve the accessibility of the region to its markets; and local infrastructural facilities such as schools, hospitals, dams, drainage systems, highways, railways and airports result, in large part, from the expansion of both the labour force and investment.

It is significant that the region's export base is not a fixed datum; that is to say, the base changes with time, as currently produced private and social goods help bring forth new goods that change the base to permit exports of capital, skills, and specialized services to less-well-developed regions. In other words, as a region's income grows, indigenous savings will tend to spill over into new kinds of activities. As first these activities satisfy local demand, but ultimately some of them will become export industries. This movement is reinforced by the tendency for transfer costs to become less significant. As a result, the export bases of regions tend to become more diversified in tandem with their aggregate predilection to become more diversified. This is well illustrated by Thompson (1965), who suggests a model from which the following synthesis is based.

1. In Export Specialization, the local economy is the lengthened shadow of a single dominant industry or even a single firm.
2. In the Export Complex, local production broadens to other

products and/or deepens by extending forwards or backwards in the stages of production, by adding local suppliers and/or consumers of intermediate products.

3. In Economic Maturation (Local Service Sector Puberty), the principal expansion of local activity is in the direction of replacing imports with new "own use" production; the local economy fills out in range and quality of both business and consumer services.

4. In the Regional Metropolis, the local economy becomes a node connecting and controlling neighbouring cities, once rivals and now satellites, and the export of services becomes a major economic function.

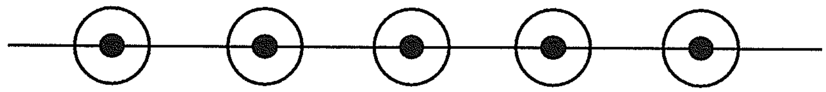
5. In Technical-Professional Virtuosity, national eminence in some specialized skill or economic function is achieved.

In relation to this model, mineral industry, as a powerful instrument of regional development, must be the leading sector of regional export industry, and mineral export-dependent activity can not only provide great opportunities to create new jobs, absorb investment and more advanced technology from the outside, and improve local inftrastructural facilities, but it can also provide the prerequisites for other production sequences and prepare the host region for achievement of the "take-off" point.

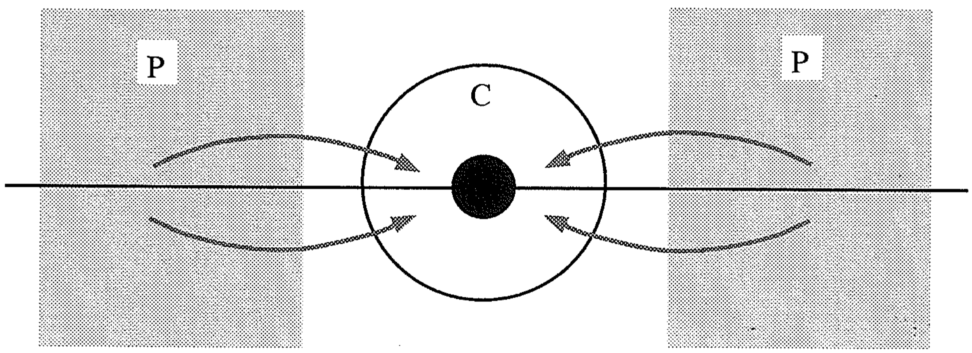
Centre-Periphery Theory. This theory dwells on the spatial organization of human activity based upon the unequal distribution of power in economy and society.

A basic concept in this theory is cumulative growth. Once a region (for whatever reason) gains an initial advantage over others, various forces tend to widen rather than reduce the gap between them; once triggered, growth proceeds by "circular and cumulative causation", while spatial interaction with other regions tends to heighten the regional disparities by the process of 'backwash' (Myrdal, 1957). Although eventually counteracting 'spread' effects may develop, these tend to be weaker, and cannot prevent the development of a 'central (core)-periphery' or 'heartland-hinterland' structure. The hinterland or peripheries of a nation develop a dependent relationship to the industrial heartland or centre with resource inputs, and persist in lagging behind it in development. When economic growth is sustained over long periods, some equilibrating tendency may occur and progressive integration of the space economy may result, through outward flows of growth impulses down the urban hierarchy and catalytic impacts on surrounding areas (Berry, 1973). However, the 'power' of the centre to continuously innovate new dynamic forms of activity (Thompson, 1968) is just as likely to leave the periphery condemned to a lower rate of growth. These central-periphery relations were seen by John Friedmann (1966) as being reflected in the extent of regional disparities which, in turn, derived from the stage of development attained by the nation containing the regions. The stages delimited by Friedmann are worth elaborating (also see Figure 1-4).

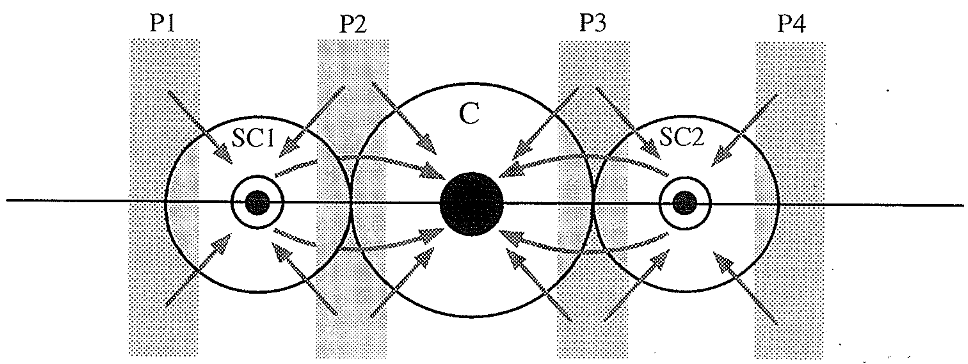
1. *Pre-industrial societies* occur where economies are highly localized and there is no nationally-integrated spatial



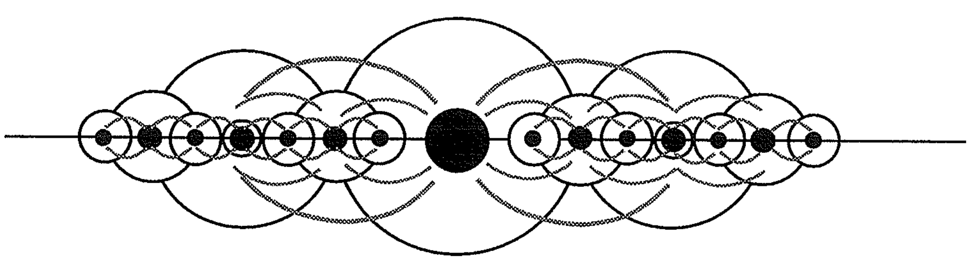
Stage 1 Independent local centres, no hierarchy.



Stage 2 A single strong centre. C=centre; P=periphery



Stage 3 A single national centre, strong peripheral subcentres. Pn= peripheries; SCn= subcentres.



Stage 4 A functionally-interdependent system of cities.

Figure 1-4 A Sequence of Stages in Spatial Organization (after Friedmann)

framework.

2. *Transitional societies* are characterized by rapid industrialization and "take-off" in which dramatic spatial shifts occur, especially in association with movement from agriculture to industry. A dualistic centre-periphery structure develops as investment is concentrated in favoured areas. The periphery begins to lag, though resource exploitation may trigger growth in some areas. Regional development levels diverge strongly.
3. *Industrial societies* are those approaching economic maturity where considerable problems of regional backwardness emerge. Some areas are stranded by depletion of their resources or a drop in demand for their major product. They need conversion to a new economic base. Regional policy becomes prominent. In time strong peripheral sub-centres may develop and promote regional convergence.
4. *Post-industrial societies* are the final outcome; that is, a space economy with a functionally-interdependent system of cities. More speculatively, the periphery is absorbed and regional balance achieved. Metropolitan organization, urban renewal and environmental quality become dominant planning concerns.

In relation to this model, regions are classified according to the problems that they pose for development. Centre areas, consisting of metropolitan areas, are characterized by high promise for economic growth. Periphery regions are those where natural endowments and location with respect to the centre areas suggest the possibility of greatly intensified use of mineral resources (through spread effects). Of particular importance in the context of this study is the periphery regions, since their development is frequently based upon large-scale investment in mineral resources. Periphery regions can involve substantial urbanization, with the cities acting as an agent for transformation of wilderness. The whole set of periphery regions form a spatial system governed by the centre area.

1.4 Objectives

The plan of this study is inspired by the framework of relevant theories outlined above. Considering China's size and prolonged evolution, it is necessary to construct a set of targets in order to come to grips with the general hypothesis that mineral industry acts as an instrument in furthering regional development. In this sense, it is expected that the development of mineral industry can act as a catalyst in effecting the structural transformation of a country from a lower value-added type, which is dominated by primary products such as grain and foodstuff, to a higher value-added one, which is led by manufacturing goods such as machines and chemical products, so that a higher growth rate of national economy can be achieved in comparison with that which went before. As part and parcel of this structural transformation, it is also expected that mineral industry will accelerate the concentration of economic activity, particularly manufacturing industry, through the expansion of mineral-export and, in consequence, a centre-periphery pattern in regional growth will either be created or, if already present, will be reinforced. At one and the same time, then, the general hypothesis addresses aggregated, national-level development and disaggregated, interregional aspects of development. In doing so, the targets, six in number, are given below:

A. peruse the changing pattern of mineral consumption and development;

B. examine the resource base and mineral supply;

C. infer the degree of foreign trade in mineral products;

D. define the initial stage of mineral development;

E. monitor the diversification of the mineral economy;

F. establish the contribution of the mineral industry to the spatial organization of the country as a whole.

Targets A, B and C are designed to concentrate on determining the role of minerals in national development while the last three targets (D, E and F) focus on examining mineral's contribution to regional development.

1.5 Methodology and Data

All that awaits addressing at this point is the question of methodology. A range of methodologies will be pursued in order to examine the aforesaid hypothesis and several are the subject of comprehensive application. It is a basic characteristic of social science that isomorphism, or the existence of simple, one-to-one causal relationships, is rare. By default, then, I am forced into an investigation of a series of causally-related variables. Such an examination may be made more rigorous and less time-consuming if the explanatory variables can be considered simultaneously, rather than in a stepwise, "one-after-another" manner. It is to accomplish this aim that accounts for my interest in multivariate techniques. I have elected two for extensive use: factor analysis and cluster analysis. However, this is not to say that factor analysis (FA) and cluster analysis (CA) are the sole or main methodologies germane to my research, merely that they are the two most appropriate for ordering the mass of data collected. The order ensuing from the application of these two techniques will still allow this study to use other methodologies, especially the input-output approach (I-O) and regression analysis. A methodological framework for relating mineral industry and regional development can be listed as follows:

(a) apply I-O to examine mining-based diversification and the performance of mineral industry in local economies;

(b) use regression analysis to test the impacts of mineral industry on regional economic well-being; and

(c) apply FA/CA to ascertain the independent contribution of mineral industry to socio-economic growth and the impacts on the change patterns of the national centre-periphery structure.

The data for this study have been drawn mainly from China's official sources, although some of these have been compiled by other investigators, for example, the World Bank. The <u>China Statistics Yearbook</u>, the <u>China Urban Statistics Yearbook</u>, and the

China Industries Statistics Yearbook are relied on heavily. Because China, the object of this study, is a large country with a territory of 9.6 million km^2 and a population of more than 1.1 billion people and because its modern development covers a period of more than forty years, any kind of survey and primary data collection on the subject of the relationship between mineral development and regional growth will be a very time-and-money-consuming job. Those resources of time and money are well beyond the reach of this researcher. More importantly, the data so obtained are more reliable and less controversial, and these data vocer not only the whole investigation period but also both the national and regional levels.

1.6 Thesis Organization

The subject matter of this thesis is organized into eight chapters. Chapter II addresses the target A by tracing the changing relationship between industrial development and mineral consumption. Chapter III deals with target B by presenting the general pattern of mineral supply and the development of the mineral industry. Chapter IV inquires into target C by evaluating the contribution of the mineral industry to China's foreign trade. All three chapters are designed to concentrate on examining the relationship between economic growth and mineral development at the national level so that a sound foundation can be laid for the remainder of the study, that with a regional focus. Chapter V and Chapter VI focus on estimating the contribution of mineral production to local economies at different stages of industrial development (targets D and E). Incidentally, I am alive to the fact that there is a negative side to mineral development--the externalities most vividly expressed through environmental degradation--and I have touched upon the pollution issue as it comes to bear on the mineral industry. Nevertheless, the thrust of this thesis is concentrated on the positive impacts because these, and these alone, offer the promise of economic development which will permit China to fully address the externalities in due course. The I-O technique and regression analysis will be used for determining the multiplier and linkage effects of mineral industry and the relationship between regional economic well-being and mining activity. Chapter VII presents the most important part of this thesis. Applying FA, the significance of mineral industry in China's economic development in the past forty years is assessed. It is designed to confirm the hypothesized expectation that the mineral industry makes independent positive contributions to China's socio-economic development. Furthermore, it attempts to disentangle, by means of CA, the distinct effects of mineral processing, coal and oil extraction on various parts of the country, ultimately impinging on the nature of the core-periphery structure. As can be elicited from Figure 1-5, the analytical results dealt with in this chapter influence the conclusions (Chapter VIII) that arise from the study. Long before any conclusion can be drawn, however, it is necessary to set the scene; and that is the purpose of the next chapter.

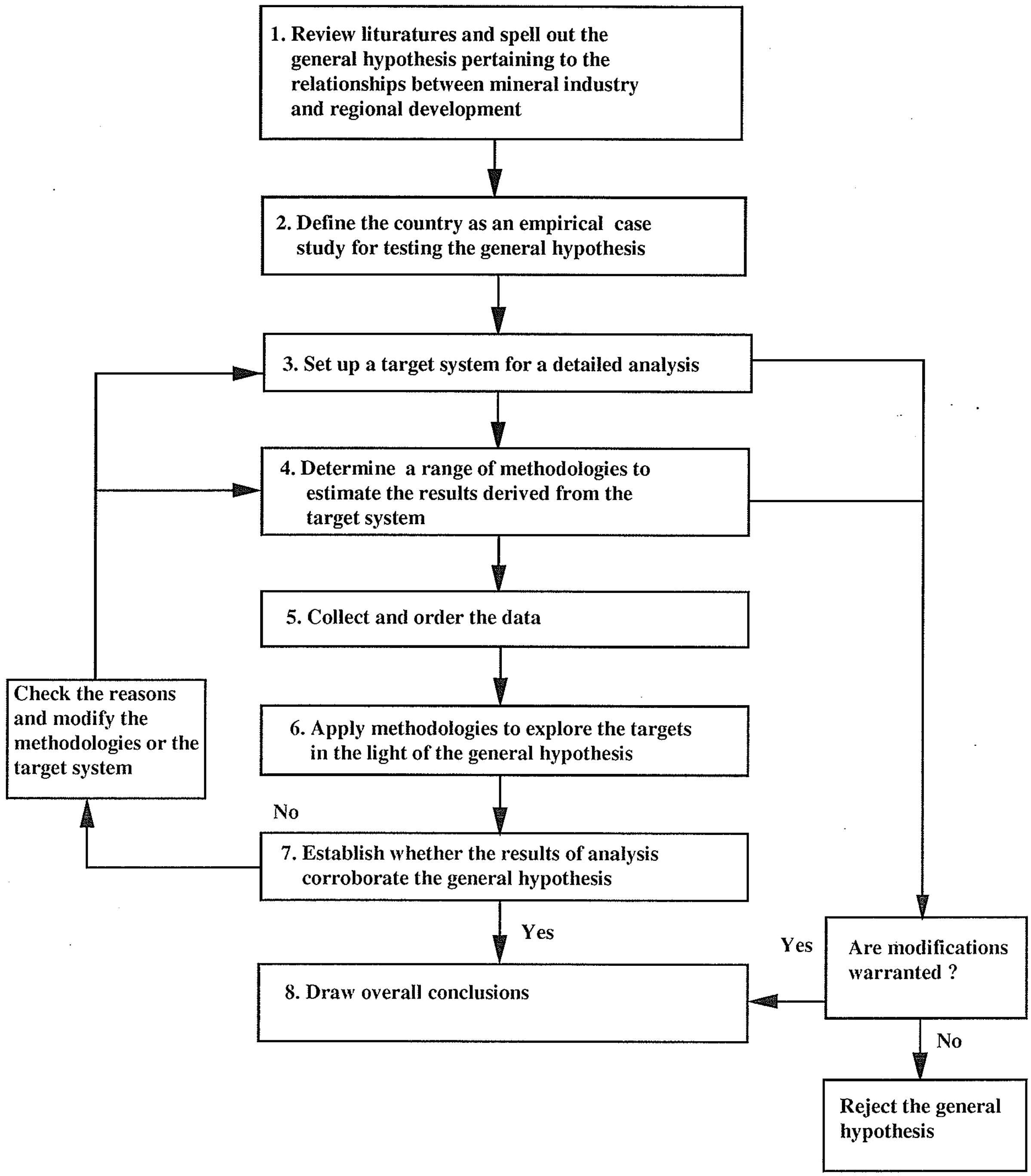


Figure 1-5 A Logical Framework for The Study

CHAPTER II

ECONOMIC DEVELOPMENT AND THE DEMAND FOR MINERAL MATERIALS

2.1 Introduction

It is undoubtedly the case that natural resources can be considered as the key to development and the foundation upon which any society is built. But the economy's dependence on the exploitation of mineral resources is not a constant, it is a function of its stage in the process of economic development in general and industrialization in particular. Chapter I was at pains to argue this point, especially with respect to the transition from industrializing to fully-industrialized economies. In the light of the discussion introduced there it is permissible to maintain that mineral consumption is vitally important at the early stage of industrialization and becomes progressively less critical as the industrial system advances. Although the interest in mineral consumption in the world, particularly in the developing countries, has been awakened recently, there is very little known either about how consumption has grown or about what causes it to grow (Tilton, 1990). The purpose of this chapter is to scrutinize the actual demand trend in China in order to corroborate the proposition that heightened mineral consumption is a critical factor shaping the early stage of industrialization. The analyses conducted herein are intended to establish the close relationship between the development of the manufacturing sector and the growth of mineral demands in China during the past forty years. The intent is also to show how important development policies have been in determining the path of national economic growth. The findings should shed light on the sensitivity of structural transformation at the national level to the intensity of mineral consumption. Overall, this chapter addresses the first target specified in the last chapter.

2.2 Ideological Grounds for Economic Development

First in Britain, then in a few regions of North-west Europe and North-eastern America, a structural transformation of the economy, seen in perspective as having been in preparation for centuries, such a change shifted the balance of productive activity from agriculture to manufacturing industry and opened up boundless possibilities for increasing the productivity of human labour. This process, best described as industrialization, brought into existence those forms of the labour process and styles of living distinguishing the modern world from the past.

A rapid widespread adoption of machine production changed the traditional ways of Man's life, particularly the usage of natural resources. Mineral resources replaced plantation and animal resources as a major input factor in economic growth. In practical terms, the amount of nearly every mineral resource worth mentioning used before that time was negligible in comparison with today's consumption. The Industrial Revolution brought mineral resources into a new prominence of social production in terms of both the variety and the volume of minerals consumed. The continued growth of industry, fed both by a growing world population and rising standards of living, resulted in ever greater demands for the earth's resources to feed, warm, house, and accommodate humankind. In the period from 1770 until 1900, when world population approximately doubled, mineral production grew tenfold. From 1900 until 1970, when world population increased about 2.3 times, mineral production increased twelvefold (Craig, Vanghun, and Skinner, 1988).

Since the Second World War, industrialization has been generally sought by the newly-developing countries as the means to raise living standards and to ensure national independence. Widely publicized tables of income levels of the countries of the world leave no doubt that incomes are generally higher the greater is the contribution made by manufacturing industry. Countries which have little or no industry are almost invariably poor. The lesson is plain and simple: to overcome poverty and economic backwardness a country must industrialize.

It has become the declared policy of the governments of new states, large and small, formed from the old colonial empires, to embark upon a programme of industrialization (explicit industrial policy). Conscious attempts have been made to follow models already in existence, as well as to develop new ones appropriate for particular areas or types of country. Industrialization has, without doubt, become a global process and, although it proceeds very unevenly, a new surge has been taking place. Even where it has scarcely begun it has been adopted as an article of faith, especially by the new governing elites hoping to consolidate their national independence, emulate the advanced countries and raise income levels. Where does China enter into this scheme of things?

In contrast with Japan and the "West", the necessity of industrialization was not fully accepted by the Qing government (1644-1911) until China was defeated by Japan in the war of 1894-95. The period from the collapse of the Qing dynasty (1911) until 1949 was turbulent, with "warlord" governments, military struggle against the Chinese Communist Party, the Anti-Japanese War and the 1946-49 Civil War. These disturbing conditions greatly handicapped economic developments in China. Overall output growth was extremely slow, with gross national product (GNP) per person estimated very roughly to have grown by just 3.3 per cent per decade from 1870 to 1952 (Swamy 1979).

The establishment of the People's Republic of China (PRC) in 1949 began to indicate that China at last had emerged from her age of famines, although some terrible conditions persisted afterwards, such as the mutual hostility between China and the West during and after The Korean War (1950-1953), the Great Leap Forward (1958-59), the Sino-Soviet antagonism (the 1960s), and the Great Cultural Revolution (1966-1976). All these events hindered China's road to development. The post-1949 government set itself the task of modernizing China and progress in industrialization was regarded as a key means by which this was to be done. Industry, especially heavy or producer sectors, was to be the leading thrust in this effort. If one compares China's present industrial structure and level of productivity with the state of the Chinese economy at the outset of such transformation some forty years ago, the progress in industrialization is undeniable. The Chinese themselves have maintained their high rate of economic growth, particularly in industrial production, mostly as a consequence of the application of the law of the priority growth of the producer goods sector (department I).

In Book II of *Capital*, Karl Marx analyses the processes of the simple and expanded reproduction of capital by attempting to show the mechanism by which capital consumed during production is replaced. He divided the gross social product (in Chinese: *shehui zongchanzhi*) into the gross social product of department I (means of production) and the gross social product of department II (means of consumption). From this analysis he deduces functional relationships that must occur for the process to be activated. His conclusion is that department I must grow more rapidly than department II. In other words, his scheme invokes a mode of extensive economic growth which is reliant on the formation of a basic economic infrastructure vital to development. This model was adopted by the former USSR and the procedure attaching priority growth to department I was erected by Stalin into an economic law imposed on former Soviet planners--and later on those of other socialist countries (Pairault, 1988).

The law of the priority growth of the producer goods sector (department I) was initially adopted by the Chinese government in its First Five-Year Plan (1952-1957), and came to dominate Chinese economic development right through to the 1980s. In practical

Table 2-1 Key Economic Indicators, China (output and income data all at comparable prices)

	Average annual growth rate (%) 1953-1990
Total social product (gross material product)	8.7
Gross value of agricultural output	3.7
Gross value of industrial output	11.6
Heavy industry	12.7
Light industry	10.7
National income (net material product)	6.7
Agriculture	3.0
Industry	11.0
Construction	7.8
Transport	7.6
Commerce	5.2
Population	2.1

Source: China's Statistics Bureau China's Statistics Yearbook, 1991.

Table 2-2 International Comparison of Growth Rates (%)

Country	Average annual rate of increase in GDP 1965-80	GDP 1980-90	Industry 1965-80	Industry 1980-90	GDP per capita 1965-1990
China	6.8	9.5	10.0	12.5	5.8
India	3.6	5.3	4.2	6.6	1.9
Indonesia	7.0	5.5	11.9	5.6	4.5
Bangladesh	1.7	4.3	1.5	4.9	0.7
Nigeria	6.0	1.4	13.1	-1.2	0.1
Brazil	9.0	2.7	10.1	2.1	3.3
Japan	6.4	4.1	7.1	4.5	4.1
U.S.A.	2.7	3.4	1.7	..	1.7

Source: World bank, World Development Report, 1988 and 1990.
* GDP roughly equals to Gross Social Value Output.
** the size of population for each country (in millions) in mid-1990: China (1137.0); India (849.5); Indonesia (178.2); Bangladesh (106.7); Nigeria (115.5); Brazil (150.4); Japan (123.5); and the U.S.A. (250.0).

terms, it involved the formulation of an overarching development strategy. That strategy was (and, for the most part, persists in being) mainly drawn up according to the "ratchet principle". In other words, after postulating growth rates and taking into account a number of hierarchies (before the 1980s, iron and steel, was always accorded the top priority, followed by non-ferrous metal products, crude oil and coal; then, agricultural and manufacturing goods), it simultaneously derives final output and the material outlays of the various sectors of the economy. The logic of this procedure is to maximize output in order to maximize final consumption (of producer goods in the first instance, and, then, of consumer goods), and, therefore, leads to rational choices in resource allocation.

A first logical consequence of assigning top priority to the law of the department I growth is that Gross Social Value Output (GSVO) [1] grows faster than National Income (NI) [2], as shown in Table 2-1, where, for the period 1953-1990, the GSVO grew at an annual average rate of 8.7 per cent as against the 6.7 per cent applying for NI. The growth rate of net material product was inferior to the growth of GSVO because of the increasing amount of material input used to produce a unit of output: a circumstance arising largely from such poor initial conditions as the want of infrastructure facilities and suitable technical know-how and personnel on the one hand, and the rapid spread of rural industrialization during the period of the Great Lead Forward and the Great Cultural Revolution on the other. But, even so, a growth rate of more than 6 per cent per annum during the period in question was a strong performance compared both with China's past and with what was occurring in most developing countries. World Bank estimates of the growth rates of different countries are given in Table 2-2 for the sake of comparison (with the exception of Bangladesh, Japan and Nigeria, only countries with very large populations are included in the table). In the period of 1965-80, China's average annual rate of growth in GDP was 6.8 per cent, a relatively impressive figure and one only just lower than those of Brazil and Indonesia.

A second logical consequence of the law is the increase in the capital-labour ratio (the organic composition of capital in Marxist terminology). In China this ratio appears to have doubled between 1957 and 1990 (see Table 2-3). This evolution is quite normal in a country which emphasizes capital investment. The sectors where capital intensity is above average are precisely those composing department I. In other words, the law of the priority growth imposes a disproportionable requirement for factor inputs, especially capital input. In fact, this law leaves Chinese planners with no choice but to pursue a policy of high rates of accumulation. They accomplish this by, first, maintaining pressure on consumption. The rate of accumulation , for example, was on average 33.4 per cent of National Income during the First-Five Year Plan. Secondly, they achieve it by the granting of higher interest rates for longer-term deposits. In 1983, for instance, interest rates varied from 2.9 per cent a year for immediate deposits to

Table 2-3 Gross Social Value Output, National Income and Capital-Labour Ratio (billion 1980 yuan)

	1953	1957	1965	1975	1980	1990
GSVO (*c+v+m*)	124.1	160.6	269.5	380.0	853.4	3799.6
NI (*v+m*)	70.9	90.8	138.7	250.3	368.8	1442.9
Material outlays (*c*)	53.2	69.8	130.8	129.7	484.6	2356.7
Remuneration fund (*v*)	55.9	70.2	98.2	162.1	253.1	944.4
c/v+m	0.75	0.76	0.94	1.15	1.30	1.63
c/v (capital-labour ratio)	0.89	0.99	1.33	1.77	1.90	2.50
Investment ratio	23.1	24.9	27.1	33.9	31.5	34.1

GSVO=Gross Social Value Output. NI=National Income.
m=net additional product.
Source: China's Statistics Bureau, Statistics Yearbook 1991, China.

10.4 per cent a year for eight-year deposits. Thirdly, they pursue the goal by modifying the ratio of so-called productive and consumptive or unproductive investments (the total investment in the producer goods is divided by that in the consumer goods). The distribution between these two types of investment was kept at 80/20 before the 1980s according to China's Statistics Bureau.

2.3 Changes Inherent in Economic Structures

Many countries have displayed a general pattern of change in economic structure as their economies modernized and grew. First, a long-term pattern of increasing per capita output has generally been accompanied by a continuous decline in the proportion of GNP supplied by agricultural and related primary industries. Second, shifts in the industrial structure have required a significant rise in capital formation. Third, within modern industry, a remarkable change has also occurred in the division between consumer goods and producer goods. Over the past forty years, the structure of the Chinese economy has undergone dramatic changes in terms of sectoral structure, the relationships between investment and consumption, and the relationships between industrial structure and the composition of foreign trade.

Structural changes in national product. The most distinctive feature of modern economic development is the shift of product and labour force from agriculture into manufacturing. In pre-World War II years, agriculture supplied the overwhelming share of China's national product. In 1952, agriculture accounted for 57.7 per cent of NI, leaving the industry sector to account for only 23.1 per cent. Between 1952 and 1990, the share of agriculture products in NI dropped 23 points, while that pertaining to industry rose more than 28 points. In terms of the statistical data furnished by the World Bank, the share of agriculture in GDP dropped some 9 points between 1965 and 1990, while that of industry rose 7 per cent. Also, the structure of the Chinese labour force shifted dramatically during the same period, with the share of agriculture falling from 83 to 60 per cent, the share of industry (secondary production) rising almost three-fold (from 7.4 to 21.4) and that of services more than doubling (from 9.1 to 18.6). In contrast, agriculture's share in the low-income countries (with per capita national income of less than US$420 in 1990) in general dropped only 5 points while industry's share rose at an even slower pace (see Table 2-4).

Structural change in National Income. A significant rise in

Table 2-4 Economic and Production Structure Change in China (%)

Sector	1952	1965	1970	1975	1980	1990
Share in NI (net GDP)						
China						
Agriculture	57.7	46.2	40.4	37.8	36.0	34.7
Industry	23.1	40.2	45.1	50.5	53.9	45.8
Services	19.2	13.6	14.5	11.7	10.1	19.5
Share in GDP						
China						
Agriculture		38.0				28.4
Industry		35.0				54.7
Services		27.0				16.9
Low-income countries						
Agriculture		41.0				31.0
Industry		26.0				36.0
Services		32.0				35.0
Share in labour force						
China						
Agriculture	83.5	81.5	80.7	77.1	68.7	60.0
Industry	7.4	8.3	10.1	13.3	18.3	21.4
Services	9.1	9.9	9.2	9.6	13.0	18.6
Low-income countries						
Agriculture		77.0			(1988)	72.0
Industry		9.0			(1988)	13.0
Services		14.0			(1988)	15.0

Source: 1. Statistic Bureau of China, Statistic Yearbook of China, 1991.
2. World Bank, World Development Report 1992.

Table 2-5 Composition of Aggregate Demand in China and Other Developing Countries, 1965 and 1990

	Investment (%)		Domestic savings (%)	
	1965	1990	1965	1990
China	25	39	25	43
India	18	23	16	20
Brazil	20	22	22	23
Japan	32	33	33	34
Developing countries	19	31	18	28
Middle-income countries	21	23	22	24
Industrial countries	23	22	24	22

Source: World Bank World Development Report, 1992.

the proportion of NI devoted to capital formation is a prerequisite for modern economic development. The characteristic feature of China's pre-World War II economy was stagnation in which capital formation was extremely low (Cheng Chu-yuan, 1982). The rate of investment for the period 1931-1936 was only 7.5 per cent of NI, based on 1952 prices. To achieve rapid industrialization, the new Chinese government placed great stress on promoting capital accumulation at the expense of private consumption, thus producing a radical change in the end-use of the domestic product.

According to Chinese statistical materials, private and public consumption accounted for more than 90 per cent of NI in 1933. It dropped to 78.6 per cent in 1952 and declined further to about 66 per cent in 1990. In fact, the proportion of national income devoted to capital formation in almost all phases of economic development in China was very high by international standards. For many years China's investment ratio was well over 30 per cent and in some periods even exceeded 40 per cent of the material national product. By way of comparison, India's investment ratio, for example, stood at around 20 per cent in the years between the 1970s and the 1990s. The high share of saving in China is unique among low-income countries, well above the average for the middle-income countries, and matched only by Japan and the East European countries (World Bank, 1992, see also Table 2-5 and Figure 2-1).

Industrial structure change. Within China's industrial sector, there has been a significant change in the importance of producer goods relative to consumer goods in the composition of

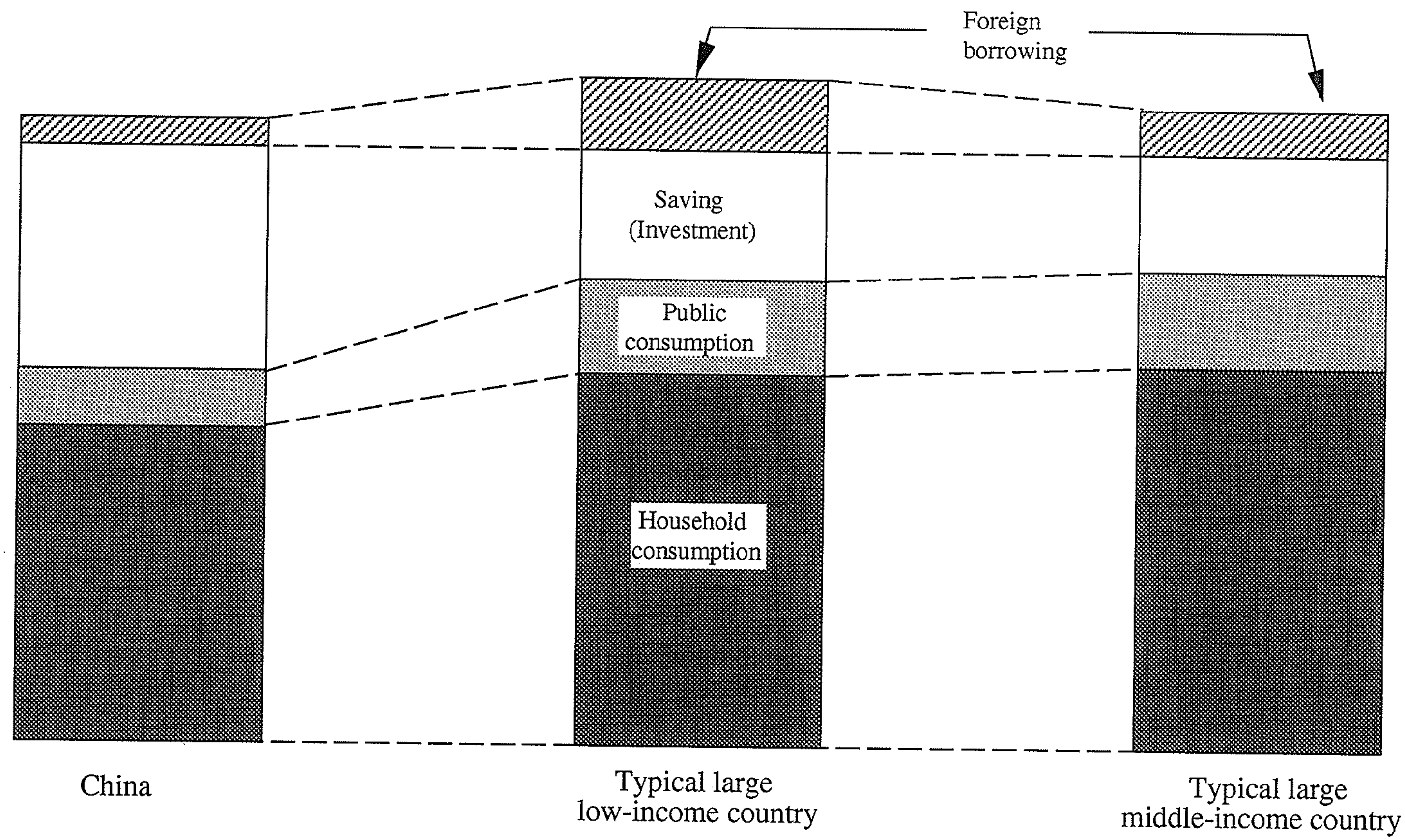


Figure 2-1 Composition of Aggregate Demand in China and Other Countries, 1990 (Share of GDP)

Source: World Bank (1992), World Development Report.

Table 2-6 Structural Change of Industrial Production in China (%)

Sector	1949	1952	1965	1975	1980	1985	1990
The Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Light industry	73.6	64.4	51.2	44.1	47.0	46.3	49.4
Heavy industry	26.4	35.6	48.3	55.9	53.0	53.3	50.6
Metal.Industry	1.8	5.9	10.7	9.0	8.6	8.0	10.4
Power industry	2.4	1.3	3.1	3.9	3.8	3.3	2.7
Coal industry	3.8	2.4	2.6	2.8	2.3	2.3	2.5
Petroleum industry	-	0.5	3.2	5.6	5.1	4.5	5.0
Chemicals industry	1.5	4.8	12.9	11.3	12.5	11.2	14.9
Machinery industry	6.8	11.4	22.3	27.7	25.5	27.0	24.4
Building Mat. ind.	1.1	3.0	2.8	3.1	3.6	4.2	4.8
Timber industry	6.9	6.5	2.9	2.0	1.7	1.6	1.6
Food proc. ind.	23.6	24.1	12.6	12.0	11.3	11.5	12.2
Textiles industry	36.9	27.5	15.8	12.3	14.7	15.3	14.5
Paper-making ind.	1.3	2.2	1.8	1.3	1.3	1.3	2.1
Other industries	13.9	10.4	9.3	9.0	9.6	9.8	4.9

Sources: 1. China's Statistics Bureau (1991) China's Statistics Yearbook, 1991.
2. Li Wen-yan (ed) (1990) Industrial Geography of China, Science Press, Beijing (in Chinese).

Note: 1. light industry consists of food, textiles, paper-making and other industries.
2. Heavy industry is equal to the department I or producer goods sector, which includes metal, power, coal, petroleum, chemical, machinery, building materials and timber industries according to China's Statistics Bureau.

output and in the roles of the steel, machine-building, and energy industries. Before 1949, consumer goods predominated in industrial production. Roughly 92 per cent of industrial capital in the 1930s was invested in consumer-goods industries, and in 1933, 81 per cent of the nation's gross value of industrial output and 76 per cent of gross value-added had been created by the consumer-goods industries. In 1936, textiles and food processing alone accounted for 63 per cent of the gross value and consumer goods as a whole accounted for 80.4 per cent of the total gross value of China's industrial output. The differing rates of growth of light and heavy industry materially altered China's industrial structure after 1949. In 1949, consumer goods accounted for 73.4 per cent of the total value of gross industrial output: a ratio in respect of heavy industry of about 3:1. In 1990 the division was 49.4 per cent for consumer goods and 50.6 per cent for producer goods. The change in industrial structure is even more striking when the relative shares of the eleven major industries in various benchmark years are compared (see Table 2-6). The great loser has been the textiles industry, which dominated Chinese industry for almost a century. In 1949, it accounted for 36.9 per cent of the total gross industrial output value, but by 1990 its share had dropped to 14.5 per cent.

The growth of the machine-building industry has been spectacular and has played a crucial role in China's industrialization. In official statements, the industry is often referred to as the basis for technological transformation of the national economy and the pillar of national defence. In 1949, machinery accounted for only 6.8 per cent of the nation's gross industrial output value. Since 1952, however, the industry has been given a high priority in development plans, and by 1960, its relative share in the total gross industrial output value had increased to 12 per cent. After reaching the peak of its development in the 1970s (27.7 per cent of the total in 1975), the machine-building industry's share diminished to 24.4 per cent by 1990 owing mainly to changes in the international political situation and the consequent large-scale introduction of equipment and technology from abroad. Nevertheless, the great progress in the machinery industry makes it one of the most dynamic branches of Chinese manufacturing. Compared with other industrial sectors, the annual growth rate of the machinery industry was 14 per cent between 1953 and 1990; a better performance than total producer goods output (12.8 per cent) or industry as a whole (11.8 per cent).

As one of the greatest contributors to China's industrial development, the expansion of the chemicals industry was mainly charged with promoting the interests of agriculture. However, the domestic production of chemical fertilizer was still not high enough to satisfy domestic demand. There were options available for improving the supply situation: firstly, to import artificial fertilizer; secondly, to import production plants for artificial fertilizer; thirdly, to build large-scale plants without foreign participation; and fourthly, to set up a large number of small-scale plants. With the third possibility ruled out because of the backwardness of domestic technological and material bases, it was decided to employ all means available, though with differing emphases. At the beginning of the Forth Five-Year Plan period (1971-75), China became the world's largest buyer of artificial fertilizer: almost half of all nitrates used were imported. In 1971 chemical fertilizers imported into China amounted to some 6.5 million tonnes. The dramatic rise in world market prices following the oil crisis of 1973 led temporarily to a noticeable decline in imports; that is, they dropped to 4.6 million tonnes in 1976. In the next ten years they rose again, now to over 10 million tonnes. At the same time, China elected to supply all its own needs through the importation of turn-key fertilizer factories. Since 1973, for example, the Chinese government has invested more than 4 billion yuan to import 15 complete factory installations for ammonia production, with a capacity of 4.29 million tonnes annually. As a result, China became the world's third largest producer of chemical fertilizers in 1989 after the former USSR and the U.S.A. (United Nations, 1989).

Structural changes in exports and imports. In the process of industrialization and modernization, foreign trade can play divergent roles. In some countries, it serves as a prime mover such that the expansion of exports stimulates technological change and opens up new markets, leading to rapid economic growth. In other countries, foreign trade becomes a balancing factor; imports serve as a way of breaking domestic supply bottlenecks, and the primary function of exports is to finance imports. China falls into the second category.

In China's modernization, foreign trade has constituted a vital channel for introducing both equipment and new technology, providing a major reason for persisting with trade expansion. Between 1949 and 1979, foreign trade accounted for only 5 to 8 per cent of GNP. In recent years, the volume of China's international trade has expanded greatly, accounting for 31.4 per cent of GNP in 1990.

China's composition of exports and imports is unusual when compared with that of other developing countries. Unlike most other low-income and lower-middle-income countries, Chinese exports consist mainly of manufactures, which accounted in 1990 for 74.4 per cent of the total of exports, compared with averages of 29 per cent and 38 per cent for other low-income and lower-middle-income countries. In fact, China's manufactured goods export share was at the same level as that of upper-middle-income countries, despite its large fuel and mineral exports. However, a characteristic that China has in common with most low-income countries with respect to the composition of exports, is the high share appropriated by textiles (27 per cent in 1990). Taken as a whole, China's exports are quite similar to those of India, which is also unusual among low-income countries in exporting more manufactures than primary products. The primary difference between the two is that China exports a great deal more fuel and minerals than India, and less agricultural products.

In 1990, China's imports were 81.5 per cent manufactures and 18.5 per cent primary products, which is quite similar to the averages of other developing countries, although rather different from India and other large countries (see Table 2-7). In 1990, 37 per cent of India's imports consisted of primary products and 63 per cent were made up of manufactures. The main reasons for this difference are that, first, while China was a net exporter of fuel, Indian was an importer with 17 per cent of its imports consisting of oil and oil products (1990) and, secondly, China became one of the world's largest buyers of machinery and transport equipment

Table 2-7 The Commodity Composition of International Trade in China and Other Countries, 1990

	China	India	Low-income economies	Lower-middle -income	Upper-middle -income
	Composition of merchandise exports (% of Total)				
Primary	26	27	47	62	45
Fuel, minerals	10	8	27	32	32
Other primary	16	19	20	30	13
Manufactures	74	73	43	38	55
Textiles	27	23	21	9	9
Machinery	17	7	9	17	20
Other	30	40	13	12	26
	Composition of merchandise imports (% of Total)				
Primary	31	37	29	29	32
Food	8	8	12	11	10
fuels	2	17	9	10	13
Other	21	12	8	8	9
Manufactures	69	63	71	71	68
Machinery	41	18	33	34	33
Other	28	45	38	37	35

Source: World Bank, World Development Report 1992.

after 1985 (31 per cent of its total import value in 1990), purchasing such items as Boeing aircraft, whereas India was much more restrained in its purchasing practices (18 per cent of its total import value was ascribed to machinery and transport equipment in 1990).

2.4 Patterns of Capital Investment

In China the term "capital investment" refers specifically to investment in fixed assets, comprising construction and investment in replacement and renewal. Such investment is the starting point for growth in China's economy, directly affecting not only the national economy, science and technology, but also both long-term and short-term social development. Where there is public ownership dominating the social production, investment is crucial to planning, and consequently is a critical factor in the development of the national economy relative to China's huge population and its vast endowment of natural resources.

Table 2-8 presents the general patterns of gross domestic investment during the past forty years. First, setting aside the ***adjustment*** period (1963-65) and the following Third Five-Year Plan, the two most unsettling periods in the whole capital investment's pattern of investment during the past 40 years, the rate of domestic investment increased steadily from the First Five-Year Plan period up to the most recent years (see Table 2-9). The rate during the Fourth Five-Year Plan and after was very high by comparison with those of developing countries (see Fig. 2-1). Second, industry is always in the forefront of the state's investment, and its share never fell below 50 per cent before the 1980s. Following a decline between 1981 and 1985, the share of industry began creeping up again and reached 46.6 per cent during the Seventh Five-Year Plan period. This was occasioned by the severe energy shortage of 1980-81. Paradoxically, the share of investment in the service sector declined over an extended period. Therefore, in response to the growing imbalances between industry and services, the share of investment in services increased sharply in the 1980s. To ameliorate the urban employment problem, for example, the state removed many of the restrictions on the urban service sector, and, as a result, investment in restaurants, and

Table 2-8 The Structure of The Central Government's Investment in Fixed Assets in China, 1953-90

	The total (billion yuan)	The percentage of sector (%) Agriculture	Industry	Services*
China				
1FYP (1953-57)	61.2	6.8	52.9	40.3
2FYP (1958-62)	130.7	10.4	71.5	18.1
Adj. (1963-65)	50.0	14.9	54.9	30.2
3FYP (1966-70)	120.9	8.9	57.6	33.5
4FYP (1971-75)	227.6	7.6	56.6	35.8
5FYP (1976-80)	318.6	7.7	54.0	38.3
6FYP (1981-85)	533.1	3.2	42.1	54.7
7FYP (1986-90)	1249.3	2.4	46.6	51.5
Total (1953-1990)	**2691.4**	**4.4**	**49.4**	**46.2**
International comparison of national investment in fixed assets				
U.S.A. 1960		3.8	11.6	84.6
1978		3.6	13.2	83.2
Japan 1960		5.5	34.5	60.0
1976		6.3	15.6	88.1
India 1965		5.2	23.7	72.1
1976		3.5	20.0	76.5

* service sector in China includes construction, transport, post and telecommunications, commerce, trade, education, public health and welfare, government administration, urban construction and others.

Source: China's Statistics Bureau, China's Statistics Yearbook, 1990, Statistics of Investment in the Fixed Assets in China, 1953-85.

the businesses of trade and personal services, increased rapidly. The state also began putting large amounts of investment into housing. In the 1960s only 5 per cent of all capital-construction investment went into residential buildings. In the 1980s this figure had risen to 21 per cent.

Like many other countries, agriculture received the smallest share of the state investment and its share declined steadily from the early 1960s to stabilize at a very low level by 1990. After the economic reforms in China's rural areas, initially introduced in

Table 2-9 Structural Changes in Industrial Investment, China (%)

	1FYP	2FYP	63-65	3FYP	4FYP	5FYP	6FYP	7FYP
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
light	15.0	10.5	7.8	7.9	10.5	12.7	15.2	14.5
Heavy	85.0	89.5	92.2	92.1	89.5	87.3	84.3	86.5
Industrial branches								
Metal.	18.6	23.2	16.1	18.2	17.7	15.4	13.7	9.2
Power	11.9	12.2	10.5	12.7	13.2	17.8	21.2	32.2
Coal	11.9	11.9	12.0	8.6	9.3	11.1	13.1	9.2
Petroleum	4.8	3.4	7.8	7.2	9.1	10.7	9.4	9.9
Chemicals	5.4	7.6	11.2	11.5	9.8	13.6	10.3	14.6
Machinery	15.4	16.0	11.6	13.7	22.2	14.5	10.0	7.6
Timber	2.5	2.4	6.7	2.9	2.6	1.8	2.2	1.1
Building-material	2.5	3.3	3.4	2.7	3.1	3.8	5.1	4.2
Food	4.1	3.2	1.9	1.8	1.6	2.3	4.1	3.7
Textile	6.4	2.7	3.8	2.5	3.3	5.9	6.3	2.8
Paper-making	1.5	1.3	0.6	1.3	0.8	0.9	0.7	0.8
Others	15.0	12.8	14.4	16.9	7.3	2.2	3.9	4.7

Sources: see Table 2-8.

1979, the state reduced its financial support to agriculture in the 1980s and retained only a limited influence on agricultural development through a subsidiary policy of bolstering infrastructure construction in rural areas such as large irrigation projects.

The metallurgical industry was long identified as the "keylink" of modern industry and received the lion's share of capital investment. Between 1952 and 1985, the fixed investment allocated to the metallurgical industry added up to 15.8 per cent of the total industry investment and was more than three times that of the textiles industry and other light industries. During the Seventh Five-Year Plan period, however, the share receded to second place after the power industry, due mainly to the worsening of industrialization bottlenecks, especially as reflected in a widespread shortage of electric power.

From 1949 to the mid-1980s, China pursued an inconsistent policy with respect to the development of the power industry. Significant under-investment in the 1970s caused serious power shortages into the 1980s. Although China's hydroelectric power potential is the world's largest and the power capacity of the country was the forth largest in 1989, recent estimates showed that demand exceeded supply by about 40 billion kilowatt-hours per year. Because of power shortages, factories and mines routinely operated at 70- to 80- per cent capacity, and in some cases factories only operated for 3 or 4 days a week. Whole sections of cities were frequently blacked-out for hours. The government began to acknowledge the seriousness of the power shortage in 1979 and took positive steps, including importing 10,000 megawatts of thermal power-plant capacity to serve the East's large population centres. It also launched a nationwide campaign to create an additional 5,000 megawatts of electric-power capacity in 1985. Under the Seventh Five-Year Plan (1985-90), 122.5 billion yuan or one-third of the state's investment poured into the industry to add nearly 28,500 megawatts of capacity, a 33 per cent increase over all previous five-year plans.

2.5 Consumption of Mineral Materials

As mentioned above, the development policy stressing producer goods first enabled China to achieve remarkable success in embedding heavy industry; that is to say, in the area upon which most of the development effort was concentrated. Between 1952 and 1990 the output of industry in total rose 52 times, but heavy industry grew by a factor of 75 as against light industry's factor of 40 (Table 2-2). Undoubtedly, the resultant rapid growth in the industrial economy, especially in heavy industry, put severe pressure on raw mineral materials and energy supplies, and demand for all types of industrial minerals has expanded at an unprecedented pace. There are two activities, industrial production and major construction, which require substantial material and energy inputs. For every 100 million yuan of capital investment in China in 1990, for example, there arose a corresponding need for 12,852 tonnes of cement and 2,863 tonnes of steel products. For every 100 million yuan of industrial output value, a corollary of 45,200 tonnes of coal equivalent of energy input was required, and heavy industry required about 2.8 times more than light industry in 1990.

According to the Statistics Bureau, China consumed 1.9 million tonnes of ordinary steel products in 1953, but the total consumption reached 50.9 million tonnes in 1990; an increase of nearly 27-fold. The situations for cement and crude oil are even more striking. In 1990, some 190.4 million tonnes of cement and 115 million tonnes of crude oil were used, as against 3.6 million tonnes and 1.4 million tonnes in 1953 respectively.

It has long been recognized that for the majority of countries

Table 2-10 Elasticities of Key Metals in Relation to GDP Per Capita in the World

Commodity	World	Developing countries	China	Japan	USA
Aluminum (1962-84)	2.00	2.08	1.04	2.10	1.91
Copper (1962-84)	0.74	1.85	1.17	1.14	0.70
Steel (1962-82)	0.96	2.03	1.83	1.16	0.62
Total Nonferrous (1962-84)	1.05	1.63	0.97	1.31	1.05

Source: 1. Jack Faucett Associates (1986).
2. China's Statistics Bureau, China's Statistics Yearbook, 1991.

Table 2-11 Energy Elasticities in Relation to GDP Per Capita in the World

	Energy consumption (kilograms of oil equivalent)		Energy consumption growth rate*	GNP growth rate*	Elasticities
	1965	1990	(%)(1)	(%)(2)	(1)/(2)
Low-income countries	124	339	4.1	2.9	1.41
China	178	598	5.0	5.8	0.86
India	100	231	3.4	1.9	1.79
Middle-income countries	712	1,357	2.6	2.2	1.18
Lower-middle-income	597	1,025	2.2	1.5	1.47
Upper-middle-income	884	1,818	2.1	2.8	0.75
High-income countries	3,566	5,158	1.5	2.4	0.63
Japan	1,474	3,563	2.5	4.1	0.61
U.S.A.	6,536	7,822	0.5	1.7	0.29
World	1,114	1,567	1.4	1.5	0.93

*=annual growth rate.
Source: World bank World Development Report, 1992.

there is a correlation between GDP or NI on the one hand and energy and key minerals consumption on the other (Malenbaum, 1978). A common way to examine the relationship is the elasticity of consumption; an indicator estimated by comparing the growth rate of consumption per capita for a number of key metals and energy materials with that of GDP or NI per capita. The elasticity relationship is illustrated as follows: if the elasticity of a key metal is 1.3, then for each one per cent increase in GDP or NI per capita, there is an increase of 1.3 per cent in the metal consumption per capita. Table 2-10 and Table 2-11 show the elasticities for some key materials and energy materials both for the world and for China. It is evident that the key metals and energy elasticities for China are quite moderate in contrast with those of other developing countries and the world as a whole, but, in the case of all nonferrous metals, are considerably lower than developed countries. China's situation could be the outcome of a higher rate of economic development as discussed earlier (see Table 2-2 and Table 2-11), together with a lower rate of population growth (2.2 percent between 1965 and 1980, and 1.4 percent between 1980 and 1990, and also see Figures 2-2 and 2-3).

The elasticities of key metals and energy materials in relation to GDP for a country do not indicate the degree to which a country's energy and mineral materials consumptions are more or less efficient than the norm. In order to measure the efficiencies of energy and mineral consumptions in China, it is appropriate to introduce the so-called "intensity of use (IU) of materials" device

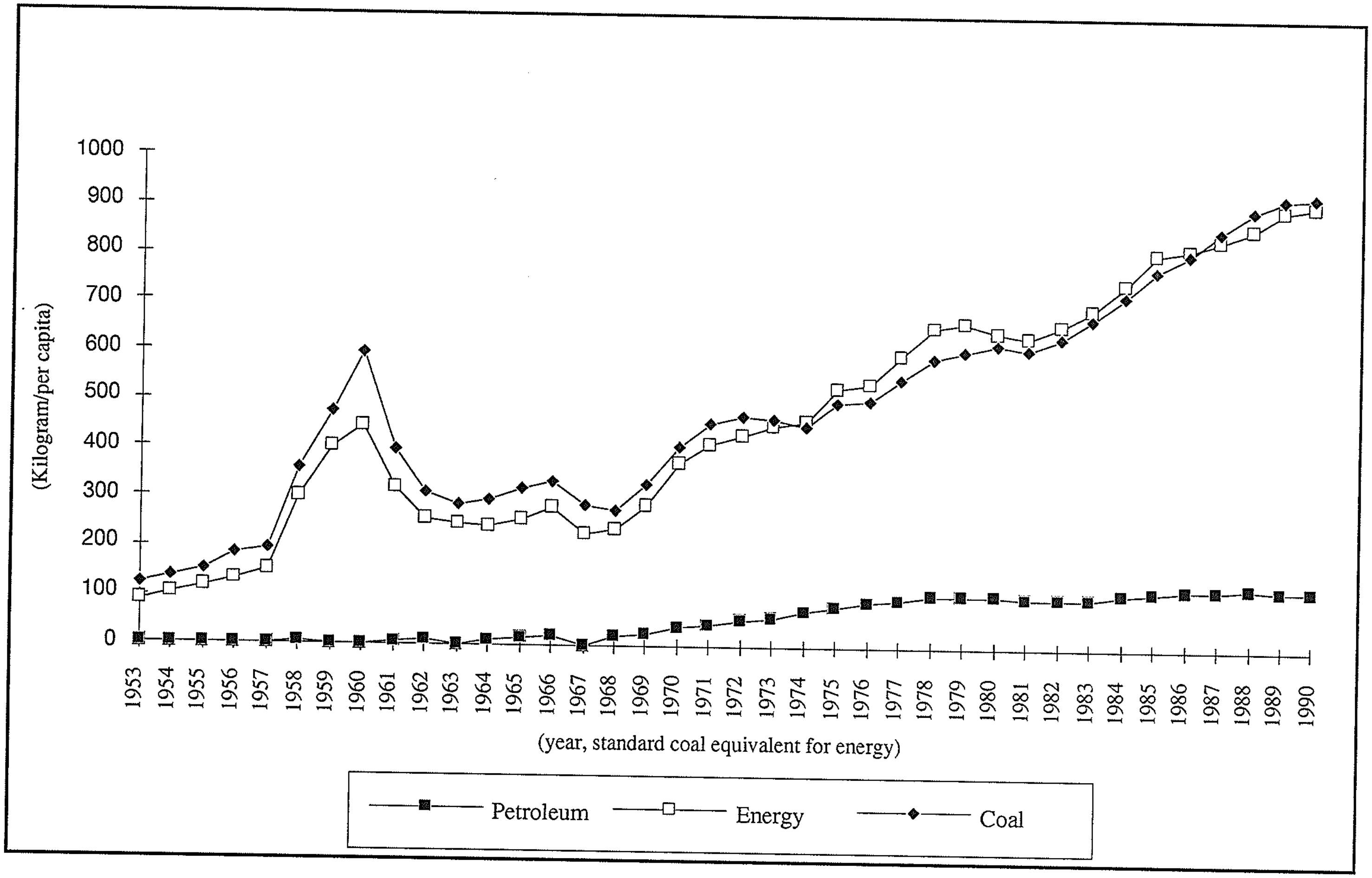


Figure 2-2 Energy Consumption Trends in China, 1953-90

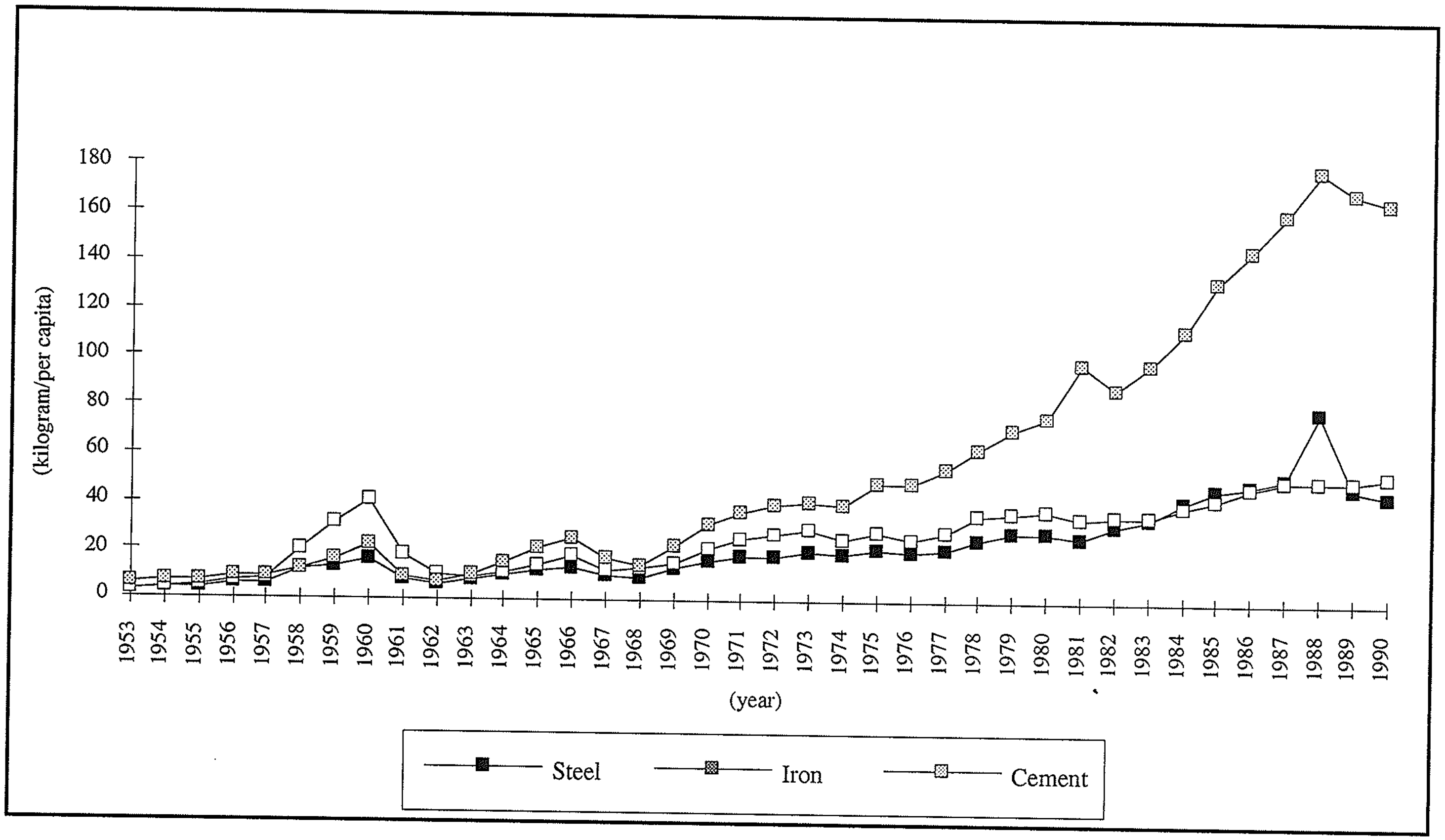


Figure 2-3 Key Mineral Materials Consumption Trends in China, 1953-90

[3]. This permits the analyst to deduce how much energy and mineral materials were used per unit of economic performance.

For comparative purposes, Figures 2-4 and 2-5 give an overview of the intensity of primary energy and iron ore consumptions by selected countries during the past 40 years, and both show that there is evidence of a changing pattern of IU of mineral materials associated with per capita income levels. In 1950, the economy of the United States was already in its mature stage with nearly US$3,500 of GDP per capita (in 1971 price), and undoubtedly, the trend of IU for the country exhibited decline during the entire period of the past forty years. In contrast, Japan initially underwent a difficult period of economic recovery after World War II. Its economy improved, however, by the mid-1950s (in 1960 Japan's GDP per capita reached a point of more than US$1,000 against US$500 in 1950, in 1971 prices. From the later 1950s, the growth pattern of IU of primary energy and iron ore for Japan began to diminish quickly, particularly after the oil crisis in the early part of the 1970s. Unlike both the United States and Japan, material inputs in the industrialization of China and India displayed a rising trend and dominated the sources of economic growth until recently. Technical factors, usually indicated through the capital-labour ratio (see Table 2-3), started to increase in importance in the total factor productivity when GDP per capita for both countries reached around US$300 (in 1971 price), with the effect that the rising trend in IU turned downwards.

China and India are the two largest developing countries in the

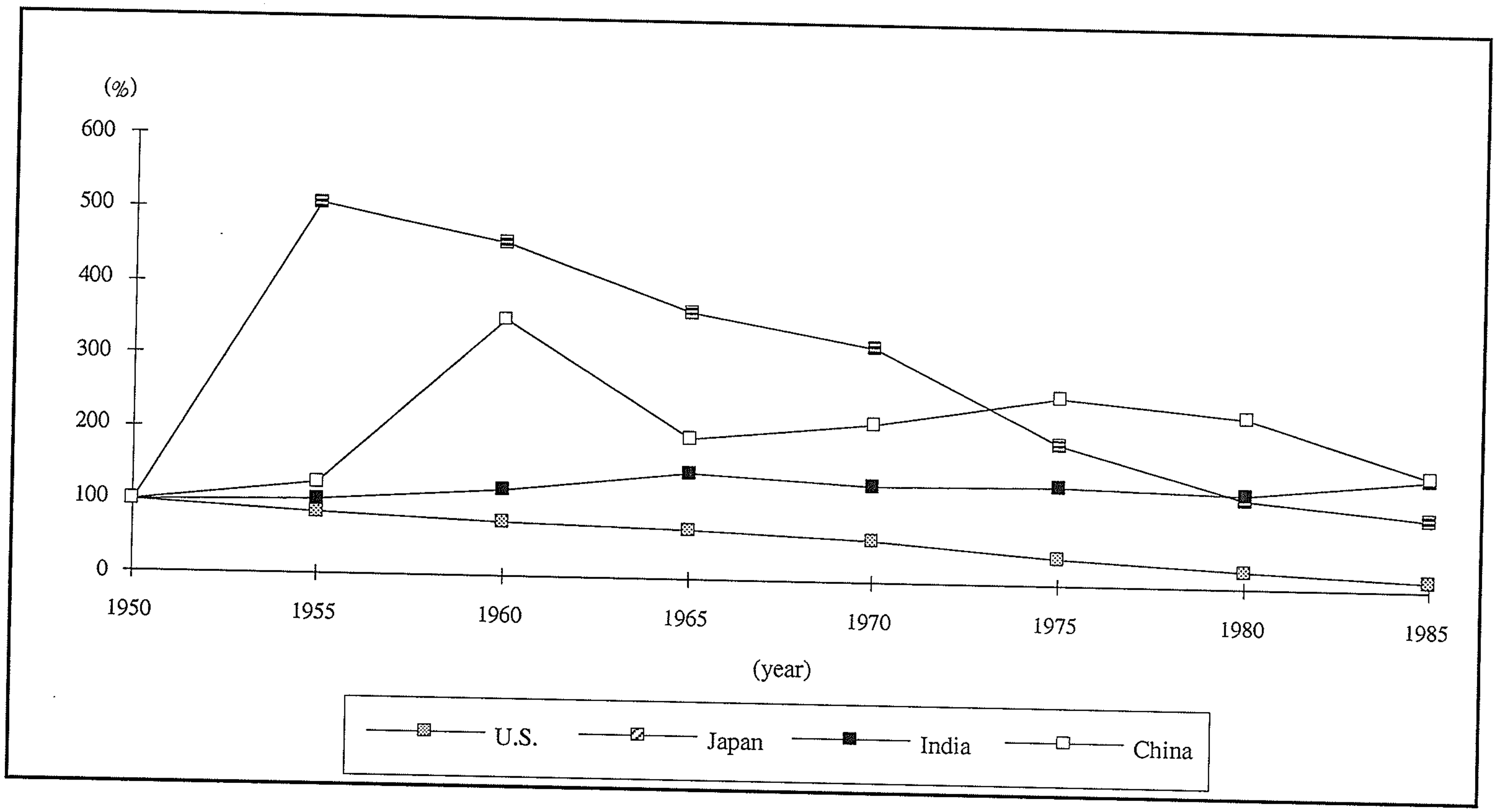


Figure 2-4. IU of Primary Energy by Selected Countries, 1950-90

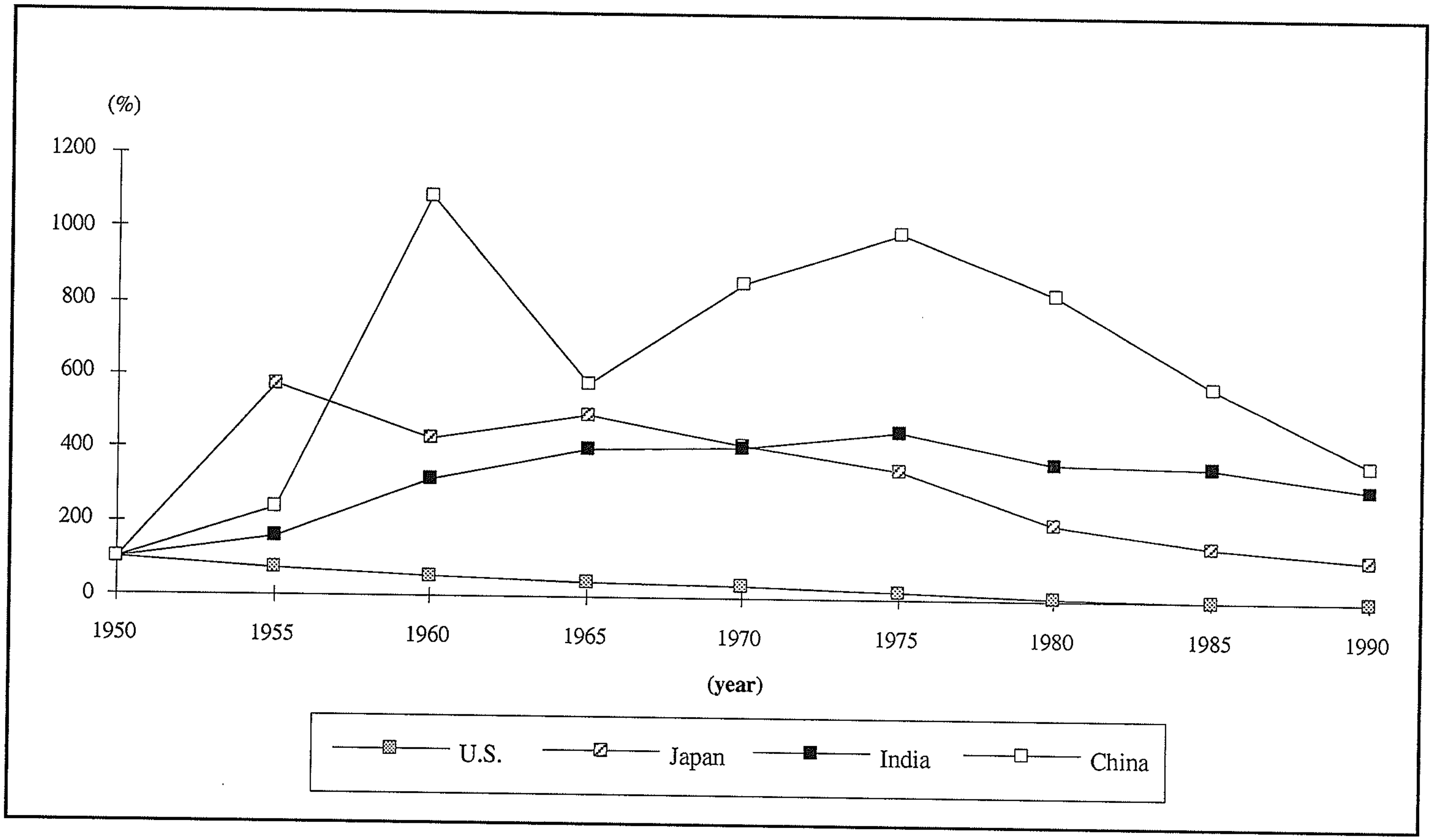


Figure 2-5 IU of Iron Ore by Selected Countries, 1950-90

world and share many characteristics in modernizing their economies. For example, industrialization in both countries started when they became fully independent nations after World War II. Governments played, and continue to play, a very important role in the national economies and, what is more, industrial development in both countries followed the Soviet-type centrally-planned model before 1980. Yet some fundamental differences occur between them, not least the fact that a more aggressive "producer goods first policy" in China makes that country quite different from India in the growth pattern of IU of materials. The iron ore intensity in China, for example, had an annual increase rate of 21.1 per cent between 1965 and 1979; a far cry from the 5.1 per cent obtaining for India.

In the 1980s China experienced marked declines in the intensities for all mineral materials, mainly on account of the large-scale introduction of foreign technology and equipment. However, this development did not alter the situation whereby the energy and material intensities in the Chinese economy still registered higher levels than those recorded by other countries, particularly in the industrial sector. A striking example is the energy consumption per unit of output value. Consumption of commercial primary energy per unit GDP in China is well above that of any of the other major developing countries reviewed (see Table 2-12). Indeed, the total of commercial energy intensities in China was considerably higher than the world average of 0.54, more than half as much again as India's 1.22, and seven times higher than

Table 2-12 International Comparisons of Energy Consumption

	Total commercial energy (kilograms coal equivalent/US$) (1990)*	Residential use (1980)**	Share of Industry (%)
Developing countries			
China	1.86	1.14	68 (1990)
India	1.22	0.83	26 (1980)
Developed countries			
Japan	0.22	0.13	41 (1980)
U.S.A.	0.53	0.35	35 (1980)
World	0.54		

Sources: * World Bank, World Development report, 1992.
** World Bank (1985), China: Long-Term Development Issue and Options.
China's Statistics Bureau, China's Statistics Yearbook, 1991.

Table 2-13 China: Energy Consumption Per Tonne Produced in Small and Large Plants, 1981

Industrial	Energy consumption* Small plant	Large plant	Small plant share of total production
Crude steel	1.57	1.20	20%
Synthetic ammonia	3.00	1.45	45%
Cement	0.18	0.12	61%
Plate glass	0.87	0.30	-

* tonnes of standard coal equivalent
Source: The World Bank, 1985 China: Long-term Development Issues and Options, Washington D.C. U.S.A.

Japan's 0.22. China's steel consumption of 127.30 tonnes per million US dollars of GDP in 1981 was about 30 per cent higher than India's, about 10 per cent higher than South Korea's and twice as high as Japan's (World Bank, 1985).

One factor contributing to China's high level of key mineral materials and energy uses relative to GDP is a high share of industrial output in GDP. While industry typically accounts for little more than one-third of GDP in other low-income countries, this sector currently accounts for more than one-half of GDP in China--a share that surpasses average levels in both middle-income and industrialized economies (recall Table 2-4).

Another important contributing factor in China's energy use, compared with most other developing countries, is the existence of substantial winter-heating requirements in many parts of the country. Economic development of a low-income country typically brings an increase in the share of industrial output in GDP, which tends to increase energy intensities. At the same time, residential/commercial sector consumption tends to rise more slowly than GDP. In China, however, both the exceptionally high share of industrial output and the high aggregate demand for basic household energy requirements relative to GDP serve to increase energy intensities.

Last, but not least, total key materials and energy consumption per unit of gross output value in the industrial sector is also exceptionally high compared with most other countries. While the energy intensity of industrial production, for instance, is similar to that in India, it is over twice the levels of South Korea and the U.S.A., almost three times the level in Brazil, and over three times the level in Japan (World Bank, 1985). At an aggregate level, the most important reasons underlying high levels of minerals and energy consumption in Chinese industries are the preponderance of small-scale enterprises in materials- and energy-intensive industries, the use of obsolescent technology, and the persistence

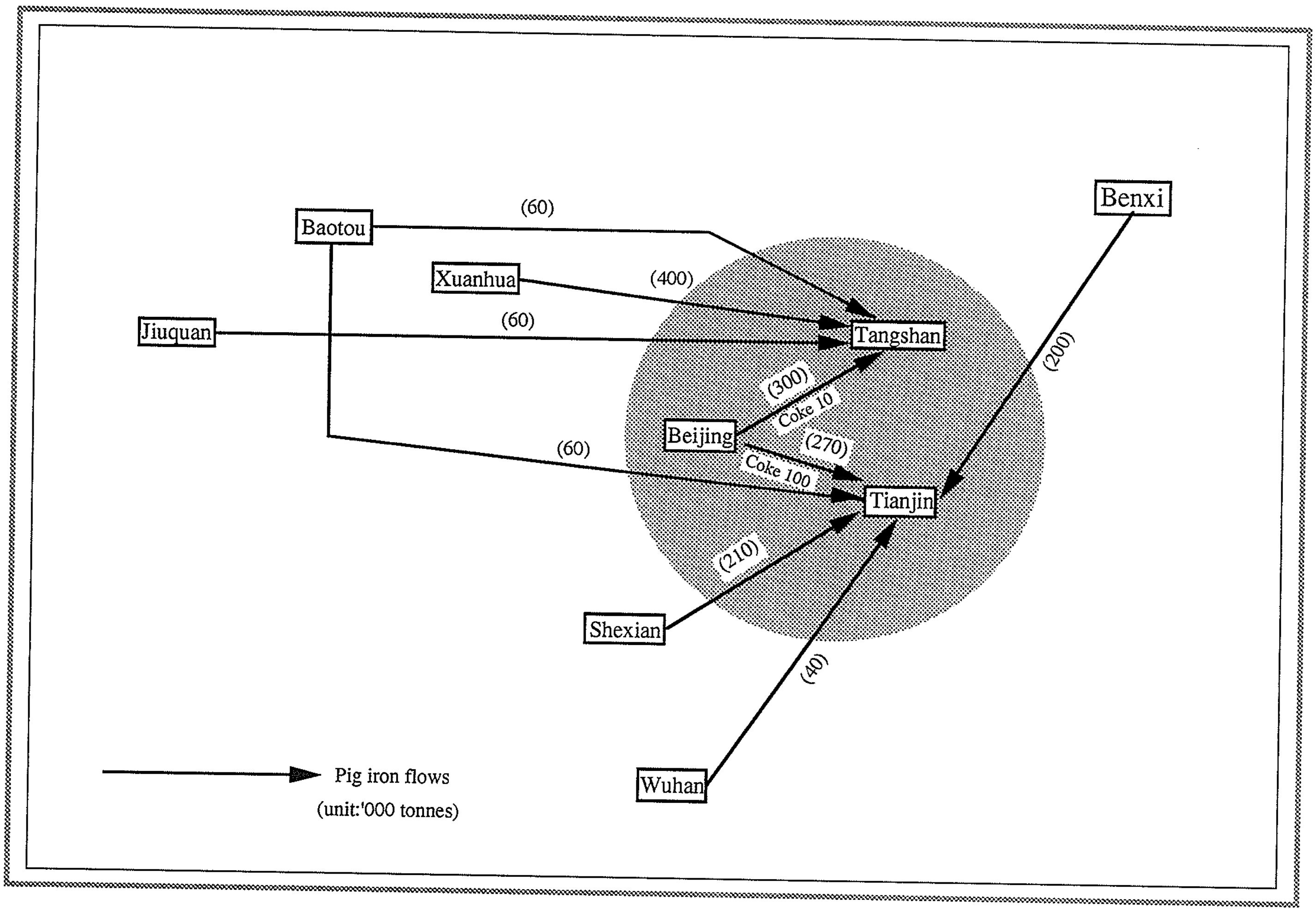


Figure 2-6 Sources of Pig Iron for the Steel-Making Industry in Beijing-Tianjin-Tangshan Region of China

Source: Liu Da-dao (1989) Industrial Location in China: Theories and Practices (in Chinese).

of inefficient operating practices in industrial production. As Table 2-13 shows, unit energy consumption in these small-scale plants tends to be well above levels in large plants, owing primarily both to the inability to realize economies of scale and to the use of less-advanced technology. In the 1980s, boiler fuel for industry and space heating accounted for more than 35 per cent of total final commercial fuel consumption. Nearly 200,000 boilers are currently used in China, of which some 70 per cent have production capacities of less than two tonnes per hour. According to Chinese estimates, average thermal efficiencies are roughly 55 per cent, compared with averages of some 70 per cent abroad. The dominance of coal helps explain this difference, but the preponderance of small unit sizes, technology dating to the 1930s and 1940s, and lack of mechanization all contribute to high consumption rates in China.

Inefficient operating practices or irrational locations also contribute to the high energy and material intensity in industrial production. A typical example is the supply of pig iron for steel-making industry in the Beijing-Tianjin-Tangshan region, one of the largest steel-making industrial bases in China. Each year, some 1.6 million tonnes of pig iron and 0.2 million tonnes of coke have to be transported from cities in Northern and Northeastern China, or even from Central China, to Tianjin and Tangshan for steel production (see Figure 2-6). Unfortunately, this is not the only case of excessive material hauls. According to one study, about 5 million tonnes of pig iron, or 10-12 per cent of the total pig iron used each year, are moved between regions in hauls of more than 900 kilometres because of the lack of integration in Chinese steel production (Liu Da-dao, 1989). Such movement results not only in greater cost of pig iron transport but also imposes larger energy requirements (and coke inputs) for reheating pig iron. It is estimated that 500 kilograms of coke are needed for reheating each tonne of pig iron, while 50 kilograms of pig iron per tonne are lost during the reheating process.

2.6 Conclusion

All the data and analysis for China in this chapter support the general hypothesis that mineral consumption and IU rise with per capita income in the early stage of industrialization. Mineral consumption in China has continued to expand over the entire period examined, although the rate of growth did decline since 1980. This slowdown occurred entirely on account of a changed development policy (from self-reliance and producer goods first, to the Open Door Policy) in conjunction with a great diversification in macroeconomic performance.

In contrast to the developed countries, China decidedly exhibits rising IU levels throughout most of the period under investigation. Meanwhile, closer scrutiny reveals that the difference between China and other developing countries is primarily due to variations in development policy and industrial performance. While stagnating in the industrialized market economies, the share of industrial groups in gross domestic product rose more rapidly in China than that in most other developing countries during the period under study. Indeed, when IU is measured on the basis of GDP or NI, the rising trend in China is consistent save only for aluminum, the "new mineral".

Although it is difficult to measure how great is the contribution of technological change to reduced mineral consumption and IU over time at each level of GDP per capita, data for China and India with respect to primary energy and iron ore consumptions over the past forty years do suggest that technological introductions play an important role in affecting material consumption and IU patterns in developing countries. In particular, such introductions have served to mitigate the upward trends caused by GDP growth and structural change.

Of all the national goals pursued by China since 1949, the overriding one has been rapid industrialization. In this scheme, manufacturing industry, especially heavy industry, has been at the forefront and has remained there even after the adoption of the Open Door policy. Despite sharp disagreement among Western observers about the course of industrialization China has taken since 1949, and how to evaluate it, there is one thing that all can agree on. This concerns mineral usage. It can be stated that implications of the economic and social changes occurring in China bear similarities to the experiences of other countries in terms of its mineral and energy consumption patterns. Mineral and energy consumption per capita increases along with the process of industrialization on the one hand, and material-intensity of use turns down after reaching some point when the overall economic activity is diversified on the other.

All of the above findings unequivocally confirm that the onset of industrialization, as expressed in the characteristics of the early stage, brings about a great need for mineral materials, and along with such changes mineral resources collectively come to be the key factor in facilitating economic development. As a result, if any country wants to enjoy a rapid economic growth, it must gain access to a plentiful and stable mineral supply. Indeed, discussion of the changing pattern of mineral consumption is just a start in our understanding of the relationships between mineral activity and national development. Since consumption is determined by demand and supply, the next chapter will, therefore, focus on the role of mineral supply in national development in terms of China's experience. This addresses the second of the six targets.

Notes:

[1] The term Gross Social Value Output (GSVO) is defined as the sum of the gross value produced within a certain period by all material-producing sectors of the national economy; that is, industry, agriculture, construction, transportation and communication, and commerce.

[2] National Income (NI) represents the sum of net output value of all the five material-producing sectors of the national economy.

[3] Intensity of Use of Materials (I-U) is defined as a common way to measure the quantity of any special industrial raw material a nation uses over a given period. Mathematically, it can be expressed as follows:

$$IU = D/GDP$$

where D indicates the consumption (demand) of the material and GDP represents the gross domestic product.

CHAPTER III
MINERAL MATERIAL SUPPLY

3.1 Introduction

The initiation of industrialization causes a great change not only in the pattern of social demand but also in the form of social production. The impressive increase in mineral consumption, as discussed in chapter II, implies that any kind of societal achievement in the modern world is dependent to a great extent on the development of mineral resources. The rise of the modern industrial sector, defined as manufacturing based on mineral exploitation and processing, becomes the dominant source of economic growth. As a result, a rapid economic growth in most countries, if it is to be sustained, must have access to plentiful supplies of minerals at the lowest cost. This is particularly true for developing countries, because the initial structure of factor inputs (consisting of land, capital and labour) for social production in these societies is characterized by serious shortages of capital and skilled labour (often expressed through technology). To initiate their modern industry and develop their economies, most developing countries have little choice but to use their mineral resources (a part of land) as an instrument. In this sense, one of the most important tasks for developing countries is to build up a stable mineral supply system to secure the material inputs for the entire production system. The Chinese practice could provide a good example to test the importance of mineral supply in fostering the national economy. Considering the complication of the relationship between mineral industry and economic growth, this chapter is designed to focus mainly on the contributions of mineral industry and supply to internal development in terms of the target system of this study; namely, the second of the six targets, and leave the effects of mineral trade in the international market to the next chapter.

3.2 Resource Bases

For a prolonged period there was no clear picture of the whole situation pertaining to mineral resources in China. Indeed, because of very slow progress in modern geological work before 1949, only 18 kinds of minerals, such as iron ore, manganese, tungsten and coal, had proven reserves and even these were fairly inconsequential.

In the more than 40 years following the founding of the People's Republic, geological survey and exploration of mineral resources were dramatically stepped up. Both regional geological survey at a scale of 1:1,000,000 covering the entire country and that conforming to a scale of 1:200,000 covering two-thirds of the country were completed. Moreover, aeromagnetic surveys now cover more than 90 per cent of onshore and offshore areas, and regional gravity surveys cover 40 per cent of the land area. In fact, a general geological survey of mineral resources has been started in most parts of the country, and exploration of major minerals in large and middle-sized mining areas at varying levels of thoroughness has been carried out. As a result, proven mineral resources in China counted 137 of the 160 known kinds of minerals present in the world (using a base of 1985). Among their numbers are seven types of energy resources, five types of ferrous metal minerals, 20 kinds of nonferrous metal and noble metal minerals, 28 kinds of rare earths, rare earth metals and other rare element minerals, 10 supplementary raw material minerals for metallurgical purposes, 23 kinds of non-metal chemical materials, and 43 kinds of building material minerals and other non-metal minerals. No less than 15,000 mineral deposits in large and middle sizes have been discovered throughout the country (Figures 3-1 and 3-2). In short, China is one of only a few countries in the world enjoying a rich variety, indeed, a quite complete set of mineral reserves with a great development potential (Table 3-1).

3.3 Policy Framework for the Development of Mining Industry

As mentioned in Chapter I, the model of the priority growth of department I favours factor inputs, especially capital. Mineral products, therefore, as part of capital (in the Chinese view, mineral resources are judged to be a component of capital, a radical departure from the Western view) receive a high priority in development decisions. Following consideration of natural resources, human endowments (quantity and quality) and financial availability, the Chinese government elected to give preference to mineral resources as the first step in economic development. In order to achieve this end, some important policies have been formulated for the development of mineral industry since the 1950s.

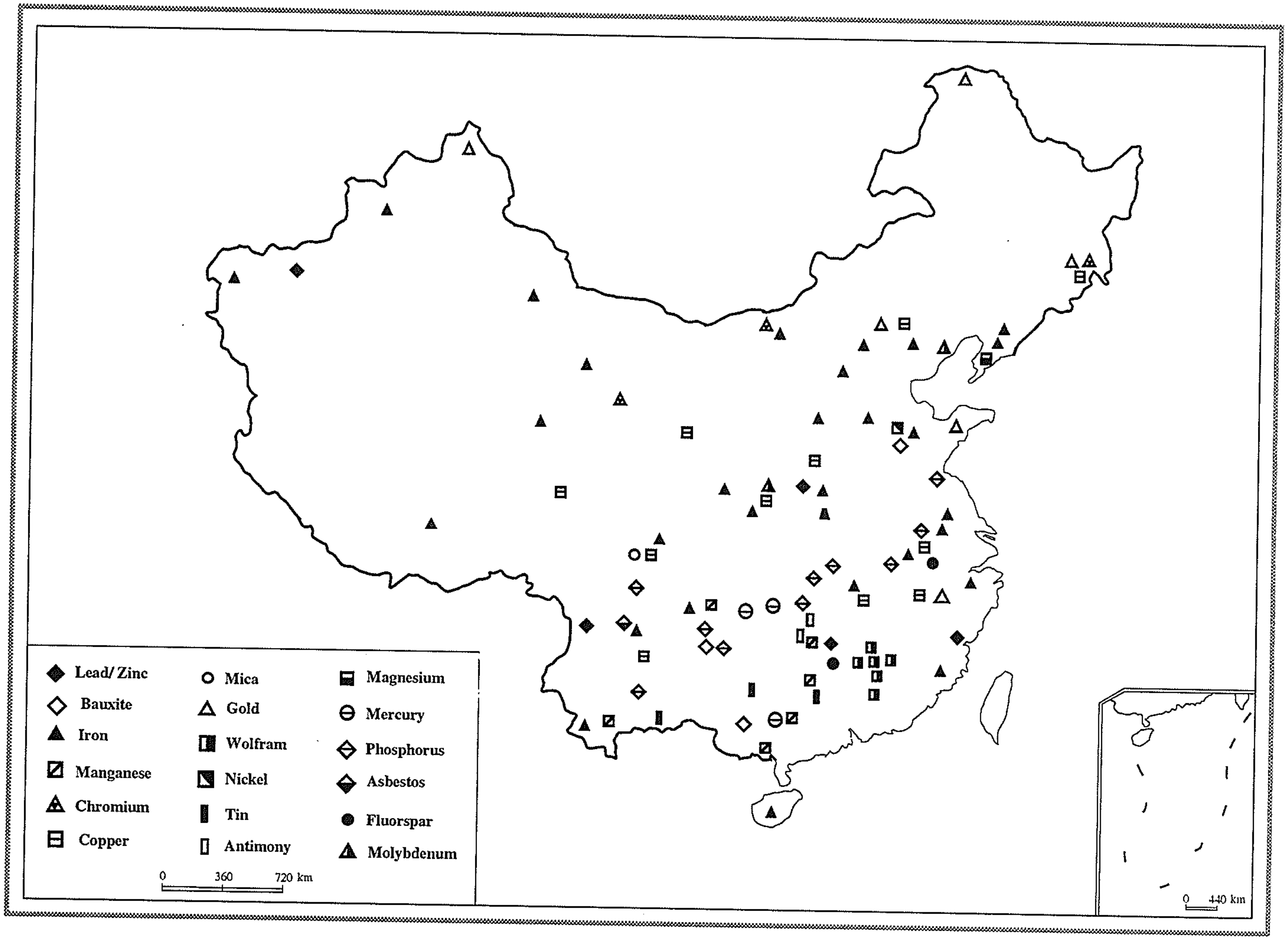


Figure 3-1 Metallurgical and Non-Fuel Minerals Deposits in China

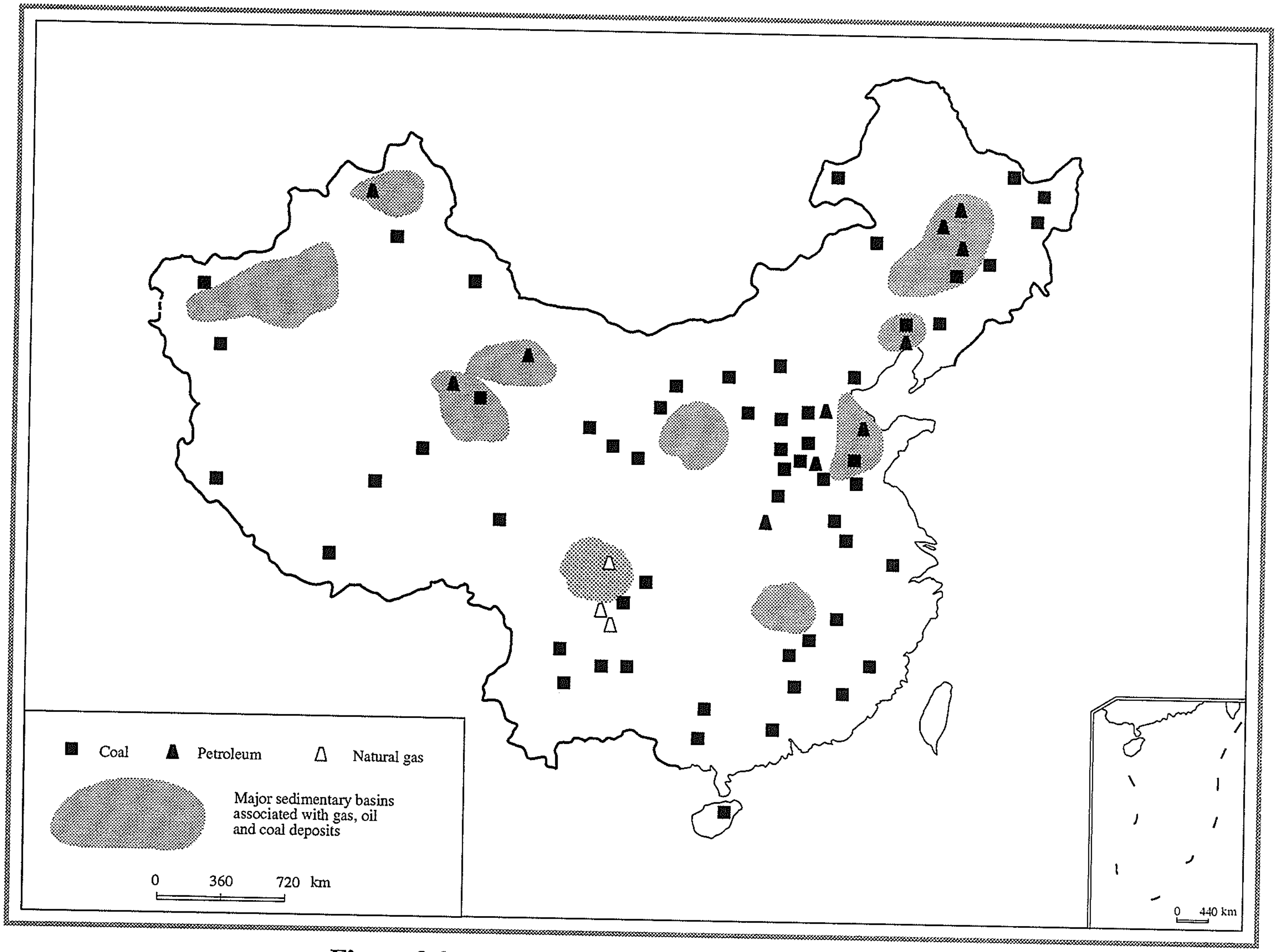


Figure 3-2. Non-Renewable Energy Resources in China

Table 3-1 Proven Mineral Resources of China, 1985

Minerals	China's rank in the World	The leading Countries
Coal	3	The United States, The Soviet Union*
Manganese	4	South Africa, The Soviet Union*, Australia
Iron ore	5	The Soviet Union*, Brazil, Canada, Australia
Copper	6	Chile, The United States, Zambia, Peru
Bauxite	6	Guinea, Australia, Brazil, Jamaica, India
Lead	5	The United States, Australia, The Soviet Union*, Canada
Zinc	3	Canada, the United States*, Australia
Nickel	9	New Caledonia, Canada, Indonesia, the Soviet Union*
Tungsten	1	Canada
Tin	4	Indonesia, Thailand, Malaysia
Molybdenum	3	The United States, Chile
Antimony	1	
Titanium	1	
Vanadium	2	South Africa
Rare earths	1	
Magnesium	1	
Phosphorus	3	Morocco, The Soviet Union*
Sulphur	2	Canada

Source: **The World Resources Institute** World Resources, 1992-93.
* the Former-Soviet Union

These policies can be summarized in terms of investment orientation, "walking on two legs", technology introduction and material incentives. The following discussion describes the initiatives in question.

Investment orientation policy. In late 1952, after a three-year period of economic recuperation, the Chinese government decided to undertake long-term economic planning centred on the so-called Five-Year Plans. The First Five-Year Plan earmarked the lion's share of investment for the development of the mineral sector.

Table 3-2 Capital Investment in Mineral Sector (Hundred million yuan)

Period	Metal sector Ferrous	Metal sector Nonferrous	Coal	Petro-leum	Building materials	Sub-total	As the total of Industry (%)
1 FYP (1953-57)	29.59	17.02	29.69	11.98	6.33	94.61	37.81
2 FYP (1958-62)	130.23	39.00	86.98	25.10	23.72	305.03	41.88
Adj. (1963-65)	17.79	16.15	25.15	16.44	7.16	82.69	39.34
3 FYP (1966-70)	70.14	28.65	46.65	38.84	14.63	198.91	36.73
4 FYP (1971-75)	138.46	34.62	90.74	89.00	30.25	383.07	39.17
5 FYP (1976-80)	148.46	41.24	136.25	131.42	46.90	504.27	40.94
6 FYP (1981-85)	148.50	63.08	203.32	141.07	78.50	639.48	41.34
7 FYP (1986-90)	261.86	143.64	350.13	377.81	124.81	1258.25	33.09
Total (1953-90)	**945.03**	**383.41**	**968.91**	**836.66**	**332.31**	**3466.32**	37.31

Source: China's Statistics Bureau, Statistics of China's Fixed Capital Investment (1950-85).
-----China's Statistics Yearbook, 1991.

According to the state's own statistics, more than one-third of the fixed capital formation in total industry went into this sector during that time. The basic investment orientation has not greatly changed since then (see Table 3-2).

In comparison with the generally stable pattern of capital investment in the mineral industry, the investment orientation among mineral sectors has shifted quite considerably in subsequent years in tune with changing political and economic circumstances (see Figure 3-3). During the period from the First Five-Year Plan to the Fourth Five-Year Plan, metallurgical industry, including ferrous and non-ferrous activities, generally dominated the investment pattern of the mineral industry. About half of the total investment in mineral industry was devoted to the iron and steel industries as well as related non-ferrous sectors such as copper, aluminum, lead, zinc, nickel, tin, antimony, mercury, magnesium and titanium so as to fulfil the goal of rapid growth of steel and

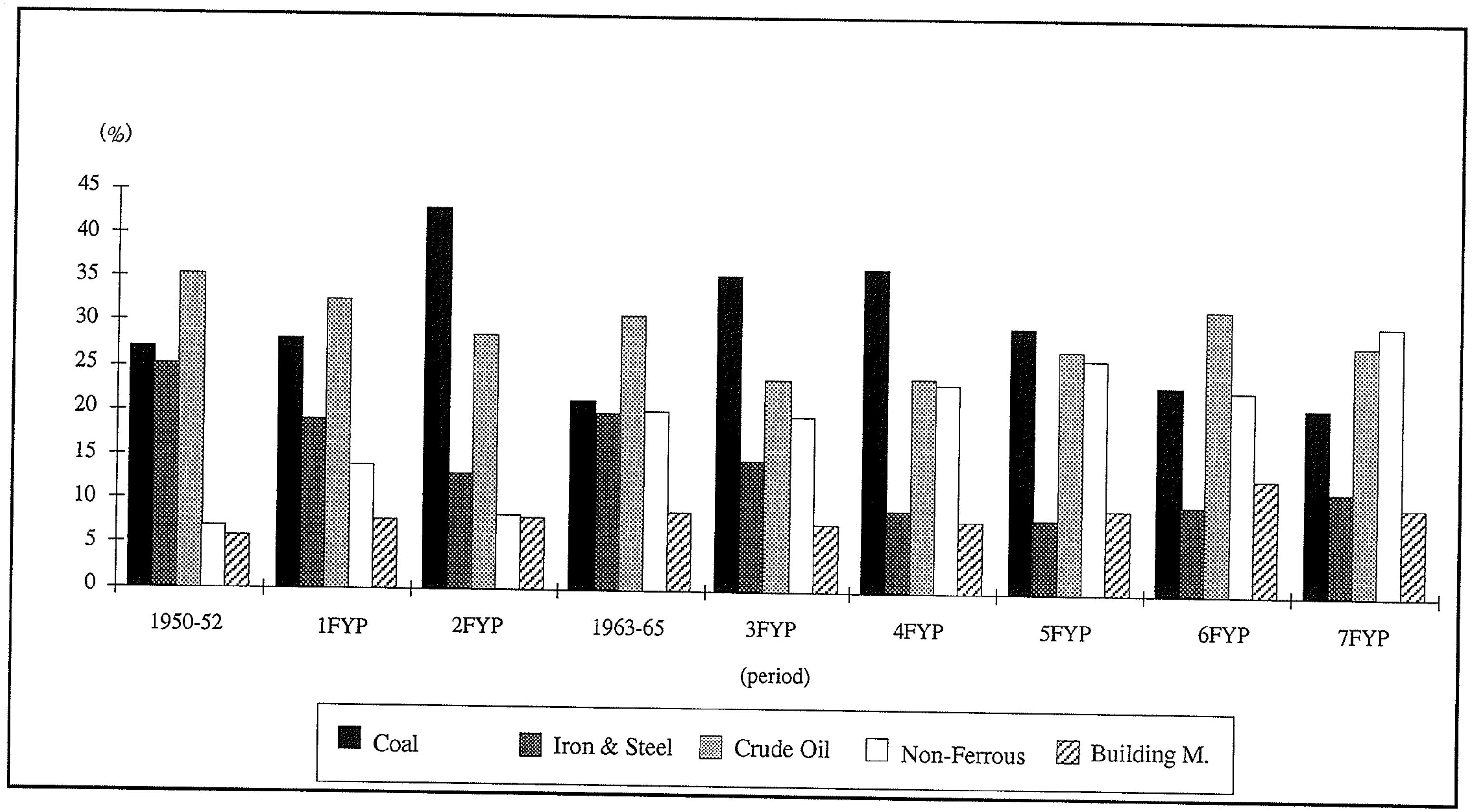


Figure 3-3 Composition of Capital Investment in China's Mineral Industry, 1950-90

related products. Steel and its affiliates were used as key indicators of the national industrialization. Since the period of the Fifth Five-Year Plan, this situation has been altered in tandem with the change in the basic development policy from the "Self-Reliance" to the "Open Door", under which the country can import some metallurgical products in sizeable volumes from the outside. Also a diversifying economic structure may play an important role in steering investment into new channels. Thus, the increased investment in the building materials' sector since 1980 partly reflects fast growing demand, especially for cement, because of the boom in house construction throughout the country.

The coal industry affords a unique situation. For years, capital investment in the coal industry has essentially stood at a share of between 27 to 30 per cent of the total investment in the mineral industry. The lower share of this sector during the period between 1966 and 1975 can be explained away by an initiative of the government to change the pattern of China's energy economy from heavy reliance on coal (86.5 per cent of the national total energy supply came from coal and its products in 1965) to petroleum. After a painful failure to discover enough proven crude oil deposits, this ambitious policy was dropped in favour of coal (Liu Da-dao, 1989). As a result, coal retains its pre-eminence, albeit constituting a reduced proportion of total energy supply (75.6 per cent of the national total energy supply in 1990, according to China's Statistics Bureau, 1991).

The petroleum industry, in consequence of limited exploration successes, has experienced a gradually increasing share of the total investment over the years. Justification for this heightened importance is two-fold. Firstly, crude oil and petroleum products play an important part in the national economy; for, not only are they collectively a major source of fuel for modern transportation, but they constitute an essential raw material for petro-chemicals and a valued means to earn foreign currency. Secondly, because of complex geological conditions, this industry needs more capital investment than other sectors in order both to maintain recent production levels of the existing oilfields (mainly located in the eastern part of the country) and to press ahead with exploring newly-proven resources offshore as well as in remote areas of the west.

'Walking on two legs'--a decentralization policy. Considering that a major part of the population (more than 80 per cent by some accounts) still lives in poor rural areas, the government decided to look for a new approach in the early 1950s to inject modern technology into the countryside immediately rather than to wait until urban industry has proceeded to a point where its methods have begun to trickle down into rural areas (Liu Da-dao, 1989). The so-called 'walking on two legs' policy, which essentially extended the role taken by the central government in the course of industrialization down to the economic units at the local level, just accounted for the initial stage of this approach (1949-57). Coverage of the policy as a whole is schematized in Figure 3-4.

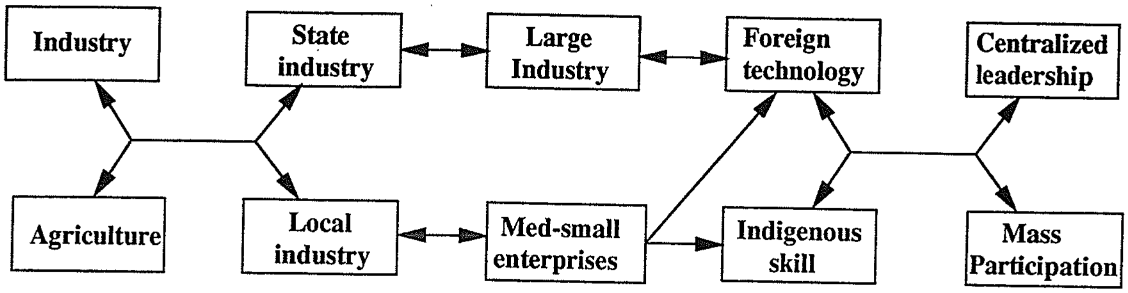


Figure 3-4 A Schematization of 'Walking on Two Legs' Policy

Owing to it being aimed at tapping the potential manpower and material resources at the local level so as to employ them to the full (for example, about 12 per cent of China's proved coal resource cannot be exploited by large-scale operations), and because of the inadequacies of China's rural transport and marketing system, the "walking on two legs" policy can be advocated as an important component of national development strategy. In particular, it showed that small industries can be developed as a fundamental part of the national economy (Table 3-3 and Table 3-4) in spite of some painful experiences, or even despite severe setbacks when half of the small enterprises closed down after the Great Leap Forward (1958-61) (Jones, 1980). The development of small coal mines can be seen as one of the best examples of this aspect of national policy.

The myth that South China does not have coal is disproved by the facts: by dint of small-to-medium-sized mines production in this part of the country has been steadily rising and new deposits are constantly being found. Coal production from similarly-scaled operations in the northwest and other relatively inaccessible areas has also been increasing. There are also many small (tributary)

Table 3-3 China's Plant-Scale Classification and Distribution

Type of plant	Scale	Standard of Classification	Number of plants	% of Overall Production accounted for 1985
Iron and steel	Large	annual production of crude steel over 1 million tonnes	13	Crude steel 85.0% Pig iron 60.0% (Produced by large plants)
	Medium	100,000 to 1 million tonnes	35	Crude steel 5.3% Pig iron 25.6% (Produced by medium plants)
	Small	less than 100,000 tonnes	In all areas other than Tibet	Crude steel 9.7% Pig iron 14.4% (Produced by small plants)
Foundry	Large	Annual production of pig iron over 1 million tonnes		
	Medium	200,000 to 1 million tonnes		
	Small	less than 200,000 tonnes		
Coal mines	Large	Annual production of raw coal over 5 million tonnes		54.3% of total output
	Medium	2-5 million tonnes		
	Small	less than 2 million tonnes	> 20,000	45.7%
Power station	Large	Installed capacity over 250,000 kw		96% (87.4% of hydroelectric power plants) of total output
	Medium	25,000 to 250,000 kw		
	Small	less than 25,000 kw	> 90,000	4% (12.6%)
Synthetic ammonia	Large	Annual production of synthetic ammonia over 150,000 tonnes	28	52.4% (50.6% of all nitrogen fertilizers) of total output
	Medium	45,000 to 150,000 tonnes	337	
	Small	less than 45,000 tonnes	1,533	47.6% (59.4%)
Cement	large	Annual production of cement over 1 million tonnes		60.8% of total output
	Medium	200,000 to 1 million tonnes	80%	
	Small	less than 200,000 tonnes	>3,400	39.2%

Source: China's Statistics Bureau Statistical Yearbook of China, 1990.

coal mines around the big mines. These small mines of, say, 100-1000 tonnes of coal per day capacity, operate at varying degrees of efficiency and at different cost levels, but they always serve local industrial complexes and agricultural communities. They help to keep industry dispersed and compensate for the lack of adequate transportation. So-called small coal mines are often either expanded or closed because of availability of reserves or for other general reasons (e.g. changing local markets and administrative justification, Li Wen-yan, 1990).

In 1973, small coal mines were said to have accounted for about 28 per cent of China's total coal production (roughly 120 million tonnes), and the output in 1985 was more than four times the 1973 level, reaching 520 million tonnes, about 60 per cent of the national total. Without this development, particularly in southern China, shipments from the large mines in Shanxi and Henan provinces to South China (including Shanghai, Jiangsu, Zhejiang, Fujian and Guangdong provinces) would have had to be increased nearly by 100 million tonnes more than the achieved level of shipment (Li Wen-yan, 1990). Output increases from small mines in Hunan, Guangdong, Fujian, Guangxi, and Sichuan were particularly striking. The same is true for some provinces in the northwest, such as Ningxia and Gansu. Development of small coal mines within the major coal-producing provinces of the north has also been rapidly implemented. For example, more than half the counties of Hebei Province now have small coal mines, and Henan Province's small-mine coal production in 1985 was more than four times the 1973 level. The development of other local industries, such as power plants, metal plants and

Table 3-4 Domestic Gross Output of Rural Areas in China, 1990 (%)

Region	Total	Agriculture	Industry	Construction	Transport	Services
China	100.0	46.1	40.4	5.9	3.5	4.1
Selected Regions						
Hebei	100.0	41.0	46.5	6.6	2.6	3.3
Shanxi	100.0	38.7	44.6	5.1	7.7	4.8
Liaoning	100.0	38.9	49.1	3.8	3.7	4.5
Shandong	100.0	36.6	52.3	6.3	1.7	3.1
Shaanxi	100.0	53.2	29.0	6.5	6.3	5.0
Gansu	100.0	60.4	20.9	5.8	6.4	6.5
Henan	100.0	48.8	31.9	7.2	6.4	5.7

Source: China's Statistics Bureau Statistical Yearbook of China, 1991.

workshops, fertilizer plants, cement plants, and machinery plants, have followed almost as a matter of course (Li Wen-yan, 1990).

The policy of foreign technology introduction. In order to exploit its rich mineral resources, China, like other developing countries, needs both to introduce more modern technology and to increase the efficiency with which all resources are used so that a rapid and sustained economic growth can be achieved. External economic contracts are desired in China primarily as a source of new technology, and they also contribute to greater efficiency. In fact, they did so even in the inward-directed development period.

As mentioned above, China's planners determined to establish a basis of heavy industry in the years between 1949 and 1960. The government, therefore, introduced, at a cost of about US$2.66 billion (which does not take into account "Russian technology transferred free") complete plants and sets of equipment from the former USSR and Eastern European countries for 156 key construction projects mainly involved in mineral-based industries such as metallurgy, energy and transportation facilities. The result, inter alia, was an increase in production of 4.66 million tonnes of iron, 5.86 million tonnes of rolled steel, 3.7 million watts of electricity and 25.25 million tonnes of coal.

Between 1961 and 1966, China's introduction of foreign technology went through an adjustment stage. The focus was primarily on remedying some shortages within the economy and voids in the technology structure. From 1962 to 1966, 84 contracts costing about US$280 million were signed, although not much in the way of large equipment was involved. The great change in this period resided in the fact that the main source of the technology shifted from the former USSR and the Eastern European countries to Japan and Western Europe. To be precise, the introduction was mostly for metallurgy, synthetic fibre, and petrochemical industries because of the exploitation of Daqin and Shengli oil-fields, the two largest oil-fields in China.

The years 1973 through 1978 witnessed a second surge in the introduction of foreign technology since 1949. In these six years, more then 300 contracts were let at a cost of about US$9.9 billion. The main emphasis was on projects which involved complete sets of equipment, including a 1.7-metre roller machine purchased from (West) Germany by the Wuhan Steel Plant, 13 sets of large chemical fibre equipment, two sets of large equipment for petrochemicals, etc.

After the "Open Door" policy was announced in 1978, China's introduction of foreign technology entered a new phase that differed markedly from the one ushered in 29 years earlier in at least three respects. In the first place, from 1979 to the end of 1984, China signed 936 contracts for the introduction of technology and equipment at a cost of about US$6.5 billion. Also China signed another 3,933 contracts for foreign capital introduction at a cost of US$17.85 billion. Secondly, in the 29 years before 1978, the general value of purely technological contracts amounted to only a little over one per cent of the general value of all contracts for high technology introduced in that period. Between 1978 and 1982, the value of pure technology contracts amounted to over 12 per cent of the general value of China's total introduction in this period, reflecting a growing proportion of pure technology in the total (Huang Fang-yi, 1987). In the third and last place, the type of foreign technology introduced changed from the purchase of complete sets of plants and equipment to a more diversified form, including joint ventures, co-operative ventures, sole foreign investment, and technical services.

Despite such great changes, there is one thing that remains constant; namely, the development of mining and mineral processing industries is still the highest priority in the technology introduction. For example, 37 offshore contracts were signed in the early 1980s with 45 oil companies from 12 countries. Over US$2 billion were invested in 200 offshore wildcat wells. In addition, about US$3.4 billion-worth of equipment in oil-fields and refineries was imported from 13 countries.

Shortages of funds have hindered the development of China's coal industry despite the country's rich coal resources. Since 1980 China has signed agreements with Japan, France, the United States and Romania as well as with the World Bank, to finance coal development using loans, compensation trade, and co-operative management. Foreign funds totalling US$1.51 billion have been devoted to the construction of 12 new coal pits and coal mines, including the Antaibao project in Shanxi Province, the biggest opencut coal mine in China with an investment totalling US$650 million. These new mines have an aggregate annual capacity of 49.2

million tonnes of coal and help lay the foundation for the steady growth of Chinese coal production in the near future.

Table 3-5 is eclectic in showing ten completed sets of foreign technology introduced during the period from 1979 to 1985 and includes the Baoshan Iron and Steel Complex in Shanghai, the single largest project dependent on foreign support. The total value of these ten projects was nearly US$3.9 billion, or about 16 per cent of the country's foreign technology introduction as a whole during that time.

Material incentive--the labour subsidy policy. In China, a labour subsidy policy has been in operation since the 1950s. This policy has set out clear-cut aims which in combination are envisaged as a key component of the country's economic growth

Table 3-5 Introduced Complete Sets of Foreign Equipment from 1979 to 1985

Project	Site	Introduced from	Started from	Investment (US $1,000,000)	Products
Coal					
Kailuan	Hebei	West Germany	1978	44.6	Raw coal
Kailuan	Hebei	West Germany	1978	41.3	Dressed coal
Houlinhe	Inner Mongolia	West Germany	1981	91.7	Raw coal
Metallurgy					
Baoshan	Shanghai	Japan & West Germany	1978	2904.3	Iron & steel Rolled steel
Guixi	Jiangxi	Japan and US	1979	138.4	Copper ore & Copper
Guiyan	Guizhou	Japan	1979	177.3	Aluminum
Synthetic fertilizers					
Luan	Shanxi	West Germany & Japan	1981	209.4	Synthetic ammonia Phosphate
Zhenhai	Zhejian	Japan & Netherlands	1980	107.5	Synthetic ammonia Carbamide
Vinchaun	Ninxia	Japan	1980	29.3	Synthetic ammonia
Urumuqi	Xinjian	Japan	1979	119.0	Synthetic Carbamide

Source: China's Statistical Bureau, Fixed Capital Investment, 1949-1985.

strategy. The labour force is to be deployed where wanted with dispatch, both to increase productivity and to advance manpower skills. Mobility requires more and more workers and peasants to redeploy to jobs in favoured branches or sectors; producing more output demands constant attention to norms for production costs, and maintenance; and learning new skills as rapid technological and organizational changes unfold calls for keen awareness of evolving technical knowledge and changing structural forms. Subsidizing mechanisms geared to these ends must systematically pay workers and peasants so that desired behaviour is differentially compensated and thus reinforced. This means graded wages (subsidizing wages) and other payments on an interindustry, interregional, and across-locality basis to channel workers and peasants where they are most needed (Bunge & Shinn, 1981).

Prior to the middle of 1956, the wage-points (later wages) were initially set up on an eight-grade system, ascending on the basis of skill from grade one through grade eight. Each grade received fixed wage-points per month:

Grade.........	1	2	3	4	5	6	7	8
Wage-point....	136	158	184	214	248	288	335	390

The points were the same throughout the country, but the monetary value of a wage-point varied according to the prices of five staple commodities (grain, oil, salt, cotton, and coal) in local areas. Thus, for example, in May, 1955, a wage-point in Shenyang was worth 0.213 yuan, while in Beijing it was 0.247 yuan, reflecting variations in commodity prices. The actual monthly wage, therefore, was the product of the total wage-points a worker earned and the local subsidy of a wage-point.

Once the wage-point system was discarded, it was replaced by a similar scheme of direct wage payments with built-in emphasis on increasing output. Standard wage scales are set up on a multiple-grade basis and can be used for time-rate payment as well as piece-rate payment with subsidies and bonuses added to time-rate scales where piece-rate techniques are not feasible. Multiple-grade wage scales have been widely implemented, but the number of grades has varied according to industry and location. A model scale of this system for the coal-mining industry was:

Wage-grade...........	1	2	3	4	5	6	7	8
Grade Coefficient.....	1.00	1.18	1.39	1.65	1.94	2.30	2.71	3.20
Monthly Wage (Yuan)...	34.50	40.70	48.10	56.80	67.10	79.30	93.60	110.40

When the straight wage-grade system superseded the wage-point mechanism, model wage-grade scales were fashioned for different industrial sectors and the ratios of highest-to-lowest grade were subsidized to conform with growth priorities geared to the goals of the development strategy, usually represented by the FYPs (Five Year Plans). Table 3-6 shows the distribution, ranges, and standard wages of eight-grade wage systems in selected industries. The data strongly reflect the FYPs' emphasis on heavy industry: the ratio of maximum grades and wage rates were higher for heavy industry, especially for mineral industry, than they were for lighter industries. Thus, while subsidized wages were used throughout industry as a spur to production, they were more pronounced in

Table 3-6 Standard Wages by Wage Grades, Selected Industries: China, 1958

Industry	1	2	3	4	5	6	7	8	Ratio of 8-1
Coal mining	34.5	40.7	48.1	56.8	67.1	79.3	93.6	110.4	3.20
Steel	34.5	40.7	48.1	56.8	67.1	79.3	93.6	110.4	3.20
Power	34.0	40.1	47.2	55.6	65.5	77.2	90.9	107.1	3.15
Petroleum	34.0	39.9	46.8	54.9	64.4	75.5	88.5	103.7	3.05
Machinery	33.0	38.9	45.8	54.0	63.6	74.9	88.2	104.0	3.15
Lumber milling	33.0	38.6	45.2	52.9	61.8	72.3	84.6	99.0	3.00
Chemicals	33.0	38.6	45.2	52.6	61.8	72.4	84.7	99.0	3.00
Textiles	30.4	34.6	41.3	48.7	56.3	67.6	79.2	...	2.60
Flour milling	29.0	34.0	39.9	46.8	54.6	64.4	75.4	...	2.60

Note: 1. This table only presents the standard wage (basic wage) and does not include various types of subsidizing payment.
2. Flour milling and textiles industries had only seven grades before 1960.
Source: China's Statistical Bureau <u>China Yearbook, 1959</u>, Tokyo, 1960.

those industries tagged for most rapid growth. Geographical wage differentials were also employed to move technicians and skilled workers to remote or desert areas. For instance, in 1956, to attract metal workers to Shanghai and Taiyuan (in Shanxi), subsidizing wages were set 9 and 20 per cent over the standard scale respectively, and the scale of the migration as a whole was nearly ten thousand workers at that time. Petroleum workers were attracted to Yumen in Gansu by subsidizing wages 30 to 50 per cent higher than the standard scale. Recently, China has been putting men into the Taklimagan Desert--the vast, barren centre of Xinjiang Autonomous Region, 3,000 km away from the coastal areas--to tap a modern treasure: oil. More than 30,000 workers have been mustered for this purpose. Half are organized into 45 drilling teams and 27 seismic crews, while the rest are engaged in road-building and other support functions. These oil men are paid princely wages of up to 2,000 yuan (US$350) a month, or two times more than that of their fellow-workers in the eastern regions. There are big bonuses (at least equalling their wages) for finishing a job early. Other subsidizing payments can vary according to the degree of inherent difficulty of the job and the more or less difficult working environment within which the job is performed (e.g. hot work, underground work, work involving health hazards or demanding above-average physical effort).

3.4 Performance of the Industry

A general pattern. Undoubtedly, all these policies enabled the country to allocate whatever resources it had at its disposal to the development of the mineral industry. Over a prolonged period, significant progress has been achieved in the face of substantial difficulties. For a start, a corps of more than 80,000 geologists has been formed, and the discovery of a number of mineral deposits has provided impetus for the rapid development of China's mineral industry. In 1990, total production of the industry reached 5.0 billion tonnes of mineral ores and 15.3 billion cubic metres of natural gas. Total output value of this production, excluding clay sand, and stone for construction, is approximately 122.3 billion yuan, nearly 6 per cent of the total industrial output. This production embraced 138 million tonnes of crude oil, 1,080 million tonnes of raw coal, 284 million tonnes of iron ore and supplementary raw materials, 70 million tonnes of nonferrous ore, 53 million tonnes of ore for the chemical industry, and 473 million tonnes of building materials (excluding clay and sand).

Table 3-7 Output of Selected Mineral Commodities in China, 1952-90

Selected Items	Unit	1952	1975	1990	(World Rank)
Coal	000,000 tonnes	66.0	482.0	1,079.9	1
Crude oil	000,000 tonnes	4.4	77.1	138.3	5
Iron ore	000,000 tonnes	--	65.2	118.0	3
Steel	000,000 tonnes	13.5	25.4	66.4	4
Rolled steel	000,000 tonnes	13.5	37.2	51.5	5
Copper	000 tonnes	--	98.6	490.0	6
Lead	000 tonnes	--	160.0	286.8	6
Zinc	000 tonnes	--	99.8	619.0	4
Aluminum	000 tonnes	--	985.5	4,000.0	7
Mercury	000 tonnes	--	0.9	0.8	2
Nickel	000 tonnes	--	--	27.4	9
Magnesium	000 tonnes	--	--	25.0	10
Tin	000 tonnes	--	22.0	40.0	1
Cement	000,000 tonnes	28.6	46.3	209.7	1
Salt	000,000 tonnes	22.9	14.8	20.2	3

Sources: 1. China's Statistics Yearbook, 1991.
2. The World Resources Institute, World Resources 1992-1993.
3. ABMS American Bureau of Metal Statistics, Non-ferrou Metal Data 1991.

China is now well up among the leaders in the world league table for many mineral commodities; she occupies the first place in the world in the production of coal and cement, third in the output of pig iron, and fourth in the output of raw steel, as well as fifth in the production of crude oil (refer to Table 3-7).

Contribution to the economy. Normally, a sector's contribution to the overall economy can be measured in terms of its shares of national production (GNP) and employment. This rule of thumb applies as much to the mineral sector as to any other.

The total added value of minerals produced in China in 1990 was 131,879 million yuan, accounting for 7.45 per cent of GNP. Of this, metallic minerals was responsible for 46,247 million yuan, or 48.07 per cent of the industry's total; energy minerals for 36,162 million yuan, or 37.58 per cent of the total; and building and other industrial mineral materials for 49,470 million yuan, or

14.35 per cent of the total.

The development of the mineral industry has been aimed principally at meeting China's domestic needs. Even so, international trade is very important. In 1990, export earnings of mineral products amounted to 38,192 million yuan, or about US$7,990 million, while imported mineral products were valued at 24,573 million yuan, or US$5,141 million. Both exported and imported mineral products, therefore, accounted for 3.55 per cent of GNP compared with a 1.43 per cent share of GNP in the 1970s. This improvement of mineral industry in foreign trade reflects a tendency of the growing Chinese economy to rely more heavily on mineral input to support its development than was the case before. All these performances of both domestic supply and foreign trade indicate that the mineral industry has already become a significant factor in the country's economy with a share of more than 11 per cent of GNP (see Figure 3-5). Incidentally, the international trade perspective will not be pursued further here, since it is the purview of the next chapter.

The total employment of the mineral industry in 1990 was about 15.6 millions; that is to say, about 3 per cent of the national employment total. A breakdown of that total revealed that the energy mineral industry employed nearly 6.7 millions, or 42.7 per cent of the industry's total; the metal mineral sector had more than 5.0 millions, or less than one-third of the total; and the building and other minerals branches accounted for the rest. It is now opportune to introduce a regional dimension to this study of

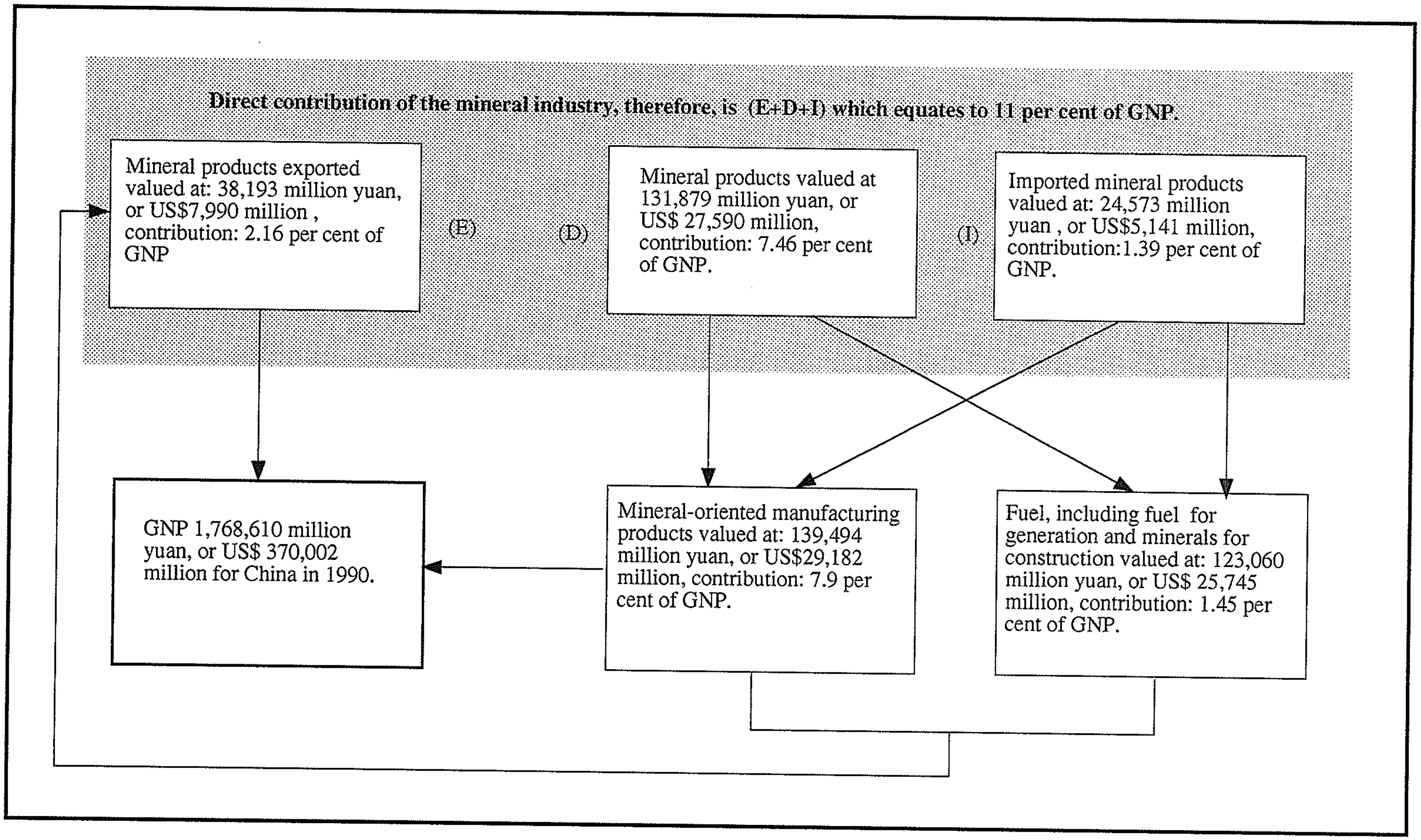


Figure 3-5. Contribution of the Mineral Industry to China's Economy, 1990

minerals' role in internal development.

3.5 Regional Pattern of the Mineral Industry

In 1949, the key feature of the regional pattern of China's economy was its disparity: the few industrial establishments were concentrated in areas close to the coast (Liaoning, Shanghai and southern Jiangsu, and Guangzhou), leaving the rest of the country virtually devoid of infrastructure and grossly undeveloped.

Correcting this disparity has been a constant concern of the Chinese government, both for economic reasons (to bring industrial activities closer to sources of raw materials) and for strategic reasons (as long as it was concentrated, industry was vulnerable in the event of foreign invasion), not to mention social reasons (promoting the reduction of inequalities in living standards). The stated goals of China's regional policy, therefore, are as follows: (a)to correct the "irrational" pattern of old-China's spatial economy; (b) to establish new economic complexes and sufficient interregional specialization; (c) to enhance industrial centres closer to raw materials and consumer markets; (d) to strike a proper balance between intraregional and interregional development; (e) to safeguard national defence; and (f) to develop medium and small cities in the interior rather than large cities on the coast (Cheng Chu-yuan, 1980). The overall goal of dispersal has not been pursued consistently, however, declining in favour especially after the "Open Door" policy of 1978.

The initial three years (1978-1980) of the modernization programme appeared to put much stress on consolidation and tapping the potential of the established industrial centres. The subsequent ten years (1981-1990), too, was destined to favour "key" projects in long-established, experienced industrial areas.

Despite the oscillations in locational policy, the actual net industrial movement over the years has been in the direction of the ostensible goal. For the whole period 1949-1977, the growth of industrial production in the interior (or Middle and Western Zones) has been more rapid than in industrially-orientated coastal (or Eastern) areas (see Tables 3-8 and 3-9). Table 3-10 gives a summary of the shifts in locational policy between 1949 and 1990.

In China's mineral industry, there are two other important factors which greatly impact on its regional distribution. First, minerals cannot be extracted where they are absent, and it is axiomatic that the location of minerals must be recognized as a determining factor for mineral industry. In China, most of the basic mineral resources are found in the northern part of the country. For example, 65 per cent of the coal resources is provided in Shanxi and Inner Mongolia, and only 4 percent is found in the south and southwest parts of the country. This locational pattern of mineral resources lays a fundamental condition for the regional production of the mining industry. Secondly, among some of the major mineral resources, there are high proportions of poor quality ores that are difficult to dress and smelt. Most of the iron resources have a low iron content (about 34 per cent), for example, and require substantial refining or benefication before being

Table 3-8 China's Dichotomous Regional Pattern, 1990 (% of nation)

Zone	Area	Population Total	Population Urban	Industrial employment	GNP	Industrial output
1949						
Coastal Areas	14.3	42.0	53.4	55.5	62.4	68.4
Interior Areas	85.7	58.0	36.6	44.5	37.6	31.6
1978						
Coastal Areas	14.3	-	-	45.2	50.9	51.1
Interior Areas	85.7	-	-	54.8	49.1	48.9
1990						
Coastal Areas	14.3	41.3	45.7	48.3	52.2	62.7
Interior Areas	85.7	58.7	54.3	51.7	47.8	37.3

Source: China's Statistics Bureau China's Statistical Yearbooks, 1988, 1990 and 1991.
Note: Appendix 3-1 shows the division of China into coastal and interior areas

Table 3-9 Regional Patterns of Selected Mineral Commodities (%)

Zone	Crude Oil 1952	Crude Oil 1990	Coal 1952	Coal 1990	Iron 1952	Iron 1990	Steel 1952	Steel 1990
The Eastern	53.7	42.7	40.4	21.9	79.2	54.5	85.9	58.0
The Middle	1.4	40.8	50.6	58.2	13.6	33.2	10.3	29.8
The Western	44.9	7.5	9.0	19.9	7.2	12.3	5.8	12.2
The Whole Country	100.0		100.0		100.0		100.0	

Source: China's Statistics Bureau Statistic Yearbook of China's Industrial Economy, 1991.
Note: Appendix 3-2 shows the division of China into three zones.

Table 3-10 Changing Emphases in China's Locational Policy

Period	State Investment ('X' denotes priority): Interior (undeveloped) areas	Coastal (developed) areas
1953-57 (1FYP)	X	
1958-60 (2FYP)	X	
1961-65 (ADJUSTMENT)		X
1966-70 (3FYP)	X	
1971-75 (4FYP)	X	
1976-80 (5FYP)		X
1981-85 (6FYP)		X
1986-90 (7FYP)		X

Source: China's Statistics Bureau China's Statistical Yearbook, 1991.

fed into blast furnaces for smelting. Only 2 per cent of the total ores extracted can go directly into the furnace. In this case, iron and steel plants have to be located in the areas where iron ores are extracted in order to reduce operating costs. Alternatively, but still governed by costs, iron and steel industry tends to be located in the coastal areas if imported iron ore is available, as the location of Baoshan Iron and Steel Complex in Shanghai attests.

Coal industry. In the first half of the twentieth century, coal-mining was more developed than most other industries (Bunge & Shinn, 1981). Such major mines as Fushun, Datong and Kailuan produced substantial quantities of coal for railways, shipping and industry. Expansion of coal-mining was a major goal of the First Five-Year Plan. The state invested heavily in modern mining equipment and in the development of large, mechanized mines. The "longwall" mining technique was adopted widely, and output reached 130 million tonnes in 1957. During the 1960s and 1970s, investment in large mines and modern equipment lagged, and much of the output growth during this period came from small local mines. A temporary but serious production setback followed the July 1976 Tangshan earthquake, which severely damaged China's most important coal centre, the Kailuan mines. It took two years for production at Kailuan to return to the 1975 level.

The programme to modernize and expand coal-mining in the 1980s emphasized the development of large, fully-mechanized facilities. Most of the machinery was to be produced domestically, but key modern technology and equipment was imported from foreign countries. As noted above, coal was the country's most important source of primary energy in 1990, meeting over 75.6 per cent of total energy demand. The 1990 production level surpassed a billion tonnes, with production being undertaken on a large scale in several regions. The North was predominant in accounting for 37.6 per cent of the total (Table 3-11). Mines which produce over 10 million tonnes per annum in the country include Datong (nearly 30.0 million tonnes or Mt), Xishan (15.1 Mt), Yangquan (16.2 Mt), Luan (10.1 Mt) and Jincheng (10.3 Mt) in Shanxi; Kailuan (17.8 Mt) and Fengfeng (11.5 Mt) in Hebei; Hegang (15.7 Mt), Jixi (15.7 Mt) and Shuangyashan (10.6 Mt) in Heilongjiang; Fuxin (11.0 Mt) in Liaoning; Pingdingshan (17.5 Mt) and Yima (10.7 Mt) in Henan; Huaibei (14.2 Mt) and Huainan (10.1 Mt) in Anhui; and Xiuzhou (13.2 Mt) in Jiangsu. Shanxi is the most important province for both coal production (over 280 million tonnes) and coal reserves (over 200

Table 3-11 Regional Production of Energy Minerals, 1990 (%)

region	Coal	Oil	Gas	Electricity	
				Total	(Hydro)
North	37.60	7.52	4.71	17.3	1.2
North-east	14.79	52.69	28.68	16.4	8.8
East	13.62	24.88	9.65	28.7	14.3
Central-South	14.12	7.42	9.58	20.4	40.4
South-west	11.77	0.12	43.46	9.2	21.3
North-west	8.10	7.37	3.92	8.0	14.0
Total	100.0	100.0	100.0	100.0	100.0
Total amount	1,079.9(mnt)	138.3(mnt)	15.2(bnsm)	410.7 (bnkwh)	92.4(bnkwh)

Source: China's Statistics Bureau, Statistical Yearbook, 1991.
Note: a. mnt=million tonnes; b. bnsm=billion square metres; c. bnkwh=billion kilowatt hours; d. Appendix 3-3 shows the division of China into six regions.

billion tonnes). It produced only one-fifth of China's coal in 1981, as compared with over one-quarter in 1990 (Fig. 3-6).

Oil and gas industry. Before 1949 most of the oil was imported. During the First Five-year Plan, the country invested heavily in exploration for new oilfields and development of new and existing wells. In 1959 the vast reserves of the Song-Liao basin were discovered and the Daqing oilfield went into operation in 1960 (Figure 3-7). Daqing had produced about 2.3 million tonnes of oil by 1963 and continued to lead the industry through the 1970s. Further important discoveries, including the major oilfields of Shengli, Dagang, and Huabei, enabled China to meet domestic needs and eliminate nearly all imports by the mid-1960s (Li Wen-yan, 1990). After 20 years of intensified geological investigation, it was confirmed that oil reserves were large and widely dispersed throughout the country. In general, development is concentrated on deposits readily accessible to major industrial and population centres. Deposits in remote areas such as the Tarim, Junggar, and Qaidam basins remain largely unexplored. Offshore exploration and drilling were first undertaken in the early 1970s and became more widespread and advanced as the decade progressed. Endeavours of this kind were concentrated in areas in the South China Sea, Gulf of Tonkin and Zhu Jiang (Pearl River) Delta in the south, and the Bohai Gulf in the north. According to the State Statistical Bureau, China's output of crude oil in 1990 was 138.3 million tonnes. Onshore production totalled 137 million tonnes compared with offshore output of 1.2 million tonnes. The Daqing oilfield in

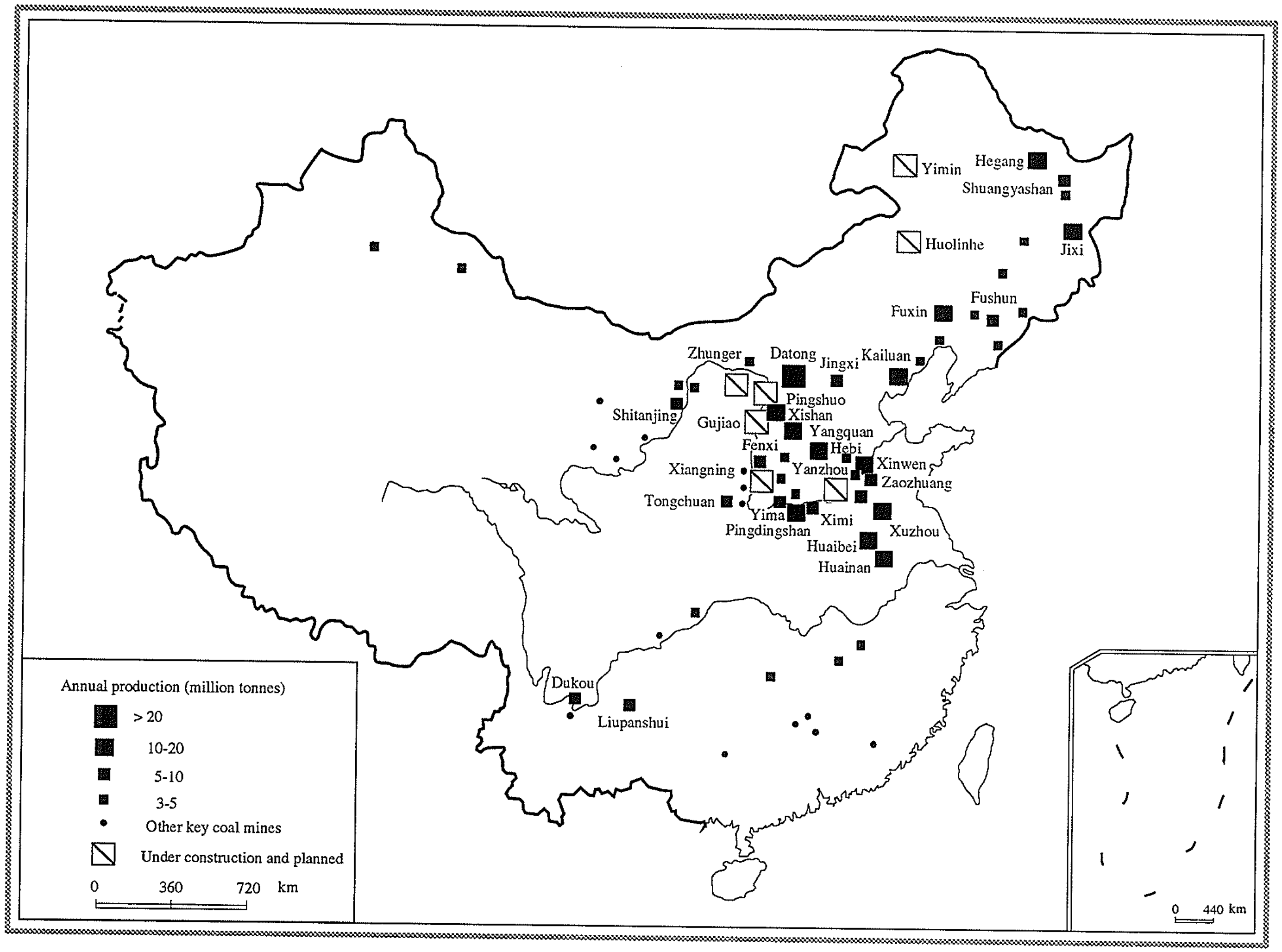


Figure 3-6. Distribution of Coal-Mining Industry in China, 1990

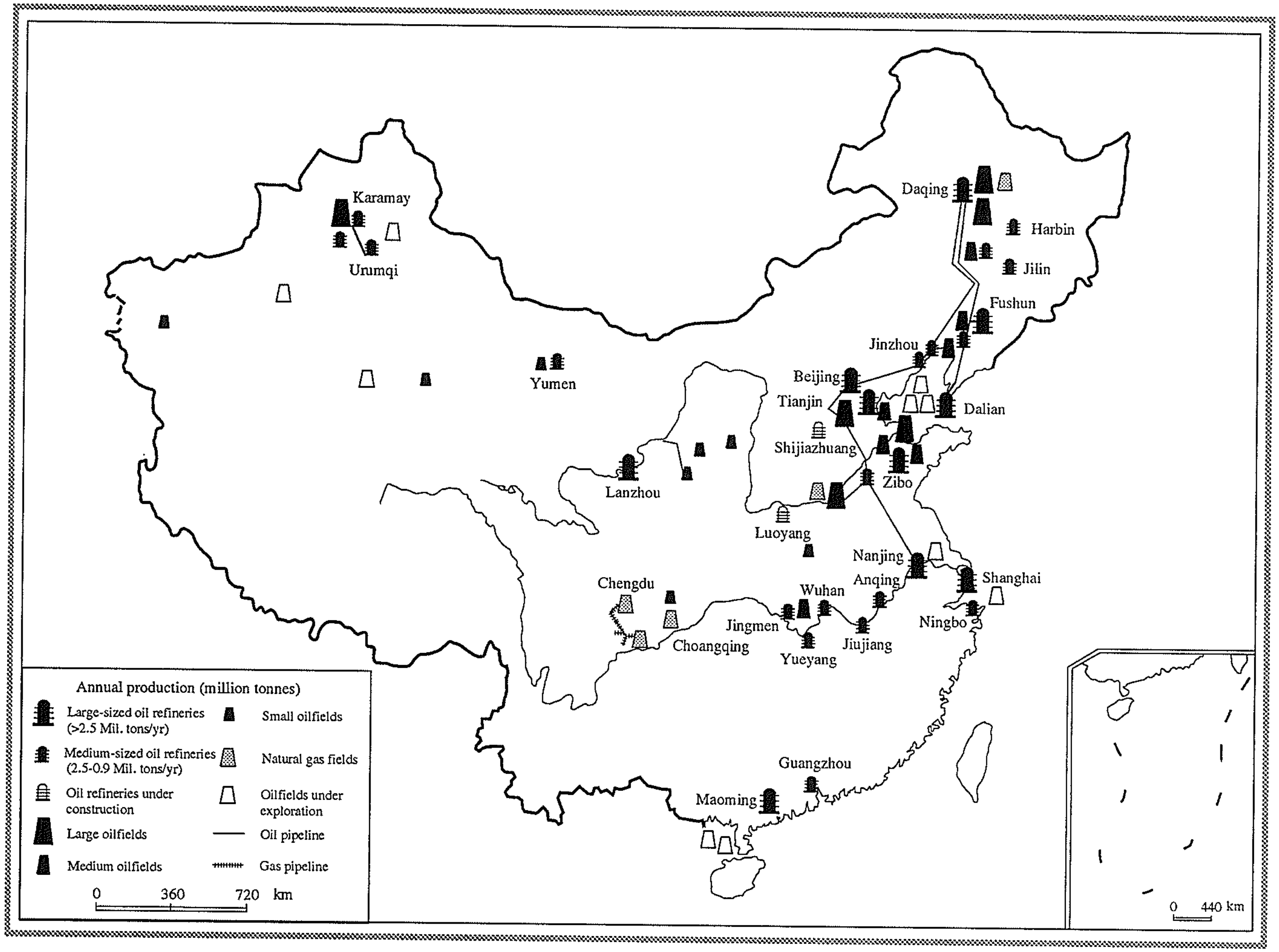


Figure 3-7. Crude Oil and Natural Gas Extraction and Refining Industry in China, 1990

Heilongjiang accounted for more than 55 million tonnes; Shengli oilfield in Shangdong added more than 33 million tonnes; Huabei oilfield in Hebei was responsible for less than 5.4 million tonnes; Liaohe oilfield in Liaoning for 13.6 million tonnes; Xinjiang oilfield in Xinjiang for less than 7 million tonnes; Dagang oilfield in Tianjin for more than 3.8 million tonnes; Zhongyuan oilfield in Henan for 6.3 million tonnes; Henan oilfield in Henan for 2.5 million tonnes; Jilin oilfield in Jilin for more than 3.5 million tonnes; and Changqing olifield in Shaanxi for less than 1.5 million tonnes. Altogether, they accounted for about 96 per cent of the national production. The output of the offshore oilfield in the Bohai Gulf alone accounted for about 75 per cent of total offshore oil production, while the South China Sea contributed the remainder.

In 1973, output was large enough to export a million tonnes of crude oil to Japan. In 1985 exports of crude oil amounted to over 30 million tonnes, 24 per cent of total production. Subsequently, exports diminished sharply because of fast-growing internal demand for petroleum products. In 1990, China exported about 24 million tonnes of crude oil, one-fifth less than the figure for 1985. Although the government temporarily abandoned its drive to broaden its oil exports in 1990, 138.3 million tonnes of crude oil still were produced, an increase of 13.4 million tonnes over 1985.

Natural gas was a relatively minor source of energy. Output grew rapidly in the 1960s and 1970s. By 1990 production was approximately 15.2 billion cubic metres--slightly more than 2 per cent of China's primary energy supply. Sichuan Province possesses about half of China's natural gas reserves and accounts for about 43 per cent of annual production. Most of the remaining natural gas is produced at the Daqing and the Liaohe oil-fields in the northeast, as well as the Zhongyuan oilfield in Henan. Other gas-producing areas include the Shengli oilfields, Zhongyuan oilfield, Xinjiang oilfield, and Dagang oilfield; the coastal plain in Jiangsu and Zhejinang provinces and the offshore oilfields nearby; the Huabei complex in Hebei Province; and the oilfields in Xinjiang A.R.

A rudimentary petroleum-refining industry was established with Soviet aid in the 1950s. In the 1960s and 1970s, this base was modernized and expanded, partly with European and Japanese equipment. In 1990 Chinese refineries were capable of processing about 2.1 million barrels per day. Of the total refining capability, 83 percent belonged to 23 large petroleum-refining plants with an annual capacity of over 2.5 million tonnes each (Li Wen-yan, 1990). There were also 13 medium and 38 small-size oil-refining plants. All these plants were dispersed throughout the country.

Iron and steel industry. Before 1949 the iron and steel industry was small and dispersed; the only modern steel facility of any size was constructed at Anshan in the Northeast by the Japanese. Total output of steel by all plants reached a maximum of 140,000 tonnes in 1949.

Since the establishment of the PRC, the country has consistently allotted large amounts of investment to expanding steel output capacity. Annual steel production, however, has proved to be extremely sensitive to changes in economic policies and political climate. In the 1950s steel output rose steadily as Soviet advisers helped create the basis of the enlarged iron and steel industry, installing numerous Soviet-designed blast furnaces and open-hearth furnaces. The Great Leap Forward saw a fantastic burgeoning of primitive backyard furnaces and small modern plants, overuse of large plants, and exaggerated production reports. In 1961 the industry broke down; nearly all the small plants were closed, and output fell to less than one-half the amount reported for 1960. From 1961 to 1965, output gradually recovered as damage was repaired and steel technology was advanced by the purchase of basic oxygen furnaces from Austria and electric furnaces from Japan. Production fell again during the early years of the Cultural Revolution but resumed a rapid rate of growth in the relative political stability of 1969 and the early 1970s. From 1976 output climbed steadily and in 1990 reached 66.4 million tonnes, making China the fourth largest producer in the world.

In 1990 China's steel industry was centred on 11 large facilities which had annual capacities of 1 million tonnes or more and which, in combination, produced 80 to 90 percent of total output. The fully-integrated complex at Anshan was China's largest steel centre, producing over 11.6 per cent (7.71 million tonnes) of total national output. The other large facilities were at Wuhan (4.74 million tonnes) in Hubei, Shoudu (4.36 million tonnes) in

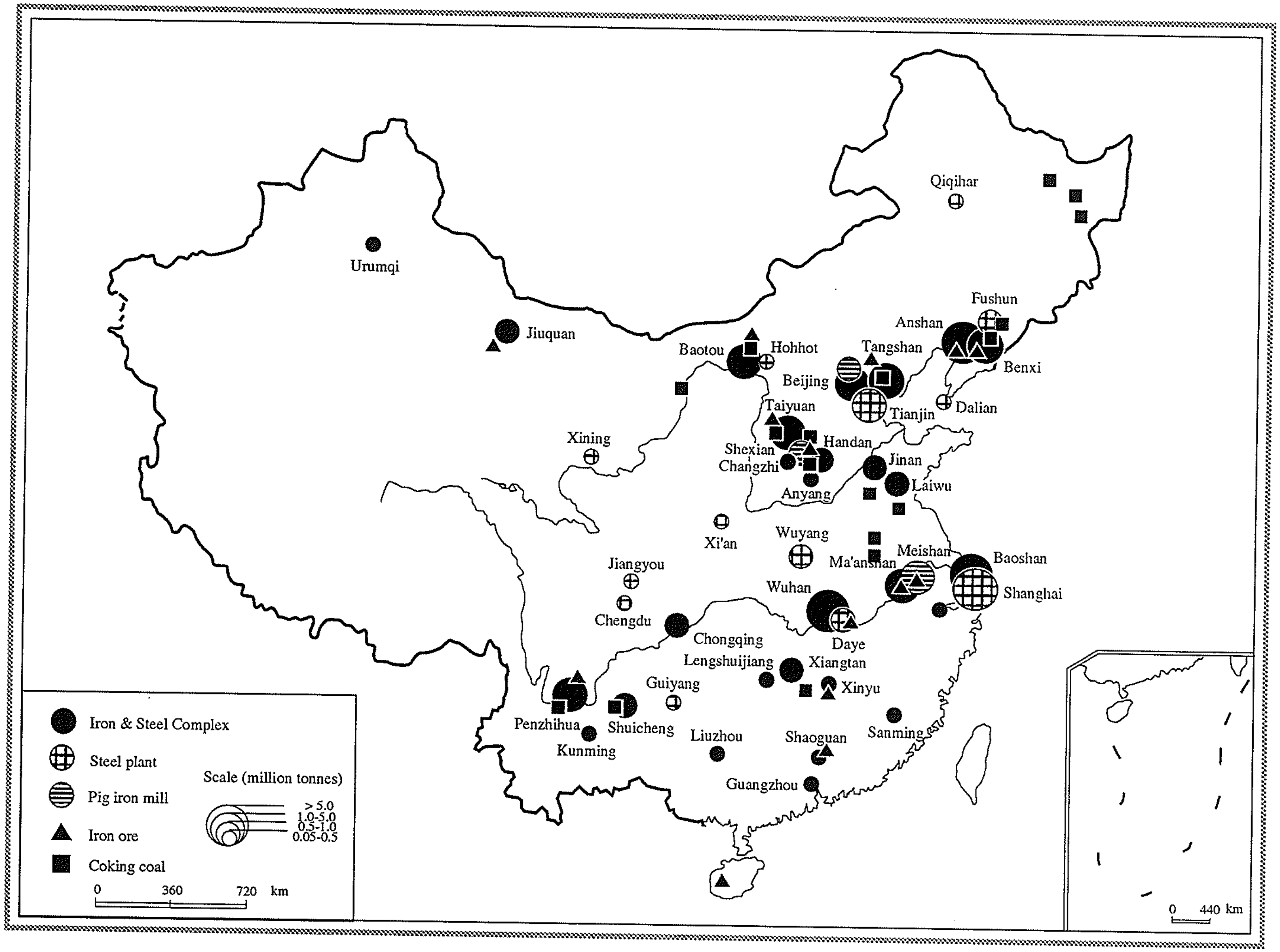


Figure 3-8. Iron and Steel Industry of China

Beijing, Baotou (2.25 million tonnes) in Inner Mogolia, Benxi (2.37 million tonnes) in Liaoning, Maanshan (2.04 million tonnes) in Anhui, Panzhihua (1.91 million tonnes) in southern Sichuan Province, Taiyuan (1.4 million tonnes) in Shanxi, Tangshan (1.58 million tonnes) in Hebei, and Chongqing (1.0 milion tonnes) in Sichuan. In 1978 China began construction of its first integrated steel complex, the Baoshan iron and steel works in Shanghai, but the completion date moved from 1982 to 1985 and finally to 1988. Its steel output was 3.87 million tonnes in 1990, the fourth largest iron and steel complex in China (Figure 3-8).

Besides the large plants, more than 1,400 medium and smaller local mills were dispersed throughout the country in 1990. They ranged from specialty mills producing under 500,000 tonnes per year to very small operations under either local jurisdiction or the control of other ministries. Most of these smaller mills produced small quantities of low-grade iron and steel to meet local needs.

3.6 Conclusion

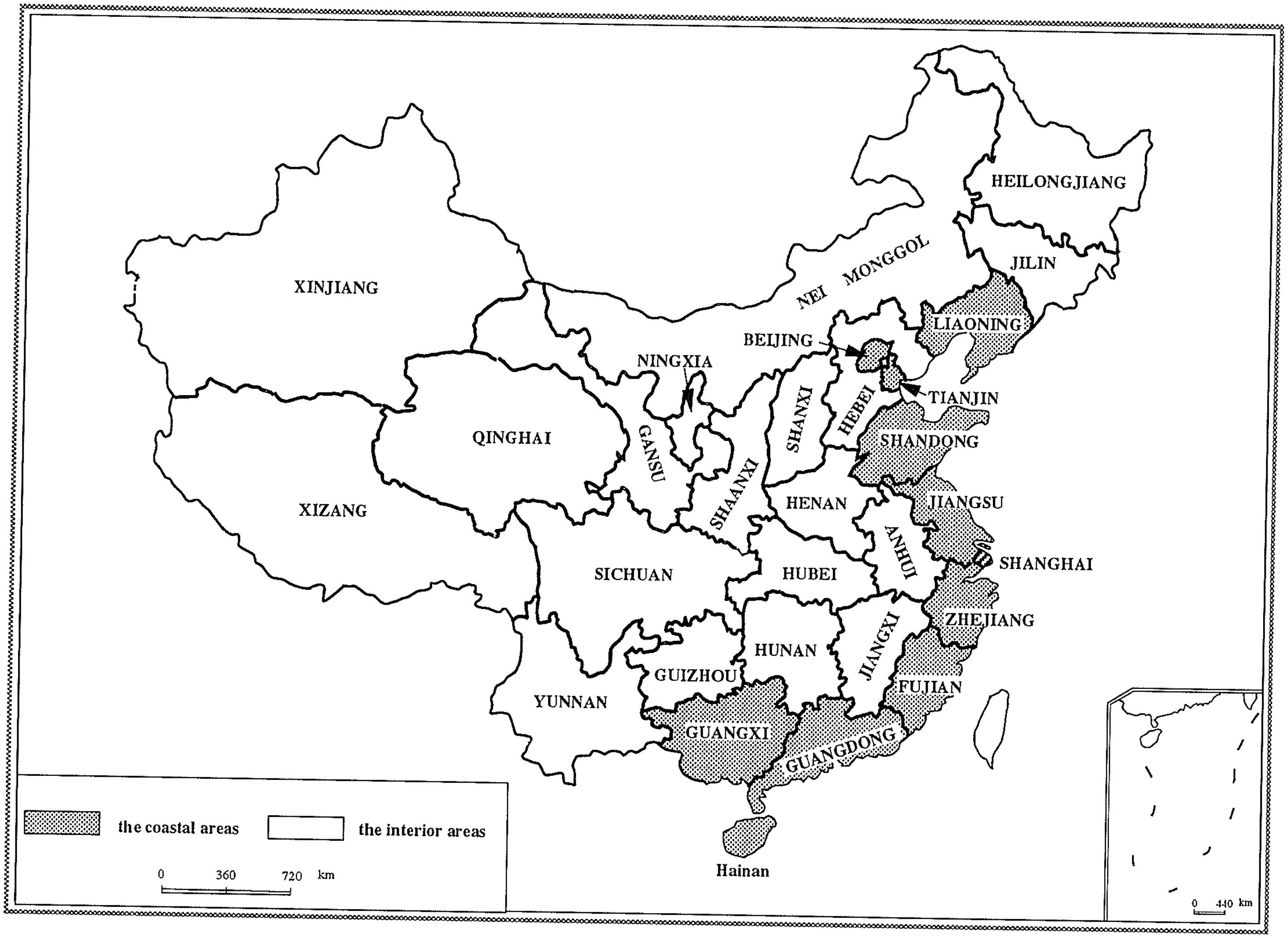
Long known only as a country poor in mineral deposits, China is now acknowledged to be a major minerals producer. For years the government has stressed the development of the mineral industry so as to foster economic growth.

The performances of the mineral industry in China during the past forty years suggest that the development of mineral industry can contribute to the national economy through, at least, two aspects.

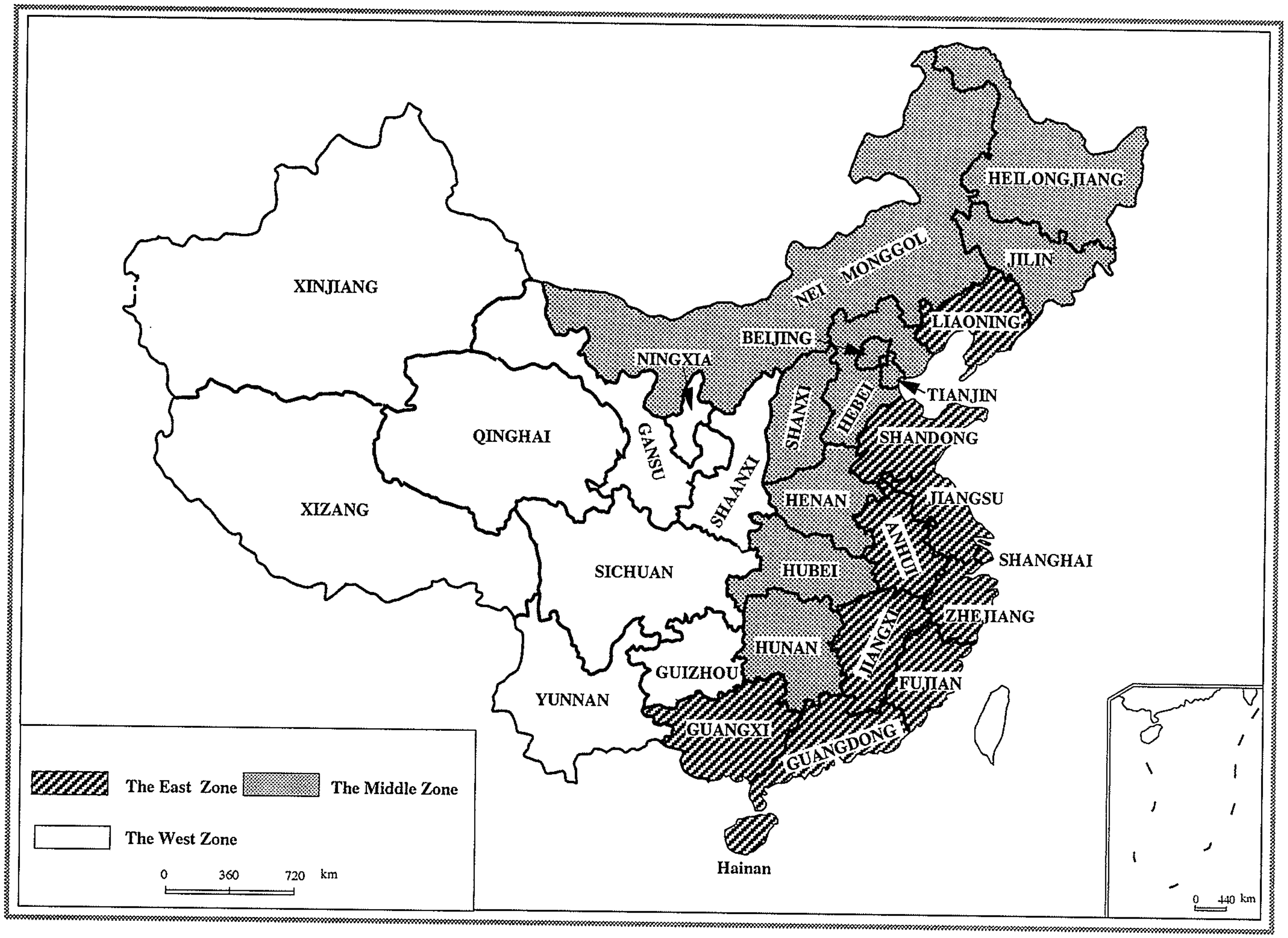
First, if developing countries want to catch the benefits of industrialization and mobilize the increasing demand for all types of mineral materials, the first objective for them to accomplish is to build up a reliable mineral supply system based on domestic resources.

Second, with the increase of mineral production, the large scale development of mineral industry can be regarded as a powerful engine for organizing and integrating all possible financial, personnel and technical resources into enterprises. This property is especially desirable in countries, like China, which are seriously lacking in capital and skilled labour and which have limited knowledge of the potential of their land resources. In this sense, the successful establishment of mineral industry can serve as a springboard for further development.

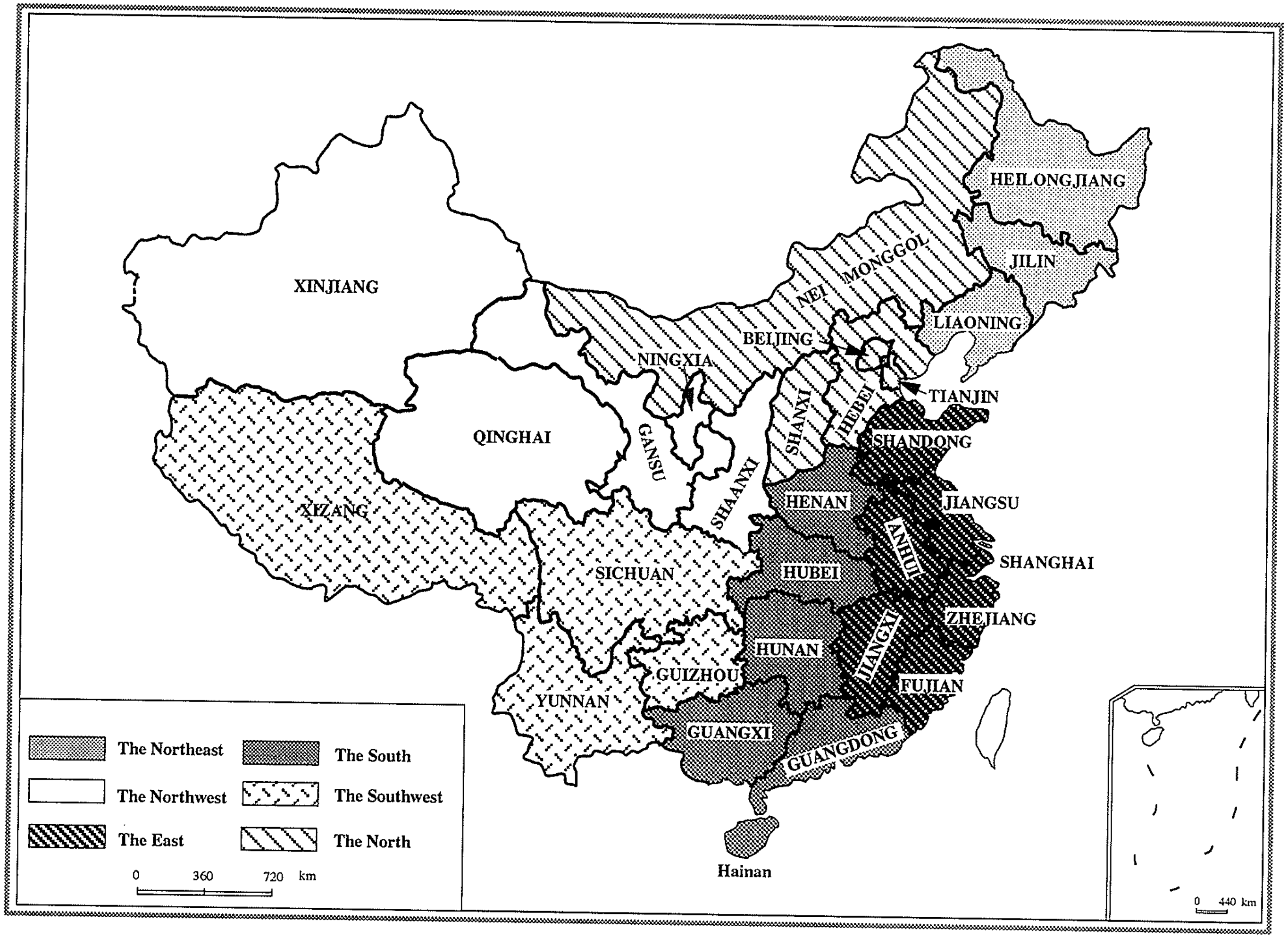
Hitherto, our attention has mainly concentrated on the changing patterns of domestic minerals' demand and supply. In the next chapter, the scrutiny will be widened, to incorporate an international trade perspective.



Appendix 3-1. The Division of China into Coastal and Interior Areas



Appendix 3-2. The Division of China into Three Zones



Appendix 3-3. The Division of China into Six Regions

CHAPTER IV

CHINA'S MINERAL INDUSTRY AND ITS RELEVANCE TO THE WORLD MARKET

4.1 Introduction

Many people believe that minerals trade makes its greatest contribution to economic development in the developing countries since much of the world's mineral trade originates in these areas. International mineral trade is far more important to the developing countries than to the industrial nations both in relative and, by and large, in absolute terms. A widely-held view is that mineral exports can inject additional income into the domestic economies of developing countries and, as a result, increase total demand for domestically-produced output. This chapter will spell out the so-called mineral-export-led growth hypothesis which I have mentioned in Chapter I under the guise of the third of the targets for enquiry.

Mindful of the then-contemporary experience, Marshall (1920) declared that 'the causes which determine the economic progress of nations belong to the study of international trade'. During the formative years 1460-1600 (Wallenstein, 1974), the growth of world trade first produced a spatially-undifferentiated pattern but, beginning with the emergence of Dutch 'hegemony' in the 17th century (Wallenstein, 1980) and more strongly following the 'Industrial Revolution', a new international trade pattern appeared. Contemporary with this period of internationalization of commodity trade (Palloix, 1977), the industrializing regions of Europe specialized in manufacturing while the colonies and other parts of the world specialized in agricultural production which was destined for markets in the industrializing regions. In the 19th century, the pattern of 'growth through trade' affected particularly the new countries or the 'regions of recent settlement' in the world's temperate latitudes: Canada, Argentina, Uruguay, South Africa, Australia and New Zealand. No doubt the United States, too, belongs substantially to this group. These regions had certain essential characteristics in common, but in the present context what matters is their high, though varying, dependence on growth through primary commodity exports and on the private foreign investment which, directly or indirectly, was thereby induced.

The historical process of international trade began entering a new phase in the 20th century and particularly since the mid-1960s (Forbes, 1982). The world economy has expanded greatly. Production processes are more and more internationalized (Grunwald and Flamm, 1985) and all kinds of international economic flows have increased in volume and importance. Virtually every national economy in the world is to some extent integrated in the international economy, and is thus affected in one way or another by decisions, processes and developments outside its borders. In this interconnected or even interdependent world, international economic co-operation is, by definition, of vital importance in regional development. It rests, in fact, on one type of international economic co-operation; namely, international trade. Although the economic relevance of other types of co-operation, such as labour migration and tourism, has increased, trade still is the single most important form of international economic co-operation. It represents a major portion of the monetary flows in circulation and it has immense direct impact on the local economies (level of employment, income etc.) involved. Most national economies have become increasingly open over the past few decades. Between 1965 and 1975, for example, the trade/GNP ratio (in percentage terms) of 96 out of the total of 116 countries increased, rising from an average of 48.1 in 1965 to 55.4 in 1975 (Taylor and Jodice, 1983). Especially noteworthy was the fact that economic policies entailing appropriate investment incentives for exports appeared to take on a central importance in the economic growth occurring in developing countries, while some other countries which neglected their export sectors through discriminatory economic policies had to settle for lower rates of economic growth as a result (Tyler, 1981). During the present century, and especially since the last world war, the density of the network of international trade relations has increased. Because of the fast development of communications and transport technologies, more and more of the potential trade links were actually made effective (Nierop and De Vos, 1988).

As to minerals trade, the U.S. Bureau of Mines maintains that mineral commodities constituted about 26 per cent of the value of total world trade in the 1960s, diminishing to approximately 20 per cent in the 1970s. By virtue of the nature of minerals, their importance in world trade assumed significantly proportion in terms of physical volume (roughly accounting for 40 per cent of the total volume of world trade in the 1970s). Reverting to value terms, by 1981 mineral commodities accounted for about 18 per cent of the total value of world trade. Crude oil alone accounted for about 16 per cent, making it the single most important commodity in international trade. The decline undergone by mineral commodities as a proportion of the value of world trade during the last three decades is attributed less to the reduction in the importance of minerals in developing countries and more to the rise of product exports from developed countries which, in any event, were responsible for two-thirds of the value of world trade. Automobiles and electronic goods loomed much larger in trade flows between advanced-industrial countries (US Department of Commerce, 1992). Notwithstanding these overarching developments, mineral commodity trade during this period expanded roughly sixfold in terms of current dollars; that is, equivalent to doubling the real value of mineral commodities in international trade in constant dollars (McCarl and Waters, 1985).

In fact, the definition enveloping all of mineral commodities in international trade is needlessly limiting. If we expand the traditional definition of mineral commodities to include semifinished products such as iron and steel (in addition to iron ore) together with refined metals such as copper, lead, zinc, aluminum, and tin, mineral commodities in world trade constituted 30 to 33 per cent of total export trade in all commodities during the period 1976-80 (US Bureau of Mines, 1982).

In addition, the US Bureau of Mines estimates the value of all mineral commodities consumed in the world (at the national level) and compares this value to total worldwide commodity consumption. By this system mineral commodities range from 35-40 per cent of all commodities consumed each year in all countries.

Granted the extended definition, it is evident that minerals, especially the fossil fuels, constitute a significant proportion of both total economic activity and total international trade. Considering that more than 40 per cent of the total mineral commodities originated in developing countries, it is obvious that mineral commodities constitute an important source of hard currency for their producers. In facilitating investment flows from developed into developing countries so as to initiate mineral exports, the trade fulfils an important catalytic role. It is because of these reasons that mineral export has become fashionable in many developing countries since the 1960s. The investment facilitating role has come to the forefront with appreciation of 'globalization' of international business.

It was only in the 1970s that academics began to focus on the role of the very large global corporations in fostering changes in industrial location at the international scale (Taylor and Thrift, 1982b; Peet, 1983). The rapidity of such changes has prompted reference to the hypermobility of capital brought about as corporations seek to maximize returns by engaging 'in a continual process of locational reselection and rationalization' (Taylor and Thrift, 1983). The major consideration in this process seems to have been the cost and control of labour, and most explanations of the redistribution of many basic manufacturing industries towards the newly-industrializing countries (NICs) have explicitly linked the organizational capabilities of the global corporation to the product-cycle hypothesis in accounting for the emergence of a 'new international division of labour' (Hymer, 1972; Frobel, Heinrichs, and Drege, 1980). Because of the widely acknowledged significance of the labour factor, the influence of spatial variations in the cost and availability of raw materials upon the location of industry is generally considered to have declined in importance as a consequence of changes in the structure of manufacturing and in the economics of transportation (Estall and Buchanan, 1980; Smith, 1981). However, this conclusion is usually based on the results of analyses couched at meso- or national scales (Hoare, 1983) and is not necessarily appropriate at the international level (Chapman, 1985). The desire to gain access to key resources has frequently been identified in studies of corporate growth as a motivation factor in the transition from national to multinational operations (Mckern, 1976; Taylor and Thrift, 1982a). Sharp increases in the cost of oil since 1973 have adversely affected industries such as iron and steel, chemicals, and glass, in which energy costs typically account for more than 10 per cent of total production cost. In these circumstances, it is not surprising to find that energy and resource costs have become a more important consideration in the international investment strategies of such corporations as British chemicals giant, ICI, (Clarke, 1982) and that one consequence of such strategies has been the weakening of the position of many oil-importing countries relative to others with a comparative-cost advantage for energy-intensive manufacturing. Political considerations have reinforced these trends as the establishment of more effective cartels of raw-material producers and increased competition between the developed countries for access to key resources have made it less easy for global corporations to resist pressure to undertake value-added processing operations within the territory of the resource-owner. Recent Japanese investment in Indonesia, for example, has been interpreted as an attempt to secure control of oil and gas (Forbes, 1982), and several oil-rich states in the Middle East are attempting to institute co-operation in major industrial development programmes (El Mallakh and El Mallakh, 1982; Turner and McMullen, 1982).

As a developing country, China puts great store on foreign trade of mineral products. This trade, in turn, plays a very important role in the national economy. The following discussion sets about demonstrating this importance.

4.2 Growth and Pattern of Foreign Trade

Growth of Trade Volume. The volume of China's foreign trade has fluctuated erratically since 1949. Between 1950 and 1959, the trade volume rose at an average annual rate of 15 per cent. As a result of this increase, the growth rate of foreign trade outpaced the 9 per cent annual increase in GNP. The major reason for this impressive performance was the rapid industrialization under way during the 1950s when China's investment rose at an average annual rate of over 20 per cent. Of the total investment, approximately one-third was earmarked for the purchase of machinery and equipment, and one-half of the machinery and equipment needed was imported from abroad, mainly from the former USSR. The high import component of capital investment entailed an upsurge in imports (Cheng Chu-yuan, 1982).

In the decade of the 1960s, the growth trends were reversed. Three successive years of crop failures in 1959-61 produced an acute agricultural crisis, a crisis which spilled over into the rest of the economy. The resultant contraction led to a drastic curtailment of investment, which in turn caused a sharp decline in imports. During this ten-year period, foreign trade not only failed to grow but actually declined in absolute terms. By 1969, the combined volume of imports and exports stood at 12 per cent of GNP below the 1959 peak, although GNP had risen by approximately 40 per cent in the same period. Thus economic policy in this decade placed the emphasis on self-sufficiency and on the internal generation of growth.

The self-reliance doctrine was substantially modified in the 1970s. Capital investment in industry during 1971-72 increased dramatically. To facilitate the new expansion, China imported an increasing amount of machinery and equipment, including complete plants and technology from the West. Trade turnover more than tripled between 1970 and 1975 to achieve the highest growth rate since 1949.

In the modernization drive that started in 1979 China succeeded in unleashing a massive programme to acquire Western equipment and technology in order to break development constraints and to accelerate the pace of industrialization. Foreign trade has been pushed to the forefront, assuming a much more important role than in earlier periods. The Chinese government employed all possible means in pursuit of its target of foreign-trade development. The first law on joint ventures was issued in 1979, and it was followed by the creation of four special economic zones (SEZs) and the introduction of financial incentives to encourage traders to export. These moves, indeed, caused trade to burgeon. Between 1980 and 1990, the total volume of foreign trade increased more than threefold to over US$110 billion, equivalent to over 31 per cent of GNP--up from just 12 per cent in 1979 (see Table 4-1).

In spite of the effects on China's foreign trade of shifting international relations and domestic political movements during the last 40 years, changes in the commodity structure of trade have reflected to a large degree the transformation of the economy and the development strategy adopted. The overseers of the structure of trade long held to the view that it should fulfil a balancing role. In other words, it was envisaged that imports should top up domestic production shortfalls and provide necessities that could not be produced domestically in sufficient quantity, if at all. Exports, for their part, were not viewed as an instrument to promote growth and employment, but merely as a necessity to pay for imports. However, in recent years, China has paid more attention to

Table 4-1 China's Foreign Trade in Value, 1950-90

Year	Total (C¥ 0,000,000,000)	Export	Import	Total (US$ 0,000,000,000)	Export	Import	Foreign trade as % of GNP
1950	4.15	2.02	2.13	1.13	0.55	0.58	9.8
1951	5.95	2.42	3.53	1.96	0.76	1.20	10.2
1952	6.46	2.71	3.75	1.94	8.20	1.12	9.8
1953	8.09	3.48	4.61	2.37	1.02	1.35	10.2
1954	8.47	4.00	4.47	2.44	1.15	1.29	10.1
1955	10.98	4.87	6.11	3.14	1.41	1.73	12.2
1956	10.87	5.57	5.30	3.21	1.65	1.56	11.0
1957	10.45	5.45	5.00	3.10	1.60	1.50	10.3
1958	12.87	6.70	6.17	3.87	1.98	1.89	10.3
1959	14.93	7.81	7.12	4.38	2.26	2.12	10.9
1960	12.84	6.33	6.51	3.81	1.86	1.95	9.5
1961	9.07	4.77	4.30	2.94	1.49	1.45	8.4
1962	8.09	5.71	3.38	2.66	1.49	1.17	8.1
1963	8.57	5.00	3.57	2.92	1.65	1.27	8.0
1964	9.75	5.54	4.21	3.47	1.92	1.55	7.7
1965	11.84	6.31	5.53	4.25	2.23	2.02	7.9
1966	12.71	6.60	6.11	4.62	2.37	2.25	7.4
1967	11.22	5.88	5.34	4.16	2.14	2.02	7.0
1968	10.85	5.76	5.09	4.05	2.10	1.95	7.1
1969	10.70	5.98	4.72	4.03	2.20	1.83	6.2
1970	11.29	5.68	5.61	4.59	2.26	2.33	5.5
1971	12.09	6.85	5.24	4.84	2.64	2.20	5.5
1972	14.69	8.29	6.40	6.30	3.44	2.86	6.4
1973	22.05	11.69	10.36	10.98	5.82	5.16	8.3
1974	29.22	13.94	15.28	14.57	6.95	7.62	11.1
1975	29.04	14.30	14.74	14.75	7.26	7.49	10.4
1976	26.41	13.48	12.93	13.43	6.85	6.58	9.8
1977	27.25	13.97	13.28	14.80	7.59	7.21	9.3
1978	35.50	16.76	18.74	20.64	9.75	10.89	9.2
1979	45.46	21.17	24.29	29.33	13.66	15.67	12.0
1980	57.00	27.12	29.88	38.14	18.12	20.02	12.8
1981	73.53	36.76	36.77	44.03	22.01	22.02	15.4
1982	77.13	41.38	35.75	41.61	22.32	19.29	14.9
1983	86.01	43.83	42.18	43.62	22.23	21.39	13.8
1984	120.10	58.05	62.05	53.55	26.14	27.41	17.3
1985	206.67	80.89	125.78	69.60	27.35	42.25	24.3
1986	285.04	108.21	149.83	73.85	30.94	42.90	29.4
1987	308.42	147.00	161.42	82.65	39.44	43.22	27.3
1988	382.20	176.67	205.53	102.79	47.52	55.28	27.3
1989	415.59	195.60	219.99	111.68	52.54	59.14	26.1
1990	556.01	298.58	257.43	115.48	62.09	53.35	31.4

Source: China's Statistics Bureau (1991) China's Statistics Yearbook, 1991.

the role of foreign trade in modernization and development, and foreign-trade planning has become less rigid.

Changes in the structure of imports. Before the establishment of the People's Republic, China's foreign trade pattern was similar to that experienced by underdeveloped countries in the nineteenth century; that is, a pattern stamped by exporting raw materials and importing consumer and capital goods. After 1949, imports of consumer goods were drastically cut, except for necessities such as food-grains. Most of the scarce foreign exchange available was used to pay for imports of producer goods, mainly consisting of chemicals, and machinery and equipment for the construction of industry and the provision of transportation systems. These constituted about half of total imports during the First Five-Year Plan of the People's Republic (see Table 4-2).

There were three surges of technology introduction which greatly contributed to the importation of machinery and equipment. The first occurred in the 1950s when complete plants and sets of equipment, at a cost of US$2.66 billion, were introduced from the former USSR and Eastern European countries for 159 large projects involved in developing certain industries such as metallurgy, machinery and tractor building, coal and electricity. The years 1973 through 1978 saw the second surge when more than 1,530 contracts at a cost of about US$18 billion were signed. These emphasized complete sets of equipment, including (as recorded in the last chapter) a 1.7-metre rolled steel machine purchased from (West) Germany, 13 large sets of chemical fertilizer equipment, and

Table 4-2 Composition of China's Imports, 1952-90 (%)

Year	Total	Food	Textiles	Minerals	Machinery & chemicals	Others
1952	100.0	0.2	1.3	19.0	30.6	48.9
1953	100.0	0.2	2.5	19.0	32.5	45.8
1954	100.0	0.6	6.6	18.9	33.8	40.1
1955	100.0	2.2	9.7	19.1	32.7	36.3
1956	100.0	1.7	9.3	21.7	39.2	28.1
1957	100.0	2.2	12.2	21.6	32.2	31.8
1958	100.0	2.3	9.1	33.0	37.4	18.2
1959	100.0	0.3	7.7	24.0	48.4	19.6
1960	100.0	2.5	10.9	26.9	42.6	17.1
1961	100.0	30.6	11.4	20.8	19.0	18.2
1962	100.0	38.0	11.7	18.3	12.2	19.8
1963	100.0	36.1	16.8	14.3	18.2	14.6
1964	100.0	38.2	15.9	11.9	18.3	15.7
1965	100.0	28.9	14.8	15.0	28.5	12.8
1966	100.0	26.1	9.0	19.0	31.6	14.3
1967	100.0	22.9	9.9	27.1	29.7	10.4
1968	100.0	22.8	7.8	26.0	32.1	11.3
1969	100.0	23.0	7.9	27.2	30.4	11.5
1970	100.0	19.2	5.6	30.1	33.2	11.9
1972	100.0	16.3	8.9	30.4	31.5	12.9
1973	100.0	20.1	10.6	29.8	31.4	11.5
1974	100.0	20.4	10.3	27.5	30.6	11.2
1975	100.0	12.4	7.7	29.3	39.7	10.9
1976	100.0	9.3	7.5	34.2	40.1	8.9
1977	100.0	18.4	10.4	35.6	32.1	3.5
1978	100.0	14.6	10.6	38.7	32.8	3.3
1979	100.0	14.4	9.8	32.5	38.9	4.4
1980	100.0	15.5	15.2	23.3	41.1	4.9
1981	100.0	18.5	21.1	19.7	39.7	1.0
1982	100.0	20.6	15.7	23.9	36.4	3.6
1983	100.0	14.1	6.5	25.9	37.1	16.4
1984	100.0	8.7	9.3	27.9	51.6	2.5
1985	100.0	5.4	5.1	25.4	54.3	10.5
1986	100.0	7.1	5.8	21.4	56.4	9.3
1987	100.0	6.3	8.5	19.9	52.7	12.6
1988	100.0	8.2	7.8	13.1	51.4	19.5
1989	100.0	10.3	8.7	16.6	47.9	16.5
1990	100.0	10.2	7.0	12.8	48.6	20.9

Source: China's Statistics Bureau <u>China's Statistics Yearbook</u>, various years.

two sets of large equipment for petrochemicals. The third and the largest surge occurred in the 1980s. During this period, China spent US$ 107 billion for technology introduction, with the Shanghai Baoshan Iron and Steel Complex alone requiring nearly US$4.78 billion in foreign exchange to import equipment for both Phase I and Phase II of its construction.

Minerals and metals, the second largest group, accounted for about 20 per cent of all imports in the 1950s and 30 per cent in the 1970s. This category was dominated by semi-manufactured metal, which made up more than two-thirds of the mineral and metal imports. Among this group, nonferrous metal imports were led by copper, nickel, aluminum and lead. Improvement in Chinese steel quality and variety in the 1980s resulted in a diminishing share for this category of imports.

Food-grains comprised the bulk of agricultural imports. In the 1950s, China exported about 0.5 million tonnes of rice annually and imported virtually no grain at all. This situation changed dramatically when food imports jumped about tenfold in value in 1961 and stood at about 20 per cent of the total imports from then until the mid-1970s mainly on account of natural disasters (1960-62) and political turmoils (The Great Leap Forward and the Cultural Revolution). A sharp upturn in wheat purchases took place in 1977-83, but now the increase in the amount of food-grains imported stemmed mainly from the rapid growth of the urban population from 167 million in 1977 to 215 million in 1982.

Changes in the structure of exports. Generally speaking, before 1978 China's exports basically consisted of food, textile products and nonferrous and alloy metals. Farm products, both foodstuffs and raw materials, accounted for roughly 30-40 per cent of China's exports. After 1961, however, the export pattern altered drastically. The three years of crop failure in 1959-61 changed the relative weight of farm products in the export portfolio, and its importance plummeted from a high of 45 per cent in 1953 to a low of 19 per cent in 1961. In compensation, export of textile products rose from less than 20 per cent in the early 1950s to about 40 per cent in the early 1960s. With the improvement in the agricultural situation, foodstuffs regained the leading role in 1964 and kept it until the mid-1970s (see table 4-3).

In the early years of the 1970s, while farm products still represented about 35 per cent of Chinese sales abroad, exports of energy products began to assume growing importance. In the mid-1950s, China had to import about a quarter of its crude oil and well over half of its gasoline, kerosene, and diesel oil. In the 1950-1961 period, China annually imported more than 3 million tonnes of crude oil from the former USSR and Eastern Europe. The commissioning of the Daqing oilfield in 1964 and the subsequent exploitation of the Shengli and Dagang oilfields in North China changed the picture completely. After 1973, and for the best part of two decades, China became a net exporter of oil and this shift has been the most significant development in the country's trade composition.

Although China hoped that sales of oil would provide large

Table 4-3 Composition of China's Exports, 1952-90 (%)

Year	Total	Food	Textiles	Minerals	Machinery & chemicals	Others
1952	100.0	39.4	10.6	11.9	0.9	37.2
1953	100.0	47.5	14.2	13.5	1.1	23.7
1954	100.0	48.3	14.9	13.1	1.1	22.6
1955	100.0	45.3	17.0	13.1	1.5	23.1
1956	100.0	40.4	20.1	13.3	1.8	24.4
1957	100.0	34.2	22.9	16.0	2.2	24.7
1958	100.0	35.6	20.6	12.9	2.6	28.3
1959	100.0	37.8	38.8	11.9	1.9	9.6
1960	100.0	28.9	38.0	11.3	1.6	20.2
1961	100.0	19.4	43.2	19.1	1.8	16.5
1962	100.0	21.4	41.0	17.8	2.2	17.6
1963	100.0	25.1	39.4	13.6	3.5	18.4
1964	100.0	30.0	29.5	14.6	2.9	23.0
1965	100.0	32.5	22.6	14.9	4.1	25.9
1966	100.0	34.4	21.9	14.3	4.6	24.8
1967	100.0	34.5	21.0	14.7	4.6	24.5
1968	100.0	34.3	21.1	14.6	4.9	25.1
1969	100.0	36.2	22.3	15.1	5.0	21.4
1970	100.0	37.1	27.2	16.7	5.1	13.9
1972	100.0	37.0	26.3	17.2	5.1	14.4
1973	100.0	38.4	24.8	17.8	5.0	14.0
1974	100.0	37.2	23.7	18.1	5.9	15.1
1975	100.0	36.3	24.1	18.4	5.9	15.3
1976	100.0	37.8	27.6	20.1	6.0	8.5
1977	100.0	30.2	26.3	25.4	7.8	10.3
1978	100.0	24.6	27.9	31.5	8.2	7.8
1979	100.0	20.7	28.0	34.8	9.2	7.3
1980	100.0	18.6	26.3	37.8	9.7	7.6
1981	100.0	16.6	26.1	38.6	10.8	7.9
1982	100.0	16.0	25.1	36.4	9.3	13.2
1983	100.0	14.7	35.5	33.5	9.5	6.8
1984	100.0	13.8	30.5	33.1	9.2	13.4
1985	100.0	17.1	25.1	30.5	12.1	15.2
1986	100.0	15.1	26.7	21.3	13.8	23.1
1987	100.0	12.8	28.2	20.8	15.1	23.1
1988	100.0	16.2	30.8	11.7	16.6	25.3
1989	100.0	13.9	31.8	12.0	14.1	28.2
1990	100.0	12.7	27.7	12.8	19.3	27.0

Source: China's Statistics Bureau China's Statistics Yearbook, various years.

amounts of foreign exchange, oil has accounted for less than 10 per cent of export earnings in recent years. As the importance of foodstuffs and mineral products declined, intermediate and finished textile products became increasingly prominent. For much of the 1980s, the development of textiles and manufactured consumer goods received a high priority and, as a result of increasing investment and material supplies, textiles became the chief contributor to China's exports. Their prominence, however, should not be allowed to detract from the importance of minerals in foreign trade, as the next section makes clear.

4.3 The Role of Mineral Commodities in Foreign Trade: The Cases of Oil Exports and Iron Ore Imports

As previously stated, mineral and metal products are very important in China's foreign trade. For years 'mineral commodities' has been the second largest group in China's foreign trade, just behind the category of machinery and chemical industry. Collectively, it was responsible for more than 20 per cent of total visible foreign trade. Among the members of the mineral commodities' group, oil stands out. It is the most significant item with respect to contributions to export earnings, effects on composition of exports and balance of payments, to say nothing of its impacts on a variety of general development strategies.

The role of oil in China's exports. After achieving self-sufficiency in oil in 1965, China began to export its crude oil on a small scale in the early 1970s (see Table 4-4). More importantly, new opportunities beckoned for access to foreign equipment and

Table 4-4 Role of Oil and Fuels in Total Exports (US$ million)

	Crude oil	Oil products	Total hydrocarbon	Total fuels	Total export	% of total export	
						Hydrocarbon	Fuels
1972	-	-	-	12	3,443	-	0.3
1973	-	-	-	50	5,819	-	0.9
1974	402	134	536	670	6,949	8.0	9.6
1975	781	142	923	1,093	7,264	13.0	15.0
1976	730	146	876	942	6,854	12.0	13.7
1977	810	243	1,053	1,068	7,590	13.0	14.1
1978	1,010	202	1,212	1,345	9,745	12.0	13.8
1979	1,750	727	2,477	2,654	13,658	18.1	19.5
1980	-	-	4,221	4,588	18,120	23.3	25.3
1981	-	-	4,650	5,054	22,010	21.1	23.0
1982	3,398	1,538	4,936	5,353	22,320	22.1	24.0
1983	2,966	1,373	4,339	4,701	22,230	19.5	21.2
1984	4,262	1,421	5,683	6,062	26,140	21.7	23.2
1985	5,236	1,450	6,686	7,035	27,350	24.5	25.7
1986	2,322	715	3,037	3,582	30,940	9.8	11.6
1987	3,407	760	4,167	4,834	39,441	10.6	12.3
1988	2,638	633	3,271	4,014	47,520	6.9	10.1
1989	2,750	758	3,508	4,202	52,540	6.7	8.0
1990	3,390	877	4,267	5,036	62,090	6.9	8.1

Source: China's Statistics Bureau China's Statistics Yearbook, various years.

technology, since the breakthrough in Sino-American relations, highlighted by the July 1972 visit of Richard Nixon to Beijing, promised an end to China's isolation. In line with the new spirit of conciliation, China, with a concomitant emphasis on expanding trade with foreign countries, now could obtain advanced technology, machinery and complete plants, as well as industrial raw materials and intermediate goods that it could not produce at home. Moreover, it could obtain from abroad consumer goods in short supply in the domestic market. As a result, total trade turnover grew rapidly, rising from US$4.8 billion in 1971 to US$14.6 billion in 1974.

At the time, China adopted a very conservative attitude towards trade, making sparing use of credits while displaying a strong aversion to incurring any sizeable trade deficits. In order to expand the domestic production capacities of key materials such as metallurgical and petrochemical products, the State Council in 1973 adopted a proposal, termed "A Request to Increase the Import of Equipment and Expand Economic Exchange", which advocated the import of US$4.3 billion-worth of equipment and whole plants (known as the "4-3 Programme"). Additional items were soon approved, so that the programme eventually called for the purchase of US$5.14 billion worth of goods, including a steel rolling mill capable of producing 1.7 metre plates, 13 large-scale fertilizer plants, four large chemical-fibre plants, three petrochemical plants and one-alkyl-benzene plant.

The ambitious import programme raised a new problem: how would China pay for these plants? The answer was through higher export earnings. Up to the early 1970s, as indicated, the bulk of Chinese exports consisted of foodstuffs and textile products: in 1970, these two categories accounted for 64.3 per cent of total exports (recall Table 4-3,). Thus to enhance foreign exchange earnings, China had to find new products in demand in the world market. Under a dual policy called "oil-for-steel" and "oil-for-machine", oil soon emerged to fill the need.

Domestic oil production was growing rapidly, rising from 30.7 million tonnes in 1970 to 77.1 million tonnes in 1975, denoting an average annual growth rate of 20.34 per cent during 1971-75. This led to an increasing amount of exportable surplus each year. In the wake of the first oil crisis in 1973, prices quadrupled, rising from US$2.70 per barrel in June of that year to US$10.46 per barrel in December 1974 (Chow Chuen-ho, 1992). China naturally became interested in selling its oil in the world market so as to gain from this windfall. The total amount exported rose from 1.53 million tonnes in 1972 to nearly 12.0 million tonnes in 1975, while export receipts from fuels soared from US$12 million to US$ 1,093 million during those years (see Table 4-4). China's oil export volume remained at the 1975 level for the next two years, but rose to 13.5 million tonnes in 1978 and produced US$1.2 billion in earnings. Evidently, by the mid-1970s, oil had become an important export item, and its contribution to aggregate exports stabilized at about 12 per cent over the next few years.

China started on its second wave of machinery and equipment imports in 1979 when the 'Open Door' policy was proclaimed together with its stress on increased trade and financial exchanges. In like manner to the first wave, most of these advanced-technology imports were from Japan and the intention was to pay for them with energy exports. According to the Long-term Trade Agreement signed between the two countries, China would buy US$10 billion of plants and machinery from Japan during 1978-80. In return, China would export 47 million tonnes of crude oil to Japan, an amount constituting half the total exports (by value) of China to that country.

At the outset, China was confident of raising oil production and oil exports up to 1985, encouraged by the optimistic assessment of its offshore potential which prevailed at that time. However, disillusionment set in very quickly because geological surveys in many offshore zones failed to live up to expectations. In

Table 4-5 Oil Exports and Oil Production (million tonnes)

	Export: Crude oil	Export: Oil products	Export: total	Total output of crude oil	Exported crude oil as % of total production	Import: Crude oil
1970	0.19	0.19	0.38	30.62	0.6	-
1971	0.26	0.37	0.63	39.41	0.7	-
1972	0.64	0.89	1.53	45.67	1.4	-
1973	1.83	1.16	2.99	53.61	3.4	-
1974	5.07	1.48	6.55	64.85	7.8	-
1975	9.88	2.10	11.98	77.06	12.8	-
1976	8.50	1.95	10.45	87.16	9.7	-
1977	9.11	1.96	11.07	93.64	9.7	-
1978	11.31	2.17	13.48	104.05	10.9	-
1979	13.43	3.03	16.46	106.15	12.7	-
1980	13.31	4.20	17.51	105.95	12.6	0.8
1981	13.87	4.67	18.54	101.22	13.7	0.7
1982	14.68	4.91	19.59	102.12	14.4	1.6
1983	14.82	4.91	19.73	106.07	14.0	1.4
1984	22.01	5.70	27.71	114.61	19.2	1.1
1985	30.03	6.21	36.24	124.90	24.0	1.6
1986	28.50	5.46	33.96	130.69	21.8	4.1
1987	27.23	4.94	32.17	134.14	20.3	4.8
1988	26.05	4.79	30.84	137.05	19.0	5.9
1989	24.39	4.74	29.13	137.45	17.8	8.6
1990	23.99	5.26	29.25	138.31	17.3	8.5

Source: China's Statistics Bureau <u>China's Statistics Yearbook</u> various years.

consequence, there was actually a decline in oil production during 1980-82 (see Table 4-5). Meanwhile, serious energy shortages occurred throughout the country. It was apparent that China had entered a new stage in terms of energy balance and oil exports. Worse still, a trade deficit of US$3 billion was registered in 1978-79, and blamed in part on the expense of importing equipment and technology. The programme shifted into reverse, planned economic growth targets were reduced and a number of technology and plant acquisitions were cancelled (Chen Chu-yuan, 1982). At the same time, exports of foodstuffs and light industrial products such as textile products were temporarily reduced on account of the need to augment domestic supply so as to raise living standards. In partial compensation, there was a great effort to increase the export of heavy and chemical industrial products. Oil again emerged to play a leading role in boosting China's exports, rising uninterruptedly in the subsequent years to peak at 36.2 million tonnes in 1985.

Apart from increases in the amount exported, the sharp rise in the world oil price associated with the second oil crisis of 1979-80 undoubtedly proved crucial in bolstering China's oil export earnings. Global oil prices began to rise appreciably in 1979, and soared in 1980 and 1981: Saudi Arabian light crude was priced at US$23.34 per barrel in 1979, US$36.00 in 1980 and US$42.00 in 1981 (see Appendix 4-1). In tandem with the prices set by OPEC, Chinese oil earnings grew rapidly from 1979 to 1981 despite the fact that the total volume of oil exports increased only by 5 million tonnes between 1978 and 1981 (see Table 4-5). Oil's contribution to total exports increased from 12 per cent in 1978 to 21.1 per cent in 1981 (see Table 4-4). The amount exported rose significantly in 1984 (reaching 27.7 million tonnes) and 1985 (36.2 million tonnes), bringing in a growing amount of foreign exchange. By 1985 oil contributed 24.5 per cent of total export earnings and had become China's single largest export item.

The precipitous drop in the price of oil in the later 1980s served to alter the commodity's role in Chinese exports. In fact, world oil prices had been slipping ever since the peak of 1981; a fact reflected in the price of Daqing crude (China's most important export crude) which went down from US$37 per barrel in 1981 to

US$28.7 per barrel in February 1983 and US$26.8 per barrel in April 1985. In 1986, world oil prices plunged to as low as US$14 per barrel before stabilizing in the range of US$15-20 per barrel. The average price in 1985 was US$27 per barrel; in 1986 it was US$14.20 per barrel, denoting a drop of 47 percent (see Appendix 4-1). Naturally, all the oil-exporting countries were badly affected.

China's oil export earnings plummeted from US$ 6.7 billion in 1985 to US$3.0 billion in 1986, although the amount of oil exported was reduced only from 36.2 million tonnes to slightly less than 34 million tonnes. As a result, oil's contribution to total export earnings dropped from 25.9 per cent in 1985 to 11.2 per cent in 1986, and China lost US$3 billion in foreign exchange earnings. This change forced the government to reconsider its oil export policy, and the outcome was a cut in the amounts of oil exported in the successive years.

The drastic drop in oil export earnings led to considerable changes in the composition of Chinese exports after 1986. The average annual share of fuel (mainly crude oil) in the total was halved from 23.9 per cent during 1979-85 to less than 10 per cent during 1986-1990. The shares of foodstuffs and textile products remained essentially unchanged at about 13 per cent and 28 per cent, respectively, while those of machinery and chemical products rose appreciably: from 12 per cent to 19 per cent. It is obvious that China adopted the strategy of increasing manufactured goods' exports to compensate for the shortfall in oil export earnings. From the late 1960s oil was becoming increasingly important in the fuel mix of China, and it accounted for 14.7 per cent of total energy consumption in 1970, and 23 per cent in 1976. But production started to stagnate in 1979 and actually declined during 1980-83. Growth resumed in 1984, with respectable growth rates during 1985-88, but by 1989 output again stagnated. Overall production increased from 106 million tonnes in 1983 to 138 million tonnes in 1990.

Against this background of stagnant domestic production, it should be recalled that oil exports continued to rise uninterruptedly during 1979-82. These exports took place in the face of serious energy shortages at home, shortages which in 1981 alone idled 20 per cent of the industrial equipment and led to the loss of one-seventh of industrial output. To tackle this problem, China adjusted its economic structure to emphasize those sectors which were not energy-intensive, such as light industry, agriculture and the service sector, and energy conservation was widely practised. While this policy worked fairly well, succeeding in cutting the energy-GDP elasticity from 1.5 during 1965-78 to 0.53 during 1979-90, the industrial system was still desperate for energy, particularly the key industrialized area in the south--which had constituted, since 1980, the single most important foreign-exchange earner in China. In 1986, therefore, China amended its policy on oil imports. Previously, when the oil prices were high, imports had not been encouraged. But with the slump in price in 1986, it became economical to import crude and oil products for use in the coastal provinces. Oil imports shot up from 0.9 million tonnes in 1985 to 3.5 million tonnes in 1986, before rising further to 10.6 million tonnes in 1989. This, combined with a decline in oil exports, augmented the supply of oil to the domestic market. As a result, domestic consumption climbed from 95.1 million tonnes in 1985 to 116.0 million tonnes in 1989. The outlays of US$0.4-0.5 billion for oil imports between 1986 and 1988 did not materially diminish the net benefits that oil afforded the country through exports. However, imports soared to over 10 million tonnes in 1989 with an outlay of US$1.2 billion, threatening for the first time the country's balance of oil trade. Imports, however, receded to 6-7 million tonnes in the successive three years (1990-92) while total oil exports generally remained at the same level as 1989.

The development of oil export in China indicates that trade in mineral commodities serves as a two-edged weapon for balancing foreign-trade payments on the one hand and breaking domestic supply bottlenecks on the other. The case of iron ore imports provides additional support for this proposition.

Iron ore imports. As already mentioned in Chapter III, China abounds in iron ore, with 50 billion tonnes of proven reserves. Iron ore deposits have been discovered in nearly 2,000 sites and their distributions cover more than 600 counties in 27 provinces and Autonomous Regions. Unfortunately, the grade of iron ore is generally low and most of it has to be beneficiated. According to the Ministry of Metallurgical Industry, about 98 percent of iron ore reserves are of low quality with average iron content of around 30 per cent. Consequently, many of the technical and economic difficulties encountered by the Chinese in developing their iron and steel industry derive from inadequate supplies of high-quality iron ore.

As a leading sector of any national economy, the iron and steel industry usually enjoys a high priority, and China is no exception on this score. In the past forty years, it has invested more than C¥14.3 billion in iron ore-mining, and the output of iron ore had grown to nearly 180 million tonnes in 1990 from the 4.3 million tonnes in 1952 (see Figures 4-1 and 4-2). China's iron ore-mining has passed through three stages. In the 1950s manual labour was widely used and the resource utilization was very low. Between 1960 and 1980, semimechnized operations, in which mines were equipped with medium- and small-sized machines and equipment, dominated the industry. After 1980, however, mining operations were progressively improved, leading towards large-scale modernization. During the Sixth-Five Year Plan period, for example, the industry introduced large electric shovels with an annual capacity of 10 million tonnes of iron ore, large motor belt conveyers, large bulldozers etc. Table 4-6 highlights the labour productivity of the key iron mines in China.

In order to solve the inadequate supply of high-quality iron ore, China introduced beneficiation technology from the USSR in the early 1950s (Clark, 1973). The first completely large-scale iron ore beneficiation plant was established in Anshan in the mid-1950s, and it was followed by plants in Wuhan, Baotou, Maanshan, Taiyuan, Shoudo (Beijing), Chunqing, Jiuquan, Panzhihua and Benxi. By the

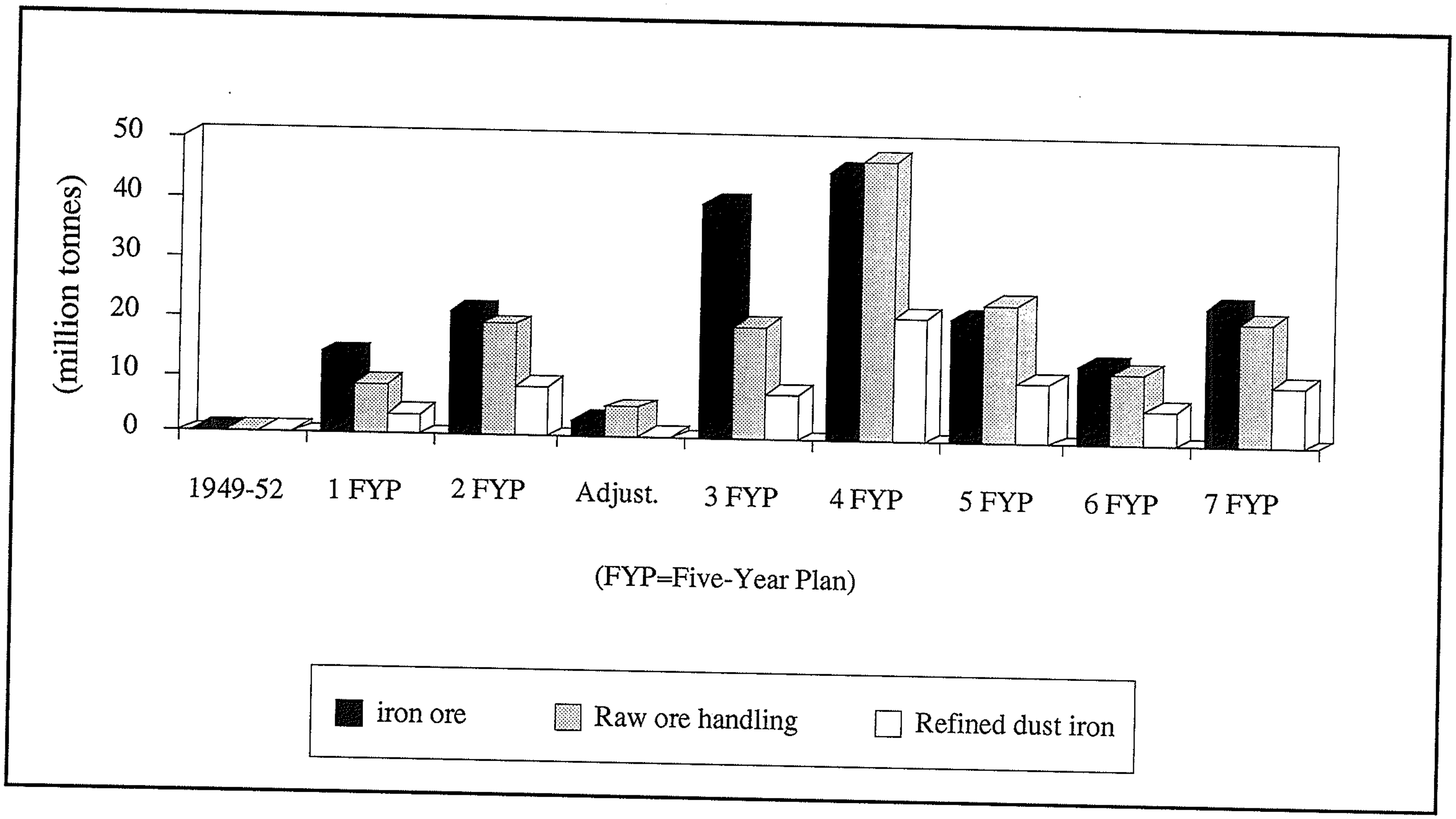


Figure 4-1 Newly-Added Capacity of Iron Ore Mining in China, 1952-90

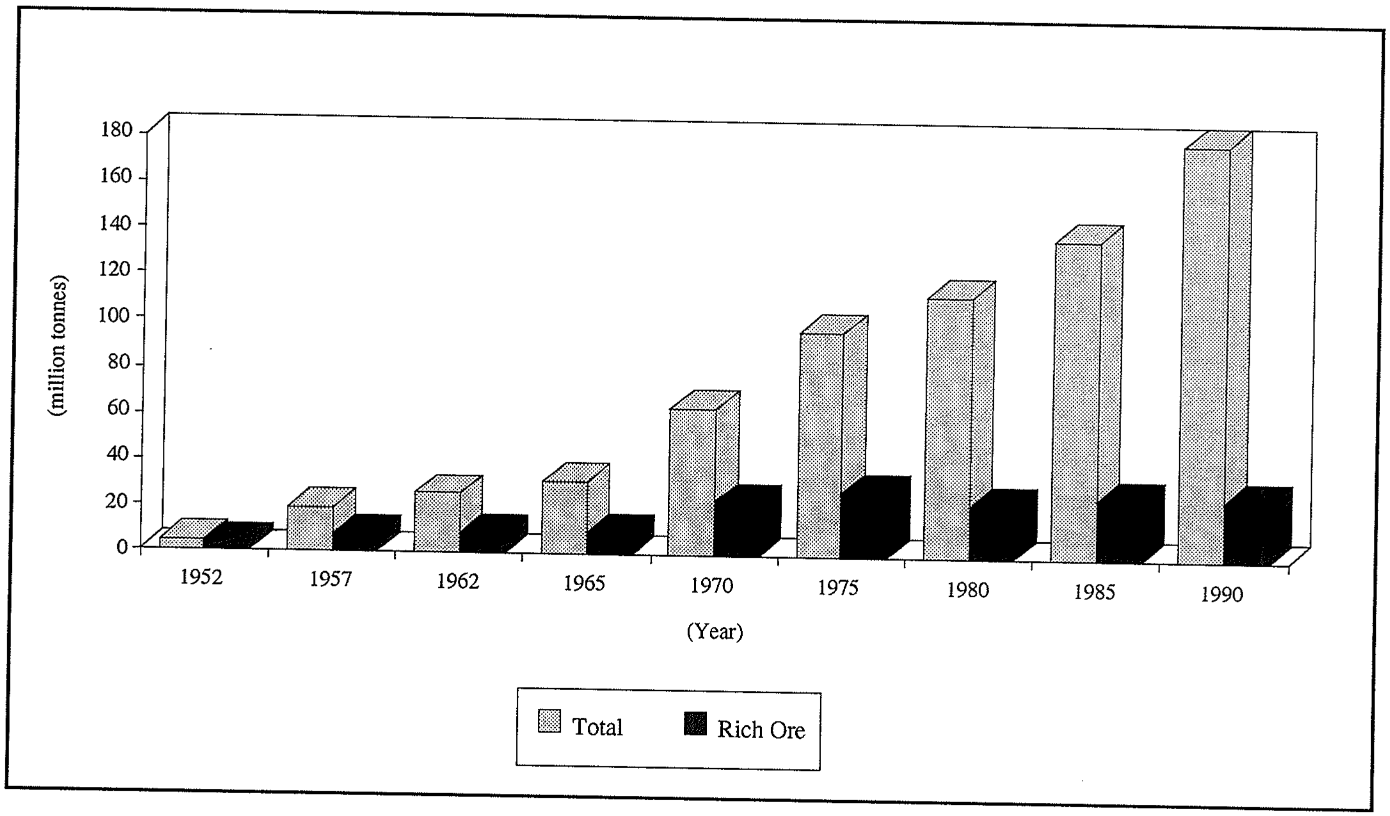


Figure 4-2 Output of Iron Ore in China for Selected Years

Table 4-6 Principal Indices of Key Open-Cut Iron Mines in China, 1985

Key enterprises	Labour productivity (t/man year)	Grade of raw ore (%)	Stripping rate (t)
Average	5,661	32.29	2.31
Shoudu	11,945	26.78	2.71
Anshan	6,905	32.35	3.32
Taiyuan	4,564	29.00	1.70
Baotou	5,568	35.77	3.10
Maanshan	5,351	33.82	1.65
Wuhan	2,999	45.65	6.30
Hainan	2,331	53.16	2.31
Panzhihua	4,030	31.02	1.87

Source: China's Metallurgical Ministry Statistics of China's Iron and Steel Industry, 1986, Beijing, China's Metallurgical Publishing House, 1987.

end of 1990, the country had built up a total annual mining capacity of 182.2 million tonnes and an annual mineral capacity of 160 million tonnes (recall Figure 4-2). However, compared with the rapid development of the iron and steel processing sector, the iron ore-handling capacity still left much to be desired. During the ten-year period 1981-1990, for example, the output of iron ore and its concentrate increased by an average of 6.6 per cent and 4.8 per cent, respectively, whereas the output of pig iron went up by 6.2 per cent and steel production rose by 6.4 per cent. Only six of the eleven key iron and steel enterprises realized self-sufficiency in ore supply; namely, the Shoudo (Beijing) Iron and Steel Company, Anshan Iron and Steel Company, Benxi Iron and Steel Company, Baotou Iron and Steel Company, Jiuquan Iron and Steel Company and Panzhihua Iron and Steel Company. There are three major reasons for the delayed development of the iron ore-dressing industry. First of all, the fairly complex technology preparation, or beneficiation, of iron ore includes a wide range of processes, starting with simple operations like sorting, crushing, screening, and so forth but extending to much more demanding operations. More complex beneficiation, which is mostly needed in steelworks such as that at Anshan, involves expensive operations which begin with fine grinding before being followed by mechanical or magnetic separation, washing, and drying. The final operation is usually agglomeration of fine particles by heat, which is called sintering. The expensive processes entailed in iron-ore dressing mean not only that substantial capital investment is required, but also that considerable lead-times are required for their implementation. According to official statistics, between 1971 and 1985, the average lead-time of seven large- and middle-sized iron-ore dressing plants was more than ten years, while the average capital investment for them reached nearly C¥70 million (China's Statistics Bureau, 1991). Secondly, the operational cost for dressed iron ore is much higher than that of undressed ore. Generally speaking, the ratio of operational costs for raw iron ore as opposed to concentrated ore can reach one to ten, implying that cost of concentrated ore is nine times higher than cost of ore in raw form (also see Table 4-7). What is more, the dressing operation results in a higher energy consumption. According to the Metallurgical Ministry, concentrated ore consumes energy at twenty times the rate of raw ore (China's Metallurgical Ministry, 1987).

After considering the overall situation pertaining to the development of the iron and steel industry, the government decided to use imported as well as domestic iron ore for its expansion

Table 4-7 Iron Ore Ex-factory Price (after July 1984) (C¥/tonne)

Grade (%)	Iron ore concentrate	Dust iron ore	Lump of Iron ore for blast furnace	Crude iron ore for blast furnace	Iron ore for open hearth
66	74.50				
65	72.50				
64	70.50				74.50
63	68.50				71.50
62	66.50				68.50
61	62.50				65.50
60	61.00	55.00	55.00	45.00	62.50
59	59.50	52.50	52.50	42.50	60.00
58	59.50	50.00	50.00	40.00	57.50
57	58.50	47.50	47.50	37.50	55.00
56	56.00	45.00	45.00	35.00	52.50
55	55.00	43.50	43.50	33.50	50.00
54	54.00	42.00	42.00	32.00	
53	53.00	41.00	40.50	30.50	
52	52.00	40.00	40.00	29.00	
51	51.00	39.00	37.50	28.50	
50	50.00	38.00	36.00	27.50	
49		37.00	35.00	26.50	
48		36.00	34.00	25.50	
47		35.00	33.00	24.00	
46		34.00	32.00	23.50	
45		33.00	31.00	23.00	
44		32.00	30.00	22.50	
43		31.00	29.00	22.00	

Source: China's Metallurgical Ministry <u>Iron and steel Industry Almanac of China, 1987</u>, Beijing, Metallurgical Industry Press 1988.

plans in the early 1980s. This policy is summarized in the extract presented below.

> We must develop our strong points and overcome our shortcomings as far as possible. The chief problem concerns iron ore. In the past we depended completely on domestic iron ore, but from the national point of view, most of our iron mines contain lean ore, and this must be transported for long distances. Because the iron ore production process is very complex, large-scale investment is needed and construction periods are very lengthy. So it has been very difficult to develop the iron and steel industry. Measures must be instituted to overcome these difficulties. It is not necessary for us to engage in all stages of the production process. Some enterprises can import iron ore, particularly those iron and steel enterprises in coastal areas. If these areas lack iron ore resources, they can import iron ore from foreign countries, and even import crude steel, rolled steel that is, because the final stage of production is most profitably undertaken in China. We can thus begin to develop the iron and steel industry from the point of iron ore or crude steel imports (Lu Zhen, 1990).

In line with this policy, the volume of iron ore imported

Table 4-8 Volume of Imported Iron Ore in China, 1981-90

Year	Total volume (000 t)	Total value (US$ million)	Import Price (US$/t)	Grade (%)	Trade Price (US$/t)
1981	3,336.4	54.71	16.40	62	16.40
1982	3,451.5	56.07	16.24	62	16.24
1983	4,348.7	91.54	20.87	62	20.87
1984	5,969.8	93.59	15.67	62	15.67
1985	10,114.0	179.09	17.70	62	17.70
1986	12,004.0	314.56	26.20	62	26.20
1987	12,790.0	330.75	25.86	62	25.59
1988	10,540.0	259.96	24.66	62	24.66
1989	12,590.0	329.95	26.20	62	26.21
1990	14,340.0	394.13	27.48	62	27.48

Source: China's Statistics Bureau China's Statistics Yearbook, various years.

increased greatly, particularly during the period between 1985 and 1990 (see Table 4-8). In 1981, imported iron ore amounted to 3.3 million tonnes and accounted for only 5 per cent of China's total iron ore consumption by volume. But by 1990 the volume of imports reached 14.3 million tonnes, and the import ratio increased to nearly 10 per cent of the total consumption. Australia is the major supplier of the imported iron ore, supplying 70 per cent of total imports. Other sources are India and North Korea.

Consequently, such a policy of iron ore importation brings a great opportunity for China to improve its steel manufacturing industry. In 1984 the output of China's fabricated steel registered 33.7 million tonnes, while the domestic production of iron ore reached 126.7 million tonnes. At the same time, China imported nearly 6 million tonnes of iron ore at a cost of US$93.6 million, and 20 million tonnes of steel products, valued at US$6.2 billion. The self-sufficiency ratios were, therefore, only 63 per cent for steel manufacturing and 91 per cent for China's iron-ore mining, and the ratio in value terms between imported iron ore and steel products was 1:67. By 1990 imports of iron ore had increased to 14.3 million tonnes (prices at US$394.1 million) while imported steel products had declined to 4.19 million tonnes (worth US$2,508.2 million). As a result, the self-sufficiency ratio for fabricated steel increased to 93 per cent while the ratio for iron ore declined to 85 per cent. In consequence, the ratio between imported iron ore and steel products diminished to 1:6, ten times less than that applying in 1984. When we consider that the cost of imported iron ore is only one-tenth of that of imported steel products, it is evident that China must undergo prodigious expansion in ore imports and expand domestic steel production rather than rely on increasing imports of steel products.

4.4 Conclusion

Generally speaking, the data and analysis for China support the hypothesis that minerals trade can act as an instrument to promote economic growth in the developing countries. The cases of crude oil and iron ore, the most significant items in China's foreign trade, with the exportation of the former and the importation of the latter dominating the minerals trade of the country, combine to provide good examples of how China uses the minerals trade as a powerful weapon intended to promote her national economy. In other words, as a direct consequence of the minerals trade China has obtained much- needed technologically-advanced machinery; equipment which, in return, helped the country to expand its capacity of mineral production. This reality is consistent with both the long-run and the short-run theoretical relationship between minerals trade and economic growth.

In the context of mining activity, modern mining and processing methods, on the one hand, have become so capital-intensive and the capital requirement of most modern mines and their attendant infrastructure so large, that few of the developing countries can expect to bring a sizeable project into operation on their own. In addition to minerals trade, mining activity in developing countries, on the other hand, can play divergent roles. In some countries, modern mining may serve as the leading sector so that the expansion of minerals exports stimulates technological change and opens up new markets, leading to rapid economic growth. In other countries, mineral production can become a balancing sector in foreign trade, and its primary function is to finance imports, which usually serves as a means of breaking domestic supply bottlenecks. China's mineral industry offers many insights into the latter course (Cheng Chu-yuan, 1982; Hsu, 1989; and Eckstein, 1981).

The minerals trade also serves as an indicator of policy--domestic and foreign--and performance alike. Changing trade policies in China reflect shifting economic needs in different phases of the development process almost as a matter of course. In this pattern, mineral movements, then, serve as tolerably-good indexes of domestic economic trends in China.

Thus in the 1950s, when China's GNP was growing very rapidly, minerals trade was expanding even more speedily. The dynamics of the trade, dominated as it was by the importation of petroleum and raw metal products, implied that the initial period of China's economic transformation required more mineral inputs into industrial growth, and the importation of key mineral products was very necessary when the domestic mineral industry was only at the gestation stage.

Disruption of the Sino-USSR relationship in conjunction with a series of natural disasters during the 1960s forced China to slow down its industrialization programme. Under the self-reliance policy, minerals trade decreased in line with the cutbacks in total foreign trade. However, some significant improvements regarding the domestic mineral industry were achieved, one of which was the discovery and exploitation of crude oil in the northeast.

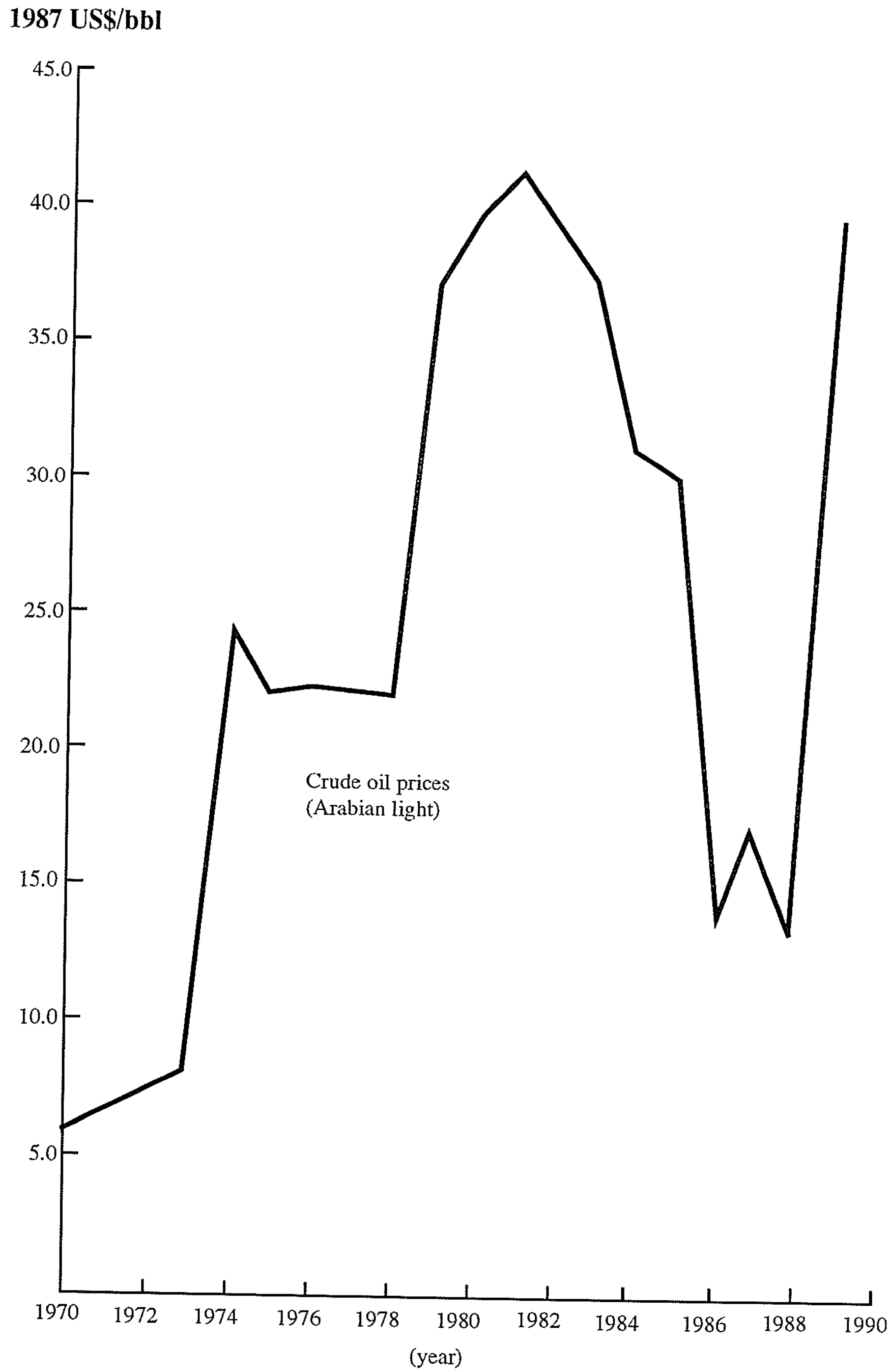
During the 1970s, the development of the oil industry galvanized the national economy. Furthermore, China became a net oil exporter after the mid-1970s. This development greatly reshaped the patterns not only of the minerals trade but also of foreign trade as a whole. On the one hand, crude oil emerged as the largest single item in China's set of exports. On the other hand, a new surge of technology introduction, aimed at improving the utilization of crude oil, occurred under the twin policy of "oil-for-steel" and "oil-for-machines".

Thanks to the 'Open Door' policy, the 1980s saw China becoming the fastest-growing economy in the fastest-growing region in the world. In contrast with past practices, the Chinese began to use foreign trade as an instrument of the country's growth much more consciously. At the beginning, China continued the "oil-for-machines" and "oil-for-steel" policies, using them to justify the ever-growing level of imports of plant and equipment. Yet, confronted with instability in international oil prices, together with failure to increase oil reserves and a strong domestic market, China began to change its foreign trade policy in the mid-1980s. Before long, oil was dislodged from its predominant position in exports, replaced by textiles and other manufactured goods. In the meantime, the government adopted a flexible import strategy both to enlarge the part played by low value-added minerals such as iron ore and to reduce the sizes of high value-added products like fabricated steel. These changes ensured that the country could concentrate its limited foreign exchange on the introduction of advanced sets of turnkey plant and equipment for both import-substitution and export-led growth activities.

So far, we have enquired into the roles of mineral development in fostering the national economy in China. It is demonstrably the case that an ever-growing mineral demand, an adequate mineral supply (mainly from domestic sources) and an increasing foreign trade in mineral products are three of the chief determinants moulding the national economy. Indeed, all the findings of the previous chapters endorse the fact that mineral activity can provide a country with a solid basis for accelerating its overall economic growth. It is the time now for the study to turn its focus to the contributions of mineral activity to regional development.

Examining the effects of mineral production on regional development will, therefore, be the centrepiece of the remainder of this study. In terms of the overall thesis plan, the next part is divided into three chapters dealing in turn with the mineral-dominant stage, mining-based diversification, and aggregate impacts and centre-periphery implications. Each chapter addresses one target, respectively the forth, the fifth and the sixth. Chapter V, lays the foundations for the entire regional focus.

Appendix 4-1: Global Oil Price Trends



Source: IMF Statistics, 1990

CHAPTER V

THE "MINERAL-DOMINANT" STAGE

5.1 Introduction

Regional development typically is promoted by the ability of a region to produce goods or services demanded by the national economy and to export them at a competitive advantage with respect to other regions. Once a region (for whatever reason) gains an initial advantage over others, various forces tend to speed the growth process by "circular and cumulative causation" and lead to the development of a "centre-periphery" or "heartland-hinterland" structure. In developing countries, "natural endowment" is always regarded as a reliable source of the initial advantages for regional development. In this sense, mineral export-dependent activity can provide the start for many production sequences and prepares the region for achievement of the "take-off" point. The aim of this chapter is to test the general hypothesis in its regional manifestation; more specially, it is to test the proposition that a nation immersed in the "mineral-dominant" phase of overall economic development can capitalize on the mining sector in order to stimulate the development of certain of its regions. The nation in question of course is China, and the objective of the chapter is to accomplish the fourth of the targets set out in the first chapter.

One of the insights emerging from an examination of the history of Chinese economic development occurs with the defining of "resource endowment" in a substantive sense. According to Perloff and Lowdon (1961) endowment is simply the inventory of those natural materials that are required in some degree by the national economy responding to internal consumption demands and to its position in international trade. As the requirements of the economy change, the composition of the inventory shifts, and in this sense "resource endowment" is a changing concept closely associated with the dynamics of economic growth. In most countries, there has appeared a growing independence of economic activity from a specific set of localized resource bases and a shifting to a reliance on other sets. The answer to what constitutes "resources endowment", therefore, is rooted in the determinants of final demand--consumer preference and income distribution, as well as foreign trade--on the one hand, and in the current organization and technology of production on the other. As these variables change, so will the content of resource endowment. Clearly, then, it follows that as the composition of resource endowment changes, there will tend to be substantial changes in the relative advantages demonstrated by regions supplying material inputs (and services) for the national economy. The impact of these shift can be sketched in with broad strokes by identifying stage-by-stage what have been the "natural resources that count" in the national economy. This requires us to tell again a familiar story, but with a special focus, that of the regions.

5.2 Initiating New Location Patterns

The agricultural period. Before the mid-twentieth century, China's economy was characterized by dualism; that is, it could be said to revolve round a small modern sector based on foreign capital and technology and a large traditional agricultural sector which accounted for 90 per cent of its total population and 60 per cent of its total domestic product. Considering such a pre-industrial economy on a comparative basis, China was at a high level of development by the eighteenth and nineteenth centuries; but it had achieved that level long before and showed no signs of a qualitative shift to a more complex structure or to a higher rate of growth.

In many ways the primarily agrarian economy of China was fully in keeping with a relatively low degree of commercialization and a limited use of money. Consumption in the economy depended largely upon accumulated stocks. Such inventories of grain and other foodstuffs were needed not only to meet inter-harvest requirements, but also to serve as a buffer against both natural and man-made disasters. To serve such a function the endowment which counted in this stage was arable land with its environmental complements of climate and water, and this set up the conditions for regional growth. It was quite logical, therefore, that the regional economies developed in conformity with a certain archetype: a good riverine port as the nucleus of an agricultural hinterland well adapted to the production of a staple commodity in demand in the national market.

The growth potential of these nucleated regions depended heavily on the extent and "richness" of the hinterland accessible to rivers. Since good agricultural land was almost a free resource while labour and capital were relatively dear, the expansion of production was effected by bringing more land into production and so extending the limits of the hinterland. Much of the early Chinese history is dominated by the great rivalries for control of hinterlands that emerged first along the Wei and Yellow rivers (in the Northwest and the North) , then the Changjiang (Yangtze River) and the Zhu rivers (in the East and the South) and finally the Liao and the Suonghua rivers (in the Northeast). The force of the outward push for land is suggested by the fact that the population of the country increased at least eight-fold between 1368 and 1937 (Fan Wen-lan, 1968).

By the latter part of the last century, China was 'drawn' into the world market by foreign forces (Kemp, 1989) and ports, railways and modern factories were installed. However, China was still a preponderantly rural and agrarian society in the 1940s while the small modern industrial sector was found as enclaves in the few areas of the treaty ports and the colonial frontier--Manchuria (the contemporary Northeast China)--and was responsible for only limited spread-effects in the rest of the country (see Appendix 5-1 for a discussion of how minerals influenced colonial frontiers in China).

The growth of mineral-based economy. Somewhere around 1950 the next important resource stage began as an aspect of the emerging minerals-dominant economy. The ambitious industrialization resulted in new input requirements: accordingly, a new set of resources became important and a new set of location forces came into play. The first part of this period was dominated by the growing demand for coal, iron and steel and by the rapid introduction of their production technology. At this point it was the geographical juxtaposition of coal, iron ore, and the market which afforded the greatest impetus for growth. The importance of minerals, unlike agricultural land, did not lie so much in their direct contribution to regional growth but rather in the nature of their linkages with succeeding stages of production. It was not so much the mining of coal and iron that was important for growth, as the making of iron and steel products; a process which could not be separated from the sources of its mineral inputs. The early concentration of intensive coal-consumption industry (such as the power industry and aluminum-refining industry) and steel-making in the central area of Liaoning (as outlined in Appendix 5-1) occurred as a result of these relationships; for this area was not only well endowed with rich deposits of iron ore and coal but was also central to a spatially-concentrated, enlarging market. During the entire decade of the 1950s, for example, 38 new cities were constructed (see Table 5-1), 18 of which were recognized as truly new cities as they had no historical antecedents as county seats or rural market towns. Most of the new cities were built as mining centres in attempting both to overturn the spatial imbalance of industrial development in favour of the coastal areas and to bring industrial activity closer to energy sources and raw materials (see Table 5-2 and Figure 5-1). With a continuing increase in the demand for all types of mineral resources, the depletion of accessible ore deposits in the coastal areas, and the westward penetration of the railway network, a new role in regional growth was played by

Table 5-1 New Cities Developed during the 1950s

Nature of development	Municipalities	Industrial towns	Total
Newly built	13	25	38
Large-scale expansion	46	6	52
General expansion	61	120	181

Source: Chang Sendou (1976) "The Changing System of Chinese cities", Annals of the Association of American Geographers pp.398-415.

Table 5-2 Major function of Newly-Developed Cities, 1950-60

Major function	Inner Mongolia	Xinjiang	Heilong-jiang	Henan	Sichuan	Anhui	Jilin	Hunan	Total
Coal mine	3		4	2			1		10
Oil field		1	1						2
Iron ore mine					1	1		1	3
Lumber industry			1						1
Hydroelectricity				1					1
Railway terminal	1								1
Total	4	1	6	3	1	1	1	1	18

see Table 5-1.

mineral resources endowment. In the mountain regions stretching from the western edges of the great plains to the northwest and the southwest provinces, it was the mining activity which was the lead factor in economic development.

A further examination of the urban development in China may shed light on the significance of the growth of a mineral-based economy during the past 40 years. According to the Chinese Statistics Bureau, there were 467 cities in China in 1990, and of these, 162 or some 35.0 per cent of the total, owe their economic

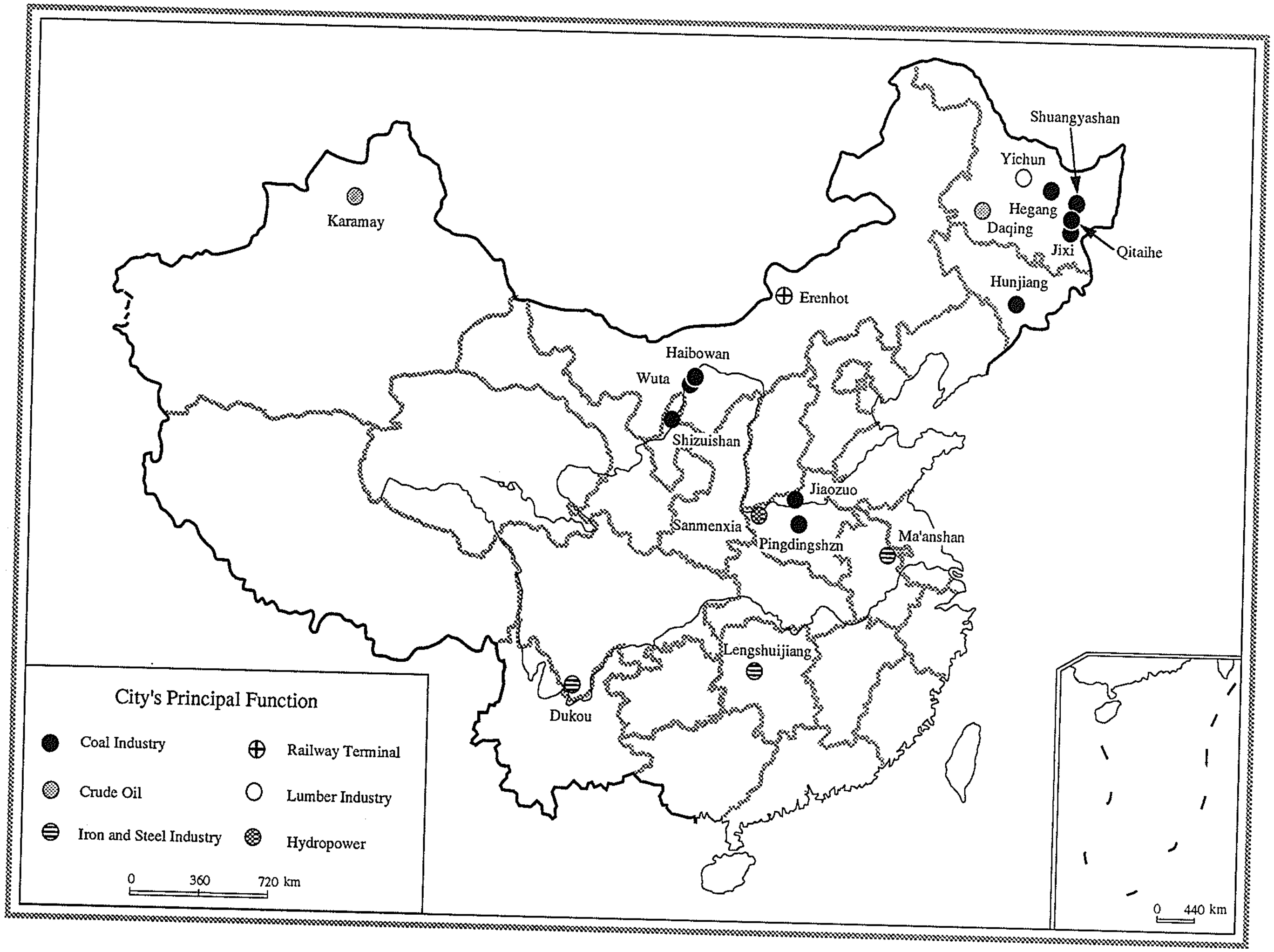


Figure 5-1. Eighteen Newly-Built Cities of China in the 1960s

development, wholly or in part, to mining activities (see Table 5-3). In other words, the penetration of industrialization into most rural areas of China during the past forty years was led by the mineral sector and closely associated with it were major changes in urbanization, particularly in the interior areas (see Figure 5-2).

Some important points can be drawn from Table 5-3. In the first place, the metal mineral sector has been more significant (44 ferrous industrial towns plus 59 nonferrous industrial towns) in terms of geographical spread than has the energy part of the industry (48 coal industrial towns plus 11 oil industrial towns) in the country as a whole. Secondly, the contributions of the minerals economy to regional development favour the energy sector (34 per cent for coal and 53 per cent for crude oil in average weight) rather than the metal portion of the mineral industry (27 per cent for ferrous industry and 19 per cent for non-ferrous industry in average weight). Thirdly, the overall regional effect of mining development varies, therefore, in proportion to the presence of the coal branch, iron and steel branch, nonferrous branch and the petroleum branch of the mineral industry. Finally, the hinterland, with a share of 70 per cent of the 162 cities, is much more inclined to host mining towns and cities than either the coastal areas or the northern heartland.

Development of mineral activity contributes not only to the growth of local economies but also to the amending of the spatial economic system of the country as a whole. By the lights of the State Planning Commission, for example, the vast territory of China

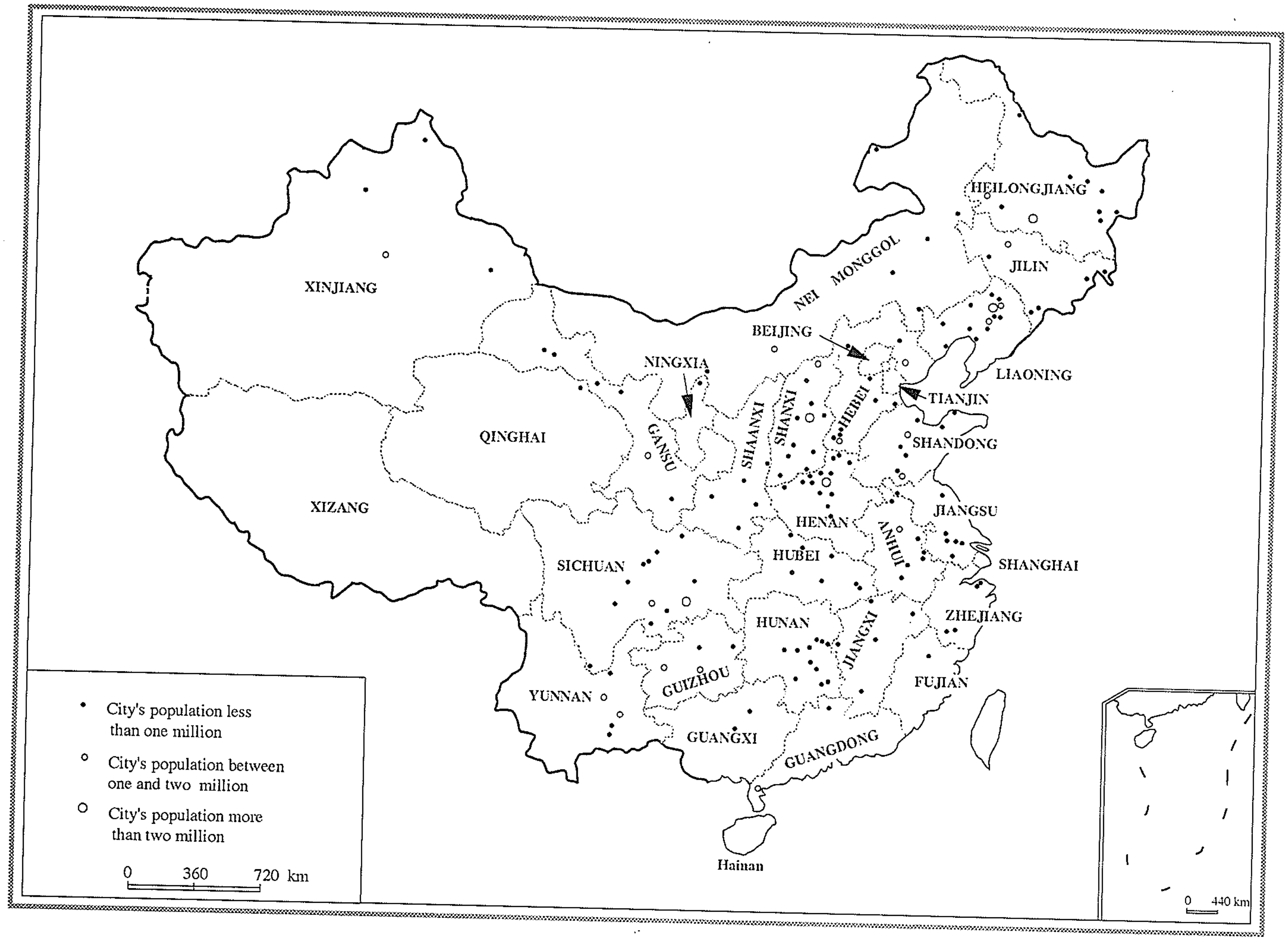


Figure 5-2. Mineral-Based or Mineral-Related Cities in China, 1990

Table 5-3. Cities' Economy Dominated by Mining Activities in China, 1990

Province	Major mineral industry and their share in the city's industrial output				
	Ferrous industry	Nonferrous industry	Coal mine	Crude oil	Total
Hebei	7 (10-43%)	1 (34%)	-	2 (50-84%)	10
Shanxi	3 (12-43%)	2 (4-9%)	6 (17-66%)	-	11
Inner Mongolia	2 (24-36%)	-	4 (19-88%)	1 (72%)	7
Liaoning	5 (10-14%)	3 (9-20%)	4 (32-76%)	1 (78%)	13
Jilin	2 (9-40%)	2 (6-11%)	2 (19-22%)	-	6
Heilong-jiang	2 (13-15%)	2 (5-24%)	5 (7-93%)	1 (74%)	10
Shandong	-	3 (7-15%)	4 (11-46%)	1 (95%)	8
Jiangsu	2 (10%)	4 (5-9%)	2 (11-18%)	-	8
Zhejiang	-	4 (10-36%)	-	-	4
Anhui	1 (66%)	3 (12-39%)	2 (23-41%)	-	6
Jiangxi	-	3 (23-75%)	2 (20-44%)	-	5
Fujian	-	1 (9%)	-	-	1
Henan	2 (27-85%)	5 (4-17%)	6 (11-88%)	1 (75%)	14
Hubei	2 (29-44%)	5 (4-20%)	-	-	7
Hunan	5 (5-63%)	2 (9-23%)	2 (32-35%)	-	9
Guangdong	1 (20%)	-	-	1 (8%)	2
Guangxi	1 (10%)	-	1 (41%)	-	2
Sichuan	5 (9-68%)	4 (5-7%)	2 (6-14%)	1 (14%)	12
Guizhou	2 (14-39%)*	3 (6-11%)	-	-	5
Yunnan	-	3 (11-74%)	1 (20%)	-	4
Shaanxi	1 (10%)	2 (6-8%)	2 (26-30%)	-	5
Gansu	-	5 (2-98%)	1 (88%)	1 (78%)	7
Ningxia	-	-	1 (28%)	-	1
Qinghai	1 (27%)	-	-	-	1
Xingjiang	-	2 (4-15%)	1 (16%)	1 (52%)	4
Total	44 (9-85%)	59 (2-98%)	48 (6-93%)	11 (8-95%)	162
Average weight	(27%)	(19%)	(34%)	(53%)	
The whole country	(8%)	(3%)	(2%)	(3%)	467

Source: China's Statistics Bureau (1991) China's Urban Statistics Yearbook, China's Statistics Press.

Note: * one of the two cities, Liupanshui, is also a coal-mine city.

can be delineated into three zones: the Eastern, the Middle, and the Western. This classification basically reflects the major spatial disparities in social and economic development across the country and constitutes the framework for the strategic allocation of national construction (Tables 5-4, 5-5 and 5-6). The Eastern Zone with a population of over 400 millions had already emerged as the industrial central area in China since the 1950s. It would be hard to imagine the zone's growth without mineral input from other areas. According to the State Statistics Bureau, about one-fifth of the whole output of China's coal-mining was shipped to the Eastern Zone each year during the 1980s. The effect was reciprocal: the Eastern Zone stimulated expansion of mining industry and the growth of the supplier regions while access to mineral products for industrial consumption helped to sustain the zone's growth. In effect, the rapid expansion of manufacturing activities in the metropolitan areas of the Eastern Zone can be imputed to the input of mineral and primary commodities from the Middle and Western Zones. In the meantime, over 33 billion yuan of capital investment, millions of tonnes of industrial equipment and nearly 5 million technicians and skilled workers flowed into the Middle Zone and the Western Zone. Using this evidence, it can be argued that the growth of the centre-periphery structure depends on the medium of spatial organization: in a word, it hinges on interaction. The various kinds of movements, flows and transactions between regions and cities are the expressions of input-output linkages, trade relationships, and all interdependencies within the spatial

Table 5-4 Regional Patterns of Population in China, 1952-90 (%)

Zone	Area	Population 1952	Population 1990	Urban Population 1952	Urban Population 1990	NI 1952	NI 1990
The Eastern	14.3	40.8	41.3	53.1	45.7	49.8	53.5
The Middle	29.4	33.5	35.8	28.8	36.2	34.1	30.3
The Western	56.3	22.7	22.9	18.1	18.1	16.1	16.2

Source: China's Statistic Bureau China's Yearbook, 1988, 1991.
Note: NI=National Income.
Note: see Appendix 3-2, p. 110.

Table 5-5 Regional Patterns of Industrial Endowment in China, 1952- 90 (%)

Zone	Industrial employment 1952	Industrial employment 1990	Industrial output 1952	Industrial output 1990
The Eastern	55.9	48.6	69.4	60.7
The Middle	31.7	35.5	21.8	26.3
The Western	12.4	15.9	8.8	13.0

Source: see Table 3-3, p.111.

Table 5-6 Regional Patterns of Staple Commodities in China, 1952-90 (%)

Zone	Crude Oil 1952	Crude Oil 1990	Coal 1952	Coal 1990	Iron 1952	Iron 1990	Steel 1952	Steel 1989
The Eastern	53.7	42.7	40.4	22.0	79.2	54.4	85.9	58.0
The Middle	1.4	49.8	50.6	58.2	13.6	32.2	10.3	30.0
The Western	44.9	7.5	9.0	19.8	7.2	13.6	5.8	12.0

Source: see Table 5-4.

economic system of a country as a whole. In the context of mining exploitation, therefore, the mineral input-output relationship reduces to an appreciation of the supply flows to the manufacturing and service heartlands or centres. By way of contrast, growth of the heartlands or centres is partly incumbent on supply to the peripheral regions of technology, equipment, information, capital and other inputs of the business and personal services kind. In other words, developments of both regions are mutually reinforcing, providing a latent market from which all can benefit.

It is possible to regard the changing pattern of regional development in China in terms of the 'internal' characteristics of the region as well as in respect of its attractiveness for *export* industry (those products intended mainly for markets outside the region). A region's growth, according to the tenets of export-base theory, typically has been promoted by its ability to produce export goods or services demanded by the national economy, and to export them at a competitive advantage with respect to other regions. Thus, the metal deposits of the mountain provinces, the Northern coal and the Northeastern oil were regional "exports" triggering development. But theory is silent on the critical issue of specifying the initial force governing take-off when all other internal conditions are ready for development. This compels us to revert to an investigation of the sources of growth.

5.3 Mining and Regional Growth: the initial impetus

The most single important factor: investment. There is a widespread belief that the source of growth resides in three factors: land (natural resources), labour and capital. According to Chenery and Robinson (1986), the contributions of these three factors to regional economic growth are very different at different stages of regional development. In their comprehensive analysis they found that, firstly, the growth of capital is the most important single factor, but that its relative contribution is reduced from over 50 per cent of average growth at the early stage of economic development to 30-40 per cent at subsequent stages; secondly, the growth of the labour force is no longer statistically significant in many developing countries as is testified by the existence of surplus labour; and, thirdly, the reallocation of capital and labour from agriculture to more productive sectors accounted for about 20 per cent of average growth. It is true in the real world that the general rate of regional development is always limited by shortage of factor inputs. Nevertheless, if any one scarce factor associated with underdevelopment should be singled out, it must be capital investment. The first goal of development programming in developing areas is, therefore, to find the best way, either from inside (domestic saving) or outside the area (foreign assistance), of breaking the vicious circle between capital shortage and underdevelopment and to design the most efficient and optimum rate of capital accumulation.

Minerals and investment. Minerals may serve as a substitute for capital when it is recollected that there is a degree of substitutability among factors of production. Minerals in the ground can be seen as a base for raising capital from the outside simply because of the uneven nature of their distribution and the increasing demand for their utilization. In this sense, then, the more mineral resources possessed by a region, the stronger is its bargaining power and the greater are its opportunities to absorb capital from the outside. The data shown in

Table 5-7 underline the regional effects of mineral resources in the industrial investment of China during the 40 years in which the growth of a minerals-based economy was given prominence. The evolving pattern tells us something of how the regions reached their present resource relationships.

During the First Five-year Plan, much attention was concentrated in Northeastern China, particularly in Liaoning and Heilongjiang provinces which were rich in metal and coal resources. Other important provinces like Shanxi, Hebei, Henan and Gansu, also received large investments due to their abundant mineral resources--coal, crude oil and bauxite. The only exception in this period was Shaanxi, where industrial investment was used for the construction of a large textile industry instead of tapping its latent mineral wealth. Between 1958 and 1965 (the Second Five-Year Plan and the Three-Year Consolidation Phase), there was a decrease in the proportion of the total industrial investment steered into the Northeast. This was in response to the policy of industrial decentralization on the one hand and the encouragement of steel-making at all costs during both the Great Leap Forward and its confusing aftermath on the other. That said, the Northeast still retained its premier position in attracting industrial investment. However, now crude oil exploitation made Heilongjiang replace Liaoning as the biggest provincial recipient in the country with a share of nearly 12 per cent of the total industrial investment. The large scale of exploitation of metal and energy resources in the western part of Sichuan province established that

Table 5-7 A Change Pattern of Industrial Investment in the State-Run Enterprises of China, by Province, 1952-1990 (%)

Province	1 FYP	2 FYP	63-65	3 FYP	4 FYP	5 FYP	6 FYP	7 FYP	Total	R
Beijin	1.96	2.24	2.67	2.46	3.22	4.10	2.63	1.86	2.52	18
Tianjin	1.37	1.75	1.73	1.74	2.61	3.64	2.32	1.09	1.91	24
Hebei	5.11	5.06	3.39	3.10	4.11	5.96	4.11	4.44	4.52	11
Shanxi	6.24	5.16	4.14	4.09	3.89	3.72	5.78	4.77	4.72	8
Inner Mongol.	1.55	3.98	3.82	2.70	2.15	2.44	3.35	2.61	2.77	17
Liaoning	19.96	8.96	7.47	4.07	7.71	8.33	6.04	7.36	7.56	1
Jilin	7.56	3.14	4.59	2.50	2.83	3.32	2.65	2.31	2.81	14
Heilongjiang	12.54	8.14	11.87	6.30	5.52	5.86	6.96	6.18	6.64	3
Shanghai	2.41	3.88	4.13	2.75	3.69	4.03	10.07	7.79	6.42	4
Jiangsu	1.79	3.40	2.93	2.07	2.90	4.54	5.04	5.94	4.68	9
Zhejiang	0.90	2.73	1.84	1.56	1.44	2.10	2.23	2.37	2.14	20
Anhui	2.15	3.45	3.29	2.14	2.87	3.02	3.02	2.81	2.88	13
Fujian	0.68	2.02	2.29	1.31	1.69	1.40	1.68	2.58	2.00	23
Jiangxi	2.32	2.32	2.09	2.61	2.37	1.81	2.52	1.75	2.07	22
Shandong	2.77	3.76	3.26	3.83	4.58	2.87	4.90	7.57	5.44	6
Henan	4.27	5.24	4.73	3.92	5.17	4.45	4.65	4.31	4.53	10
Hubei	3.38	4.88	3.01	6.45	7.33	8.76	4.83	3.44	5.08	7
Hunan	2.06	3.74	3.00	4.22	3.84	2.88	2.29	2.37	2.80	15
Guangdong	1.93	3.17	2.81	2.50	3.25	3.25	4.61	8.29	5.44	5
Guangxi	0.65	1.41	1.43	2.02	2.10	2.10	1.44	1.18	1.51	26
Hainan	0.00	0.00	0.00	0.00	0.00	0.25	0.47	0.62	0.36	29
Sichuan	4.38	6.97	9.57	14.89	9.79	6.25	4.79	5.66	6.73	2
Guizhou	0.33	1.76	2.04	4.74	3.03	2.13	1.55	1.41	1.91	25
Yunnan	2.03	3.02	3.31	3.55	2.88	2.46	2.11	1.41	2.13	21
Xizang	0.00	0.00	0.00	0.00	0.00	0.15	0.15	0.15	0.11	30
Shaanxi	5.27	3.36	3.05	4.23	4.16	3.43	2.84	2.64	3.17	12
Gansu	4.34	3.65	4.63	5.77	4.02	2.27	1.93	2.19	2.78	16
Qinghai	0.22	0.34	0.48	1.53	0.98	1.46	1.61	1.36	1.28	27
Ningxia	0.07	0.45	0.65	1.21	0.80	0.81	0.61	0.86	0.77	28
Xinjiang	1.75	1.71	1.80	1.74	1.01	2.20	2.80	2.67	2.29	19
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	
Total (bil)	23.26	69.63	20.03	53.20	97.66	121.70	154.06	371.71	9112.37	

Source: China's Statistics Bureau <u>China's Historical Statistics</u> and <u>China Statistics Yearbook, 1991</u>.
Note: R=ranke.

province in first place over the duration of the Third Five-Year Plan, a position it retained through the period of the Fourth Five-Year Plan as well. The most significant improvement in the Fifth Five-Year Plan period was achieved by Hubei, as its iron and steel industry was consolidated during this time. It was eclipsed by Shanghai in the Sixth Five-Year Plan period, however. As the largest introduced industrial project (started up in December 1978), the Baoshang Iron and Steel Factory had been allocated C¥ 13.48 billion in investment by the end of 1985; that is, a sum equal to 30.7 per cent of Shanghai's total industrial investment in this period. Only in the recent five-year plan period has the general pattern of industrial investment in China began to change, exhibiting a declining relative allocation in mineral exploitation in proportion with the rising economic development in the coastal areas, particularly those in South China.

Generally speaking, the pattern of civil industrial investment in the past was largely dominated by minerals activity, and this phenomenon can be styled a mineral-oriented investment phase. There are eleven chief provinces, each with a share of more than 4 per cent of the total industrial investment. In combination, they accounted for more than three-fifths of the total industrial investment taking place in China between 1952 and 1990. Eight of these, namely, Hebei, Shanxi, Liaoning, Heilongjiang, Shandong, Henan, Hubei and Sichuan, are heavily reliant on mineral-oriented industrial investment; leaving only three, that is to say, Shanghai, Jiangsu and Guangdong, that could point to activities other than those of a mineral-orientation for developing their local economies.

Comparing Table 5-7 with the four Tables 5-8 to 5-11, one is led to conclude that two characteristics of mineral exploitation are very important if regional development based on "export-orientation" is both to be achieved and sustained over the long run. Firstly, the regional mineral endowment in terms of the numbers of the key minerals is the single most important determinant factor in the pattern of industrial investment. The more types of minerals the region can lay claim to, the more investment it can command. Liaoning is the "biggest brother" in mineral production, and its ability to attract industrial investment is the most telling, not just among the group of eight largest mineral producers (provinces) but also in the country as a whole, thanks to its ownership of three key minerals: iron ore, coal and crude oil. Sichuan, Heilongjiang and Shandong, ranking as the second, third and fourth producers of the mineral provinces, each enjoys two key minerals of its own: crude oil and coal for Heilongjiang and Shandong, and iron ore and coal for Sichuan. The remainder of the mineral provinces mainly rely on only a single mineral product to attract outside industrial investment; for example, Shanxi and Henan depend on coal, Hubei relies on iron ore and Hebei is reliant on crude oil. Secondly, large scale is also crucial and this is the advantage of coal. It is a regulating factor in the transformation of Shanxi into the biggest coal producer in China. In fact, no other province relying only on a

Table 5-8 A Change Pattern of Newly-added Capacity of Coal Production in the State-Run Enterprises of China, by Provinces, 1952-90 (%)

Province	1 FYP	2 FYP	1963-65	3 FYP	4 FYP	5 FYP	6 FYP	7 FYP
Beijin	2.24	2.64	1.39	0.43	1.15	0.00	0.18	0.00
Tianjin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hebei	8.08	9.52	9.79	5.22	3.64	3.23	5.91	0.00
Shanxi	15.20	8.50	9.74	8.10	10.23	12.01	24.39	4.64
Inner Mongolia	1.55	2.48	4.87	5.31	1.61	2.63	11.09	28.58
Liaoning	10.71	6.87	15.59	4.16	5.65	6.65	4.59	4.75
Jilin	5.66	5.83	6.13	1.78	4.21	4.02	5.55	7.38
Heilongjiang	12.39	7.11	4.78	2.26	5.13	5.54	5.29	2.99
Shanghai	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.38
Jiangsu	0.56	3.62	3.20	2.70	2.46	10.72	1.23	0.00
Zhejiang	0.00	0.31	0.00	0.30	0.31	0.82	0.00	3.18
Anhui	7.59	3.74	6.96	3.83	2.77	1.94	8.54	0.38
Fujian	0.03	0.06	2.41	1.00	3.32	2.28	0.59	3.61
Jiangxi	2.67	1.96	1.67	6.32	1.70	1.19	1.70	0.66
Shandong	3.31	10.23	3.48	1.52	6.86	5.33	9.93	1.35
Henan	6.03	14.01	11.37	6.46	10.73	10.93	8.01	10.35
Hubei	0.03	0.03	1.39	1.58	1.71	2.11	0.68	5.26
Hunan	2.51	3.01	3.34	10.87	3.88	2.53	1.99	0.29
Guangdong	0.72	0.83	0.56	2.39	3.56	1.57	0.37	1.62
Guangxi	0.50	1.24	0.00	1.43	2.84	4.14	1.07	0.55
Hainan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.66
Sichuan	3.56	7.04	7.52	8.92	8.60	4.14	3.10	0.02
Guizhou	0.22	2.12	1.90	7.00	6.90	0.46	1.48	3.88
Yunnan	1.27	0.37	1.67	1.49	1.53	1.93	0.15	1.56
Xizang	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.56
Shaanxi	1.33	2.55	2.46	6.06	3.50	10.77	2.55	0.17
Gansu	2.92	1.25	0.00	2.73	3.03	1.76	1.00	1.44
Qinghai	0.91	0.22	0.00	0.56	0.85	0.79	0.00	3.48
Ningxia	0.00	2.85	0.00	3.50	4.30	0.46	0.37	0.36
Xinjiang	0.00	1.34	0.00	4.06	0.18	2.05	0.26	0.64
								0.24
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total (mil t)	63.76	96.76	21.55	69.15	81.21	64.93	81.27	126.34

Source: China's Statistics Bureau, China's Capital Investment Statistics and China's Energy Statistics Yearbook, 1991.

Table 5-9 A Change Pattern of Newly-added Capacity of Crude Oil Production in the State-Run Enterprises of China, by Provinces, 1952-90 (%)

Province	1 FYP	2 FYP	1963-65	3 FYP	4 FYP	5 FYP	6 FYP	7 FYP
Beijin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tianjin	0.00	0.00	0.00	5.60	9.40	1.47	3.71	3.92
Hebei	0.00	0.00	0.00	0.00	0.62	44.78	9.11	2.85
Shanxi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Inner Mongolia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13
Liaoning	0.00	0.00	0.00	1.08	7.90	10.12	10.47	14.37
Jilin	0.00	0.37	0.25	5.46	22.98	0.81	1.54	2.74
Heilongjiang	0.00	49.66	88.20	57.82	45.34	14.82	34.46	25.27
Shanghai	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jiangsu	0.00	0.00	0.00	0.00	0.00	0.63	0.47	0.64
Zhejiang	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Anhui	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fujian	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jiangxi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.87
Shandong	0.00	0.00	7.41	19.15	29.30	14.06	24.51	29.22
Henan	0.00	0.00	0.00	0.00	0.00	5.76	12.06	8.44
Hubei	0.00	0.00	0.00	3.61	1.08	0.00	0.30	0.20
Hunan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Guangdong	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Guangxi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hainan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sichuan	0.00	0.00	0.00	0.15	0.23	0.00	0.00	0.00
Guizhou	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yunnan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Xizang	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Shaanxi	0.23	0.20	0.03	0.03	0.06	0.04	0.23	0.47
Gansu	85.37	12.17	0.00	0.70	0.07	0.83	0.21	0.02
Qinghai	0.00	9.61	0.58	0.54	0.26	0.38	0.00	1.34
Ningxia	0.00	0.00	0.00	0.00	0.00	1.42	0.00	0.00
Xinjiang	14.41	28.00	3.53	5.85	3.20	4.87	5.00	7.52
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total (mil t)	**1.31**	**8.16**	**6.75**	**27.67**	**40.65**	**39.41**	**49.76**	**25.16**

Source: China's Statistics Bureau, China's Capital Investment Statistics and China's Energy Statistics Yearbook, 1991.

Table 5-10 A Change Pattern of Newly-added Capacity of Iron Ore Production in the State-Run Enterprises of China, by Provinces, 1952-85 (%)

Province	1 FYP	2 FYP	1963-65	3 FYP	4 FYP	5 FYP	6 FYP
Beijin	0.00	3.81	0.00	9.18	18.53	16.69	5.22
Tianjin	0.00	0.00	0.00	0.00	0.00	0.72	0.00
Hebei	3.82	12.13	3.95	6.60	7.41	18.36	0.00
Shanxi	0.00	0.05	0.00	0.00	1.24	9.54	16.41
Inner Mongolia	0.00	0.00	0.00	1.12	1.92	2.38	1.12
Liaoning	77.09	27.59	65.79	15.50	31.00	10.01	18.64
Jilin	0.00	0.00	0.00	1.11	1.92	2.38	1.12
Heilongjiang	0.00	0.48	0.00	0.10	1.20	0.38	0.00
Shanghai	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jiangsu	4.68	0.00	4.28	0.30	9.85	0.33	29.83
Zhejiang	0.00	1.24	0.00	1.24	0.81	3.05	0.75
Anhui	3.60	3.09	0.00	10.62	3.16	5.72	7.46
Fujian	0.00	0.71	0.00	0.87	0.70	0.00	0.00
Jiangxi	0.00	0.95	0.00	0.82	0.65	5.25	0.00
Shandong	2.16	4.19	19.41	0.82	2.01	6.15	0.00
Henan	0.00	4.28	0.00	1.36	1.48	0.48	0.00
Hubei	0.00	16.18	0.00	5.88	4.23	3.39	1.19
Hunan	0.00	0.00	0.00	1.59	2.14	0.81	0.00
Guangdong	8.65	3.33	0.00	0.99	1.81	10.59	8.20
Guangxi	0.00	0.00	0.00	3.10	1.85	0.05	4.10
Hainan	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sichuan	0.00	2.62	4.93	18.38	0.59	3.20	0.00
Guizhou	0.00	0.00	1.64	0.99	0.00	0.00	1.12
Yunnan	0.00	1.28	0.00	0.86	3.34	0.00	0.00
Xizang	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Shaanxi	0.00	0.00	0.00	0.10	1.33	0.05	3.73
Gansu	0.00	0.00	0.00	7.94	4.36	0.00	2.24
Qinghai	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ningxia	0.00	0.00	0.00	0.00	0.02	0.00	0.00
Xinjiang	0.00	0.00	0.00	1.24	0.09	0.72	0.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total (mil t)	**13.88**	**21.02**	**3.04**	**40.32**	**45.87**	**20.97**	**13.41**

Source: China's Statistics Bureau, China's Capital Investment Statistics (1950-85).

Table 5-11 A Change Pattern of Newly-added Capacity of Steel Production in the State-Run Enterprises of China, by Provinces, 1952-85 (%)

Province	1 FYP	2 FYP	1963-65	3 FYP	4 FYP	5 FYP	6 FYP
Beijin	0.00	2.23	39.11	4.37	0.59	0.00	0.00
Tianjin	0.07	4.25	0.00	1.62	0.00	0.00	0.00
Hebei	3.48	5.14	1.56	2.06	1.22	24.87	0.00
Shanxi	2.87	2.74	0.00	9.00	1.27	2.92	0.00
Inner Mongolia	0.00	9.58	0.00	13.65	0.12	9.86	0.00
Liaoning	74.40	17.81	2.61	12.40	31.78	2.28	0.00
Jilin	0.00	0.51	0.00	1.73	1.31	1.20	0.00
Heilongjiang	6.31	0.00	0.00	0.67	0.17	1.20	0.00
Shanghai	5.38	19.91	0.00	13.06	3.73	0.00	0.00
Jiangsu	0.00	1.81	1.30	0.14	6.11	0.14	0.00
Zhejiang	0.00	0.16	9.26	0.49	0.14	0.86	0.00
Anhui	0.00	1.99	35.85	2.86	0.87	10.29	0.00
Fujian	0.00	0.42	1.69	0.69	0.36	4.03	0.00
Jiangxi	0.00	1.92	2.61	2.65	0.05	1.37	0.00
Shandong	0.00	2.83	0.00	5.86	0.93	0.00	0.00
Henan	0.00	1.70	0.00	0.12	4.87	0.00	0.00
Hubei	2.58	22.00	0.00	7.09	5.68	26.57	0.00
Hunan	0.00	0.64	0.00	4.84	7.48	0.00	0.00
Guangdong	0.00	0.97	0.00	3.20	2.99	0.00	40.00
Guangxi	0.00	0.00	0.00	2.56	3.24	1.89	0.00
Hainan	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sichuan	4.30	1.85	0.13	4.89	22.90	8.66	0.00
Guizhou	0.00	0.16	3.91	0.76	0.00	0.68	0.00
Yunnan	0.00	1.06	1.96	1.92	1.95	0.00	60.00
Xizang	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Shaanxi	0.00	0.00	0.00	0.07	1.75	0.07	0.00
Gansu	0.00	0.00	0.00	0.08	0.00	1.72	0.00
Qinghai	0.00	0.00	0.00	1.37	0.51	0.00	0.00
Ningxia	0.00	0.00	0.00	0.00	0.00	0.07	0.00
Xingjiang	0.00	0.32	0.00	0.55	0.00	0.05	0.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total (mil t)	2.79	9.39	0.77	7.28	5.90	5.83	0.30

Source: China's Statistics Bureau, China's Capital Investment Statistics (1950-85).

single mineral resource can compete with Shanxi in attracting prodigious amounts of industrial investment.

5.4 Mineral Production and Regional Development: A Fundamental Factor

A key precondition for development. Economic development, even at the simplest level, must create a movement of goods and persons from one place to another. The mining industry, both in its role as a vital part of economic activity and a dealer in commodities of great bulk and low value per unit weight, is always regarded as one of the most powerful agents for improving the spatial flow of goods and, on that account, promoting regional development. Indeed, there is little doubt that mining industry can make its greatest contribution to the latter by disrupting the consolidation of centre-periphery structure; an action brought about through the outward orientation of its transport infrastructure.

Although the first railway line fully opened to traffic in China (built completely by British capital) dated from 1881, China's transport system was marked by extreme backwardness before 1949. In fact, at a density of 2.3 kilometres (km) of railways per thousand square kilometres of territory, China was less well provided with transport facilities than any other large country in the world. There was a particularly marked dichotomy between the few areas of ready accessibility and the vast areas of limited or no accessibility and about 60 per cent of the total 21,800 km of railways of different gauges and types were concentrated in Northeast China and along the coast. More specifically, more than

50 per cent of the provincial capitals had no rail connections with the national capital--Beijing (see Figure 5-3). Also, in 1949 there were only 80,768 km of highways, a network which was characterized by roads with little or no surfacing and by bridges and ferries of low capacity. In addition, there were only 73,615 km of navigable inland waterways in China in 1949 despite their historical and geographical significance, and many rivers were still in their natural states with a depth of less than one metre, rendering them useless for commercial traffic on any scale. This aggregate transportation network in China was the result of long historical development where the area of greatest transportation accessibility became the core or central area. The accessibility of this early core area was further reinforced by the colonial establishment of trading ports. Since the purpose of a substantial part of the transportation network was to meet colonial needs and goals, it is hardly surprising that the resulting network was not geared to national needs of spatial integration which would have linked together the development areas and exploited to the full the potential of the interior.

Development and the changing pattern. To connect the four corners of a country as vast as China requires enormous efforts. The new government of 1949 attempted to accomplish the task through investment in a combination of modern and traditional transport modes. In this effort, the modern transport sector is the more powerful instrument in lending support to China's mineral-based industrialization. The Chinese government invested more than C¥ 220

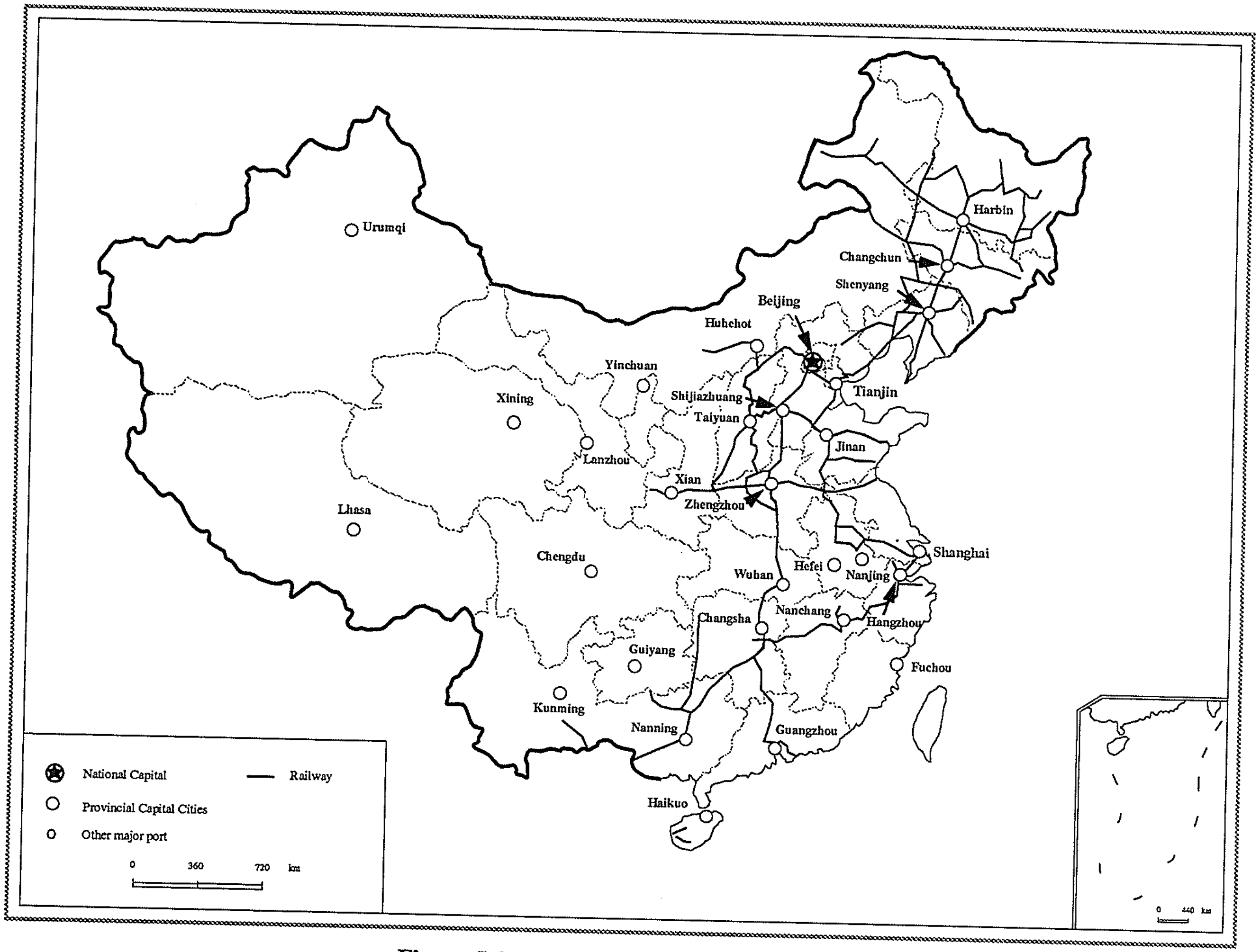


Figure 5-3. Railway Network in China, 1949

billion in the transportation sector between 1953 and 1990, a total second only to the amount found for industrial investment. As a result, China's modern transportation system has shown remarkable growth since 1950 (see Table 5-12).

The first target of this development is to build up an integrated network to connect the mineral-producing and mineral-consuming areas. Based on location patterns of mineral resources and regional development (see Chapter III), expansion of the inland transport system was given a high priority before the mid-1970s, and this applied particularly to the railway system. In the First Five-Year Plan, for example, the important Zhengzhou-Lanzhou rail line from the capital of Henan to the capital of Gansu received attention so that it could transfer crude oil from the Yumen oilfield to the coastal areas. The completion of Lanzhou-Urumqi rail line in the Second Five-Year Plan period also served the same propose, conveying crude oil for the Karamai oilfield to the oil refinery centre at Lanzhou. Another example is the construction of the Chengdu-Kunmin rail line. In order to exploit the iron ore and coal resources in the western part of Sichuan, the government spent more than C¥ 3.3 billion and took 12 years to install the nearly 2,000 kms long "iron and steel dragon" in the western mountain areas. Moreover by that time, a modern transportation system in the southwestern part of the country was coming into existence. The railway system, at the end of 1990, covered all the provinces and autonomous regions except Xizang AR (see Figure 5-4). None the less, at least 40 per cent of the network was concentrated in the

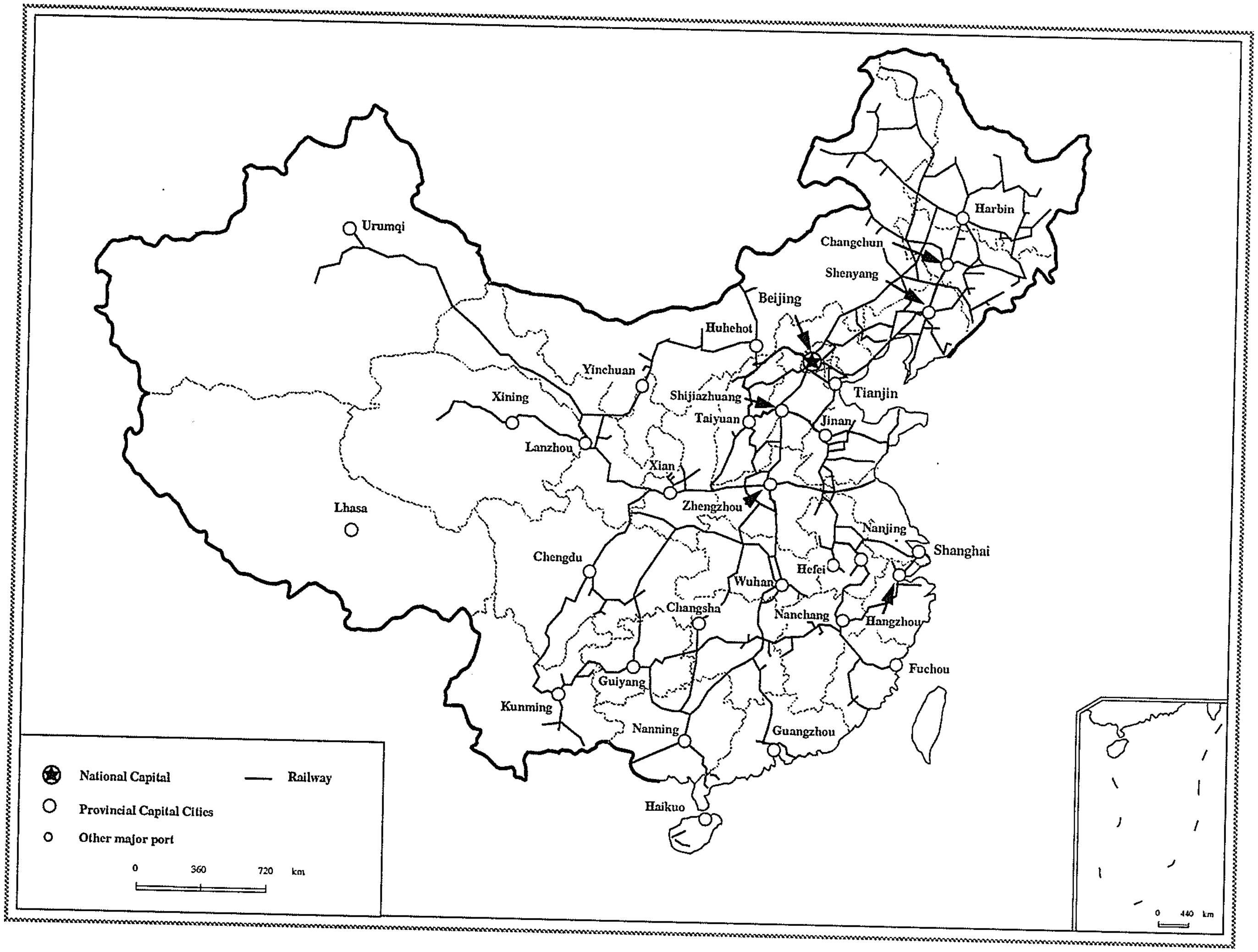


Figure 5-4. Railway Network in China, 1990

Table 5-12 The Development of the Transport Network in China, 1949-90

Year	Length in operation (kms)						
	Railways				Airways		
	Total	(E)	Highways	Waterways	D	I	Pipelines
1949	21,800		80,768	73,615			
1952	22,900		126,675	95,025	8,023	5,100	
1957	26,700		254,624	144,101	22,145	4,300	
1962	34,600	100	463,500	161,900	30,900	4,400	100
1965	36,400	100	514,500	157,700	34,900	4,500	100
1970	41,000	300	636,700	148,800	36,200	4,400	400
1975	46,000	700	783,600	135,600	47,100	37,100	5,300
1980	49,940	1,700	888,250	108,508	110,500	81,200	8,600
1985	52,100	4,500	942,400	109,100	171,200	106,000	11,700
1990	53,378	6,900	1,028,300	109,200	340,400	166,400	15,900

Source: China's Statistics Bureau Statistical Yearbook of China, 1991.
Note: E=Electrified lines; D=Domestic Routes; I=International Routes.

Northeast and lines in other parts of the country were still mainly north-south oriented.

The second target of this development is to improve the efficiency of the transportation network in order to convey more mineral products. Freight traffic in China has grown from 315 million tonnes in 1952 to 9,706 million tonnes in 1990, attaining an average growth rate of 9.4 per cent per annum. Comparing this rate with that of the total tonne-kilometre ratio in the same period--a rate of increase at the level of 9.8 per cent per annum--means that while the transport system has experienced remarkable development since the 1950s, more expansion in fact has been achieved in highly-intensive freight transport as a direct result of the development of the long-distance routes, notably with respect to the railway system (see Figure 5-5). China now stands high in the world regarding highly-intensive freight transport. Expressed in tonne-km of freight per dollar of GNP, China's ratio

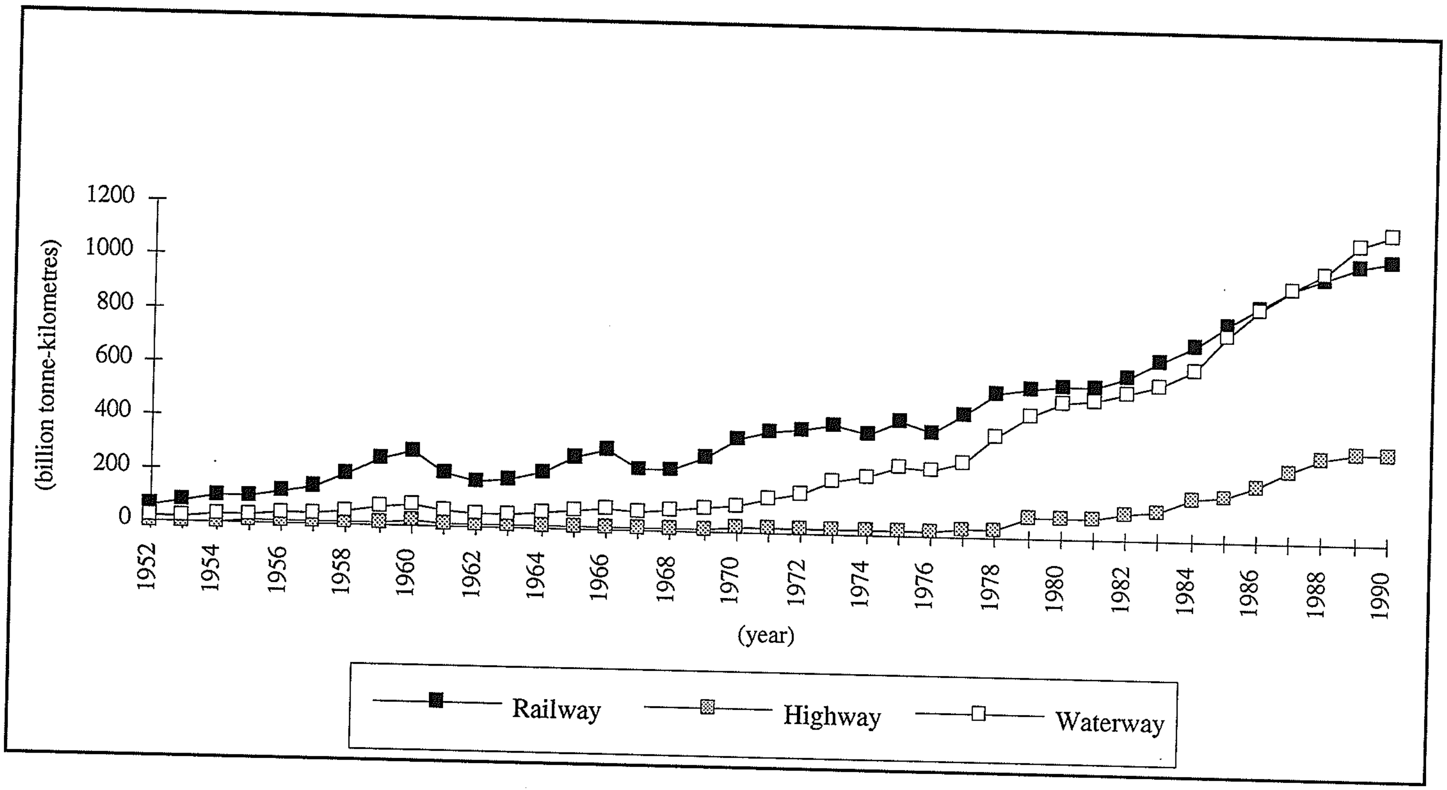


Figure 5-5 A Changing Pattern of Freight Traffic in China by Volume

(3.17 tkm/$GNP) is almost twice as intensive as the United States (1.87), India (1.67) and Brazil (1.40) (World Bank, 1985). Clearly, country size and resource location are decisive factors in the high intensity recorded by China. While the country is as large as the United States, the population is far more concentrated. Over 70 per cent of the population lives east of a Beijing-Guangzhou line, while in the United States both the east and west coasts are highly developed. Regarding mineral resources, the most common, such as coal and iron ore, are spread throughout the country. However, the conditions for exploitations of coal and iron ore in the North and the Northeast are more favourable than in the other regions. Concentrating on these resources will increase transport intensity more than would the development of local production closer to demand areas. The trade-offs are between higher mining costs and the lower transport costs of regional mines on the one hand, and lower mining costs and higher transport costs of concentrated mining on the other. According to the World Bank (1985), Shanxi coal can be competitive in coastal China, despite transport distances generally exceeding 1,000 kms, because of its favourable conditions for coal exploitation, lower costs in capital construction, operation and maintenance, as well as high quality of coal. Considering that most rail lines out of the coal-producing areas of North China are operating at or near capacity, the appropriate transport cost to use for the purpose of comparison is the long-run marginal costs (LRMC are total costs including capital construction, operation, and maintenance costs, calculated by using an appropriate factor to reflect the opportunity cost of capital based on construction of new lines). Such cost varies from place to place depending on local conditions and topography. Transport over 1,000 kilometres' distance by double-track railway may be some C¥ 20 per tonne, but about C¥ 30 per tonne on a single-track railway line. Coastal shipping over several thousand kilometres may be C¥ 20-30 per tonne, but road transport cost might be just as high for a distance of only 200-300 kms (see Table 5-13). If several modal transfers (for example, rail to ship to rail to road) are required to transport coal, say, from Shanxi to an inland city in the South, total transport costs could be C¥ 40-60 per ton, justifying coal production in the South even under unfavourable conditions and at high costs (up to C¥ 80-100 per tonne--or 2 to 2.5 times the production costs at the more favourable deposits in Shanxi province). By these lights, local production cost, for example,

Table 5-13 Indicative Costs of Coal Transport by Modes, 1986

Transport mode	Route	Distance (km)	cost (C¥/t)
Railways			
	Datong-Beijing	300	6
	-Qinhuangdao	658	12
	-Shenyang	1,000	20
	-Wuhan	1,500	30
	-Guangzhou	2,400	48
	Taiyuan-Shanghai	1,500	30
	-Qingdao	900	10
	-Wuhan	1,200	24
Waterways			
30,000 dwt bulker	Qinhuangdao-Shanghai	1,350	14
10,000 dwt coaster	Qingdao-Shanghai	750	10
3,000 tonne barge	Wuhan-Nanjing	800	12
1,500 tonne barge	Xuzhou-Nanjing	400	7
Roads			
25 tonne track	Datong-Beijing	300	75

Source: World Bank (1985) China: Long-Term Development Issues and Options, Washington, World Bank.

in Liaoning province approximately 1,000 kms away from the Shanxi coal-fields, could still be competitive. Unfortunately, this issue of comparative costs was not emphasized until recent years.

At the provincial level, railway freight intensity measured in km/ptskm and tkm/C¥ GDP is above the national average in the North, Northeast, Northwest and the five southern provinces of Anhui, Henan, Hunan, Guangxi and Guizhou. All provinces, except for the three municipalities of Beijing, Tianjin and Shanghai, are intricately involved more or less in either coal production or nonferrous material supply. Table 5-14 shows the intensity of rail network along with the outputs of their coal and pig iron activities at the provincial level, and the provinces or AR with above average endowments both in railway and mining terms are Hebei, Shanxi in the North; Liaoning, Jilin and Heilongjiang in the Northeast; Henan, Hunan and Guangxi in the South; Guizhou in the Southwest; and Shaanxi and Ningxia in the Northwest.

Coal production and supply: meshing the national transportation network. A unique feature of mineral production and supply in China is the high share of coal in both commercial and total energy consumption. In 1990, coal accounted for more than three-quarters of primary commercial energy consumption, the highest proportion it enjoys in any major country. From a chronic perspective, nearly 75 per cent of the tonnage carried by the modern transportation system revolves round coal, construction materials, materials for the iron and steel industry and petroleum.

Table 5-14 The Development of Mineral Production and Railway Network, by Provinces, 1990

Province	Coal (million t)	Pig iron (million t)	Railway intensity (km/ptskm)*	(tkm/C¥)**
Beijin	10.1	3.6	61.5	0.48
Tianjin	0.0	1.4	38.7	0.78
Hebei	62.4	5.2	15.8	1.56
Shanxi	286.0	4.6	14.9	1.20
Inner Mongolia	47.6	2.8	4.5	1.81
Liaoning	51.0	11.5	24.3	1.02
Jilin	26.1	0.7	18.4	0.96
Heilongjiang	82.6	0.6	11.0	1.14
Shanghai	0.0	5.3	34.1	0.05
Jiangsu	24.1	1.5	7.1	0.23
Zhejiang	1.4	0.6	8.3	0.17
Anhui	32.1	2.9	11.0	0.72
Fujian	9.3	0.6	8.4	0.22
Jiangxi	20.3	0.9	9.5	0.49
Shandong	60.0	2.9	12.9	0.44
Henan	90.8	1.7	12.6	1.17
Hubei	9.2	5.1	9.0	0.55
Hunan	33.7	1.5	10.7	0.82
Guangdong	8.9	0.8	3.8	0.12
Guangxi	9.8	0.6	7.1	0.62
Hainan	0.0	0.0	6.5	0.02
Sichuan	67.9	4.5	5.1	0.33
Guizhou	36.9	0.6	8.1	0.70
Yunnan	22.3	1.2	4.3	0.24
Xizang	0.0	0.0	0.0	0.00
Shaanxi	33.3	0.4	9.0	0.89
Gansu	15.6	0.5	5.4	1.45
Qinghai	3.2	0.0	1.5	0.45
Ningxia	14.4	0.1	8.3	1.05
Xingjiang	21.0	0.4	0.8	0.43
The country	1080.0	62.4	5.6	0.60

Source: China's Statistics Bureau, China's Statistics Yearbook, 1991"

Note: km=kilometre; ptskm=per thousand square kilometres; tkm=tonne kilometre.

Coal alone accounted for more than 40 per cent of the total tonnage (see Figure 5-6). The prodigious growth in demand since 1950 had the effect of creating a much-expanded market for coal in most parts of the country. Coal flow, at the same time, acted as a contributor to, and a corollary of, rapid industrialization in general, and the development of transport networks in particular.

The symbiotic relationship between coal and transport is totally determined by the regional pattern of coal consumption and production. Total coal consumption of China was 1,055 million tonnes in 1990 in comparison with a mere 30 million tonnes in 1949. Liaoning constituted the largest single coal market, taking about 83 million tonnes, some 7.82 per cent of the total. It was followed by Hebei, Shanxi and Shandong. Overall, the coastal region was estimated to consume 450 million tonnes of coal, about 42.55 per cent of the total, leaving the remainder to be shared among the provinces of the interior. The regional pattern of coal consumption is roughly consistent with that of population distribution, but quite at odds with that of industrial output.

Concoction of a simple ratio in which coal production is divided by coal consumption for a given region suffices to provide a measure of regional coal self-supply. In 1990, there were 19 provinces (including Autonomous Regions and Municipalities) which fell into the category of net coal-importer (also see Figure 5-7). Jiangsu was by for the largest, with a net import requirement that amounted to nearly 40 million tonnes, and it was followed by Liaoning with more than 31 million tonnes of net import coal. The

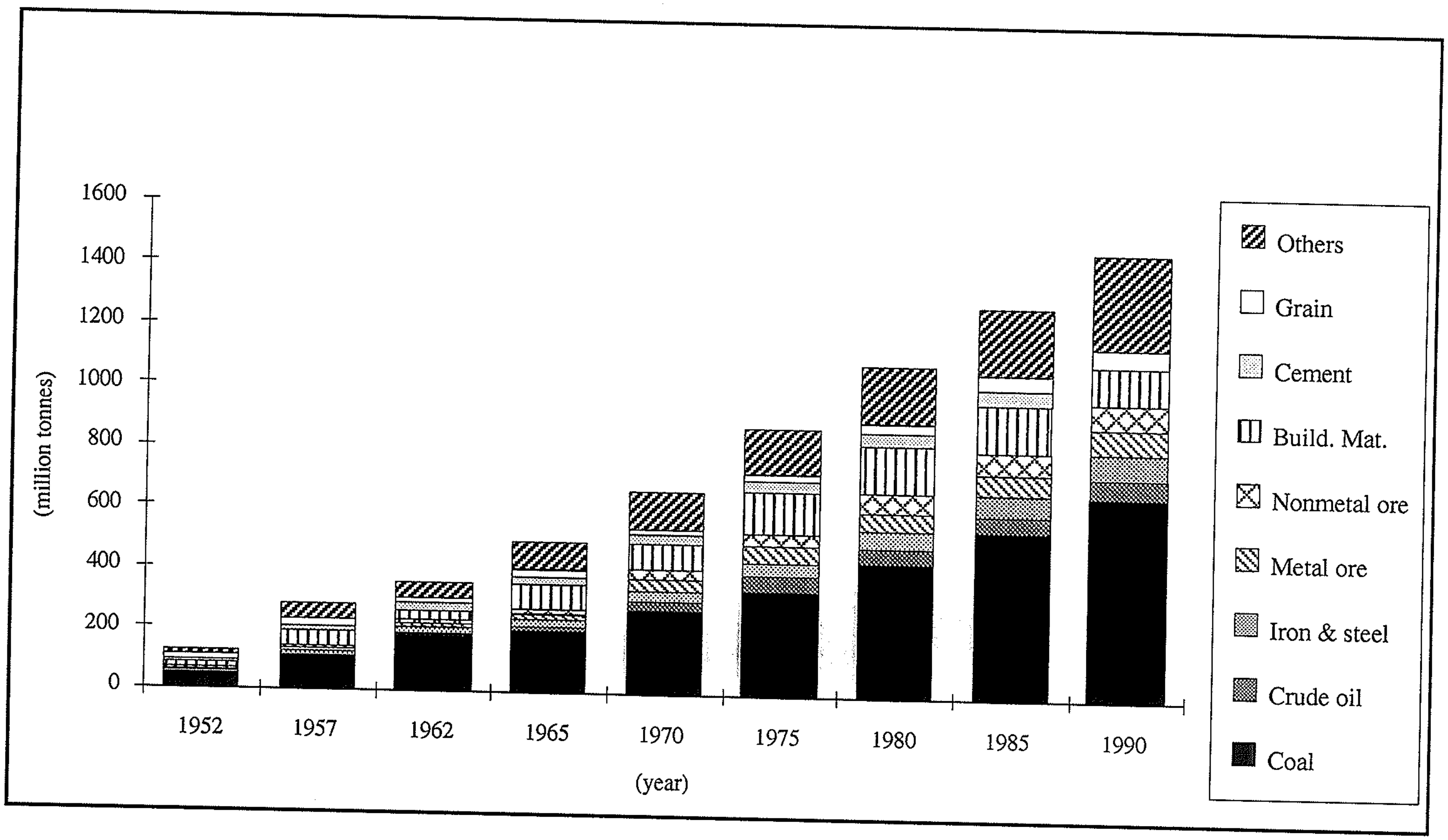


Figure 5-6 Composition of Railway Freight in China, by Selected Years

addition of Shanghai, Hubei, Zhejiang, Guangdong, Tianjin, Hebei, Beijing, Jilin and Shandong, each demanding imports of between 10 to 30 million tonnes, combined to account for 171 million tonnes, or two-thirds of the total interregional coal import figure. Reorganization of this data so as to merge the 19 provinces into seven regions (Table 5-15) serves for two purposes. First, it confirms the suggestion that inland areas display higher coal self-supply ratios than their coastal counterparts and, secondly, it endorses the view that coal consumption in the coastal region as a whole has grown more rapidly than in the aggregate interior since the mid-1970s in line with the shift in regional policy from an "inward-looking" orientation to an "outward-looking" perspective. Between 1981 and 1990, for example, coal consumption in the coastal region of Shanghai-Jiangsu-Zhejiang grew by an impressive 296 per cent in comparison with only slightly under 6 per cent registered for the interior Gansu-Qinghai region. Resort to the ratio enables us to arrive at coal net-exporter regions as well. Only ten provinces emerge in the category of net coal exporters, of which

Table 5-15 Net Coal Imported for Seven Regions, Selected Years (million tonnes)

Region	1957	1967	1975	1981	1985	1990
Shanghai-Jiangsu-Zhejiang	6.56	13.93	19.71	30.10	39.93	89.06
Beijing-Tianjin-Hebei	4.38	4.55	5.64	16.58	26.36	48.27
Liaoning-Jilin	1.04	10.20	6.09	23.38	32.32	45.56
Hubei-Hunan-Jiangxi	-	4.13	11.25	15.76	23.64	32.43
Guangdong-Guangxi-Fujian	1.17	2.40	5.77	8.25	12.22	31.33
Gansu-Qinghai	0.77	1.94	4.41	4.21	5.72	4.45
Sichuan-Yunnan	-	-	-	1.54	1.61	-

Sources: Li Wen-yan (1990) China' Industrial Geography, Science Press, Beijing.
China Statistics Bureau (1992) Chian's Statistics Yearbook, 1991.

Shanxi is by far the most prominent. Its net coal export in 1990 reached over 200 million tonnes, some 72 per cent of the total. Henan is the second largest coal exporter and its net coal export reached nearly 30 million tonnes. Another eight provinces, Heilongjiang, Guizhou, Inner Mongolia, Shaanxi, Ningxia, Sichuan, Xinjiang and Yunnan achieved export levels of between 3 and 20 million tonnes (see Figure 5-7). There arises, therefore, an obvious need to transport coal products from producers to consumers even over fairly long distances.

Major coal routes are illustrated in Figures 5-8 and 5-9. Two general directions of coal flows can be easily elicited from these figures; namely, from north to east, and from north to south. The rail lines can be characterized accordingly.

The main rail lines for coal transport from north to south are: (1) Beijing-Xuzhou-Nanjing-Shanghai-Hangzhou-Fuzhou; (2)Beijing-Zhengzhou-Wuhan-Guangzhou; (3) Datong-Taiyuan-Jiaozou-Zhizheng; and (4) Harbin-Shenyang-Dalian. Within this network, the two most important track sections are Zhengzhou-Wuhan and Xuzhou-Nanjing: both carrying more than 25 million tonnes of coal per year.

The main railway lines for coal transport from the west to east are: (1) Baotou-Datong-Beijing-Qinhuangdao; (2) Taiyuan-Shijiazhuang-Dezhou-Qingdao; (3) Yanzhou-Shijiusuo; (4) Zhengzhou-Xuzhou-Lianyungang; (5) Beijing-Jinzhou-Shenyang. Without question, the most important of these is the Datong-Qinhuangdao line: its eminence is so great, indeed, that with the recent double-tracking and electrification completed, it can carry 40-50 million tonnes of

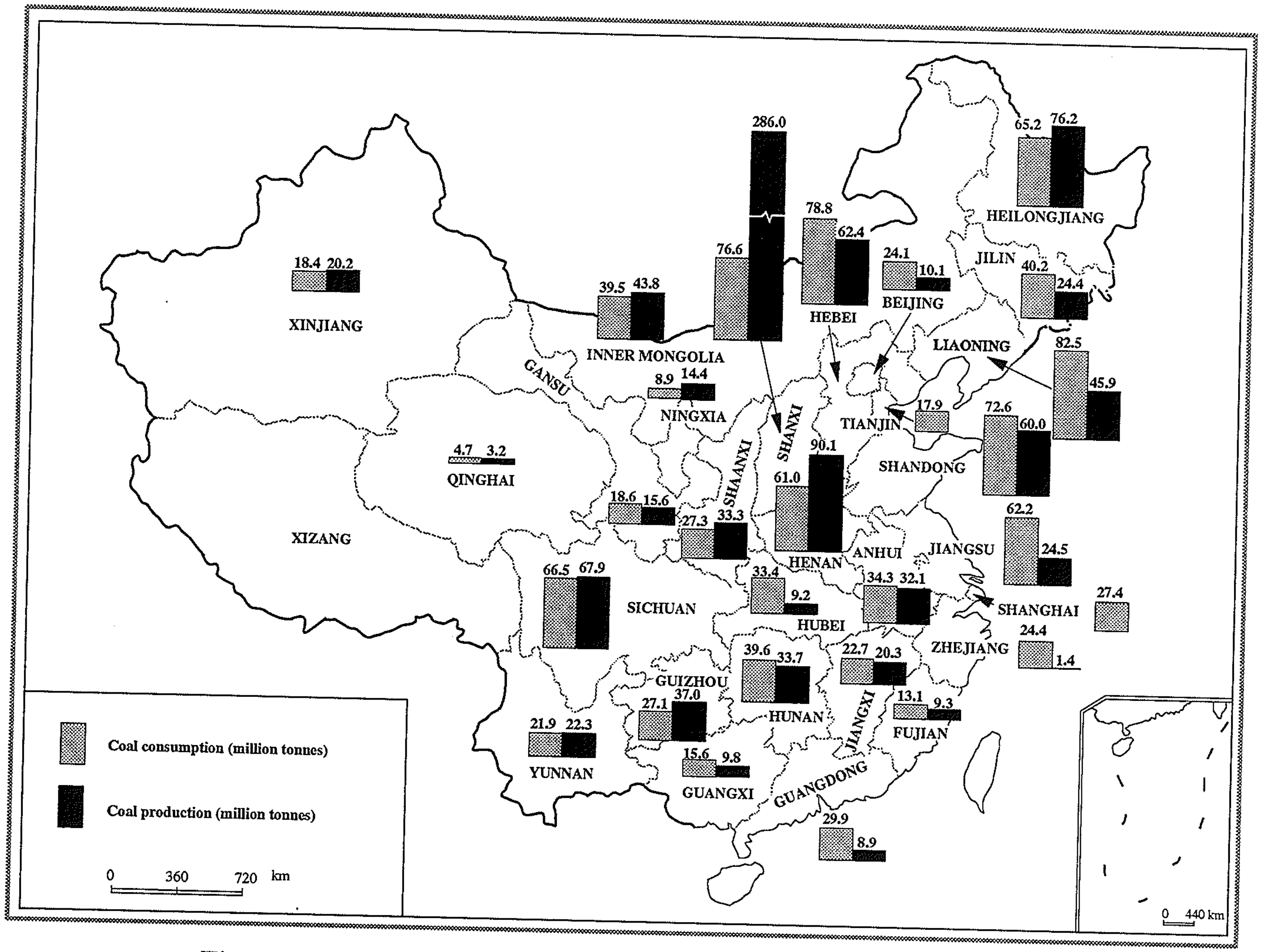


Figure 5-7. Regional Coal Production and Consumption in China, 1990

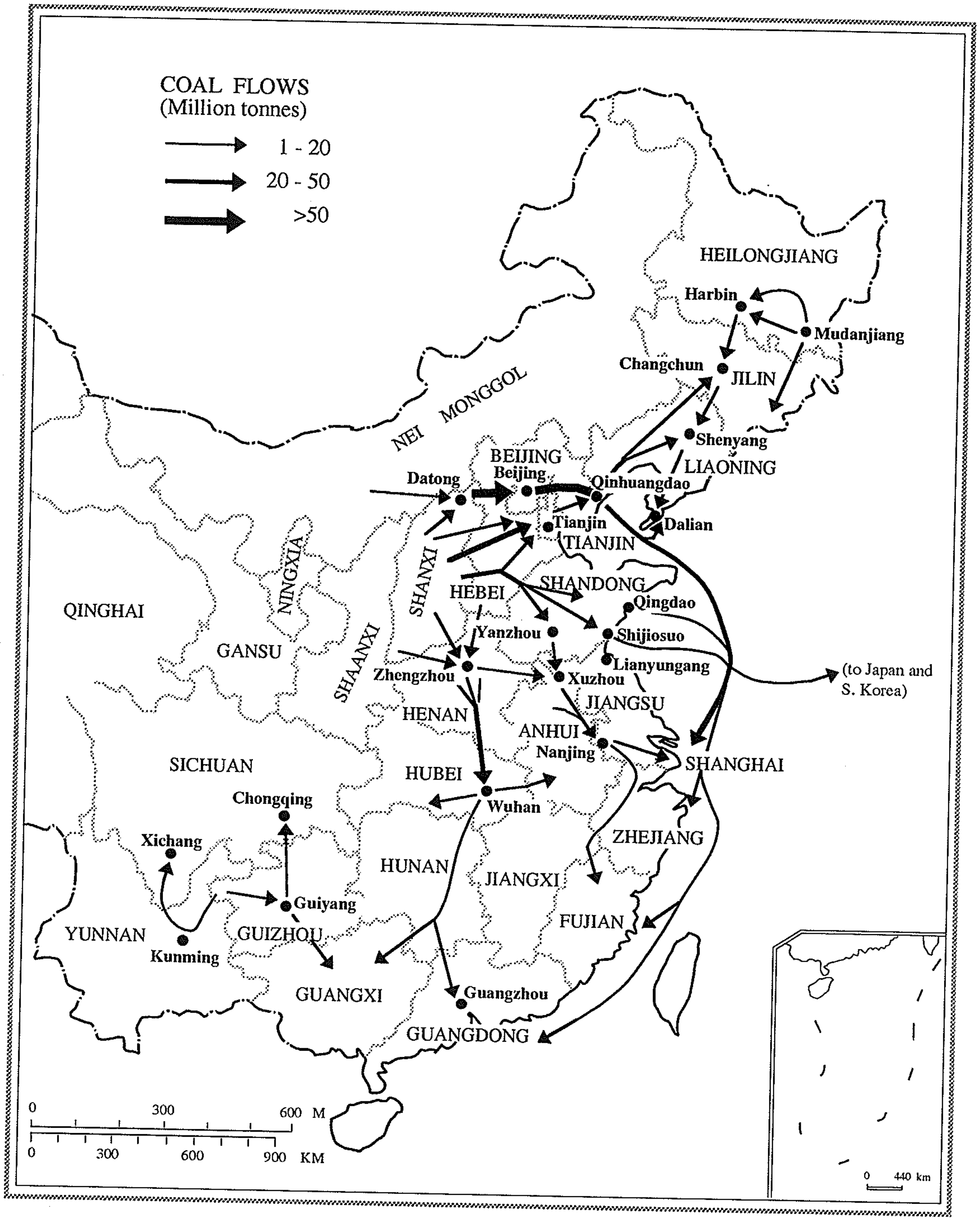


Figure 5-8. Major Coal Flows, 1990

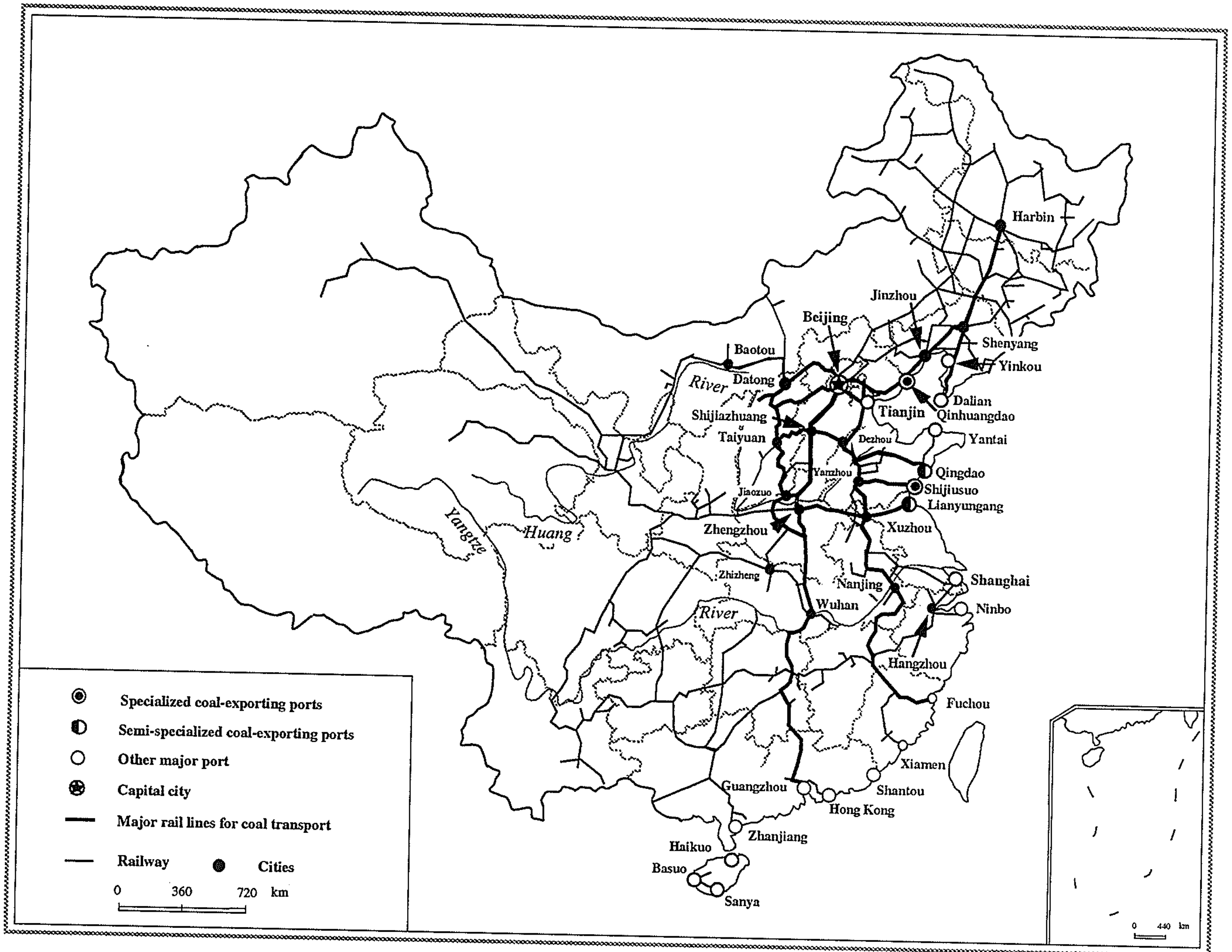


Figure 5-9. Coal-Transport and Rail-Port System in China, 1990

coal per year in the first stage.

Given the high densities of coal traffic in the north and the existence of bottlenecks, the northern rail network has been highlighted as the portion most in need of improvement. Underlining this need is the emphasis which the central government has put on developing this region as the major supplier of coal to other regions. In short, a large proportion of China's railway projects, either under construction or in the planning stage, are undertaken on the understanding that they should ease the movement of northern coal.

Historically, coal movement in China relied on an integrated transport network, particularly the dovetailing of rail and coastal shipments. But this tradition changed after the 1950s when the development of the railway system was stressed at the expense of coastal shipping. The latter was neglected on three grounds: the westward extension of mining activities, the uncertain political situation (such as The Korean War between 1951 and 1953) and the appearance of the regional self-reliance policy. As a result, the share of total tonnages handled by the waterway system in the long-distance transport sector (that is, combining railway and waterway) was reduced from over 31.3 per cent in 1949 to 27.2 per cent in 1970. In the beginning, this development seemed to work well, although the total scale of the national production was quite small and there were still some mineral resources accessible near the consumer areas. From the mid-1970s, however, circumstances began to spin out of control as industrial activities spread far and wide.

The railway system alone could not meet all the requirements of coal movement. In fact, ten million tonnes of mined coal are lost annually through spontaneous combustion in coal-producing areas for lack of transport, while perversely, industry in southern and coastal areas remain short of energy.

Confronted with the main problems of increasing demand and worsening rail congestion, the government reverted at the end of the 1970s to a transport policy which aimed at building up an integrated transport system. One upshot: coastal shipping has grown faster than both inland shipping and rail, and the tonnage of the waterway mode in the long-distance transport sector raised its share to nearly 37 per cent of the total in 1989. This change is particularly well-suited to serving the needs of the nine coastal provinces which, together with Beijing, Tianjin and Shanghai, accounted for over 53 percent of the total GNP and nearly 45 percent of the total coal consumption. In 1990, modern vessels carried over 700 million tonnes on domestic waters, a 13-fold increase on 1952. The freight volume of inland and coastal shipping, 345.1 billion tonne-km in 1990, was roughly one-third the size of the railway's freight volume. More to the point, coal cargoes amounted to 52 per cent of all centrally-controlled (Ministry of Communications) and 55 percent of all locally-controlled coastal shipping traffic.

This growth of coal traffic has been greatest at the seven major ports of Dalian, Qingdao, Shijiusuo, Lianyungang, Shanghai, Guangzhou, and especially Qinghuangdao. The major efforts to modernize ports, began in 1972, persist to this day, with particular emphasis given now to coal terminals at Qinghuangdao, the largest coal port in China. Expansion of coal facilities has also taken place at smaller ports. Coal exports are mainly funnelled through Qinghuangdao, Shijiusuo, Lianyungang and Qingdao, while coal destination favours Dalian, Shanghai and Guangzhou (see Figure 5-9).

5.5 Conclusion

There are many evidences to suggest that mineral resource is an important part of the regional advantages for economic growth, and upon it there are more opportunities afforded by mineral activity to create growth poles able to foster regional development.

In China, mineral activity has made its contribution to regional development in two fundamental ways. First, by initially attracting outside investment capital (mainly through the government's budgets) into the region before increasing the regional income and thereby allowing new injections to be used for local investment. Secondly, by bringing land into increasingly intensive use through the utilization of otherwise dormant resources of the region as a result of the establishment of an integrated infrastructural system, which is absolutely fundamental to economic development. On this account, mining was regarded from the outset as a step towards a broader mineral-based industrialization.

It is very clear that all the above analysis draws upon the inspiration of export-base theory, in which regional growth is promoted by the ability of a region to produce goods or services demanded by the national economy, and to export them at a competitive advantage with respect to other regions. In time it can be argued that the external determinants of regional growth become less important, that internal structural change (an increase in the proportion of output and employment in manufacturing and services) and expansion of local markets lead to self-reinforcing regional growth, that internal factors become important in determining regional growth rates, including external economies, and that the internal organization of production becomes more important than the dominance of export production. The export-base theory, therefore, is a much simplified explanation of regional growth and may be most usefully applied to its early stages, when mineral exploitation is often important. The extent of the multiplier effect is related to certain internal features that characterize the economic and social structure of the region, and it needs to be elaborated further in terms of diversification of the mineral-based economies. This is the subject of the next chapter.

Appendix 5-1 Industrial Development in Manchuria (Norhteast China): The Largest Japanese Colonial Frontier

Soon after defeating Russia and becoming the new master of Southern Manchuria in 1905, the Japanese devoted their principal efforts to developing the new colonial frontier as a supplier of minerals and metals to Japanese manufacturing industries in the homeland. As a result, Manchuria witnessed a marked increase in mineral production, particularly coal, iron and steel and other metal minerals, and it became the largest heavy-industry centre in Eastern Asia. In 1944 there was an estimated production of about 30 million tonnes of coal, three million tonnes of pig iron and 1.5 million tonnes of steel ingots.

Coal had been mined in Manchuria by traditional methods for centuries. The big development came after 1907 when the South Manchuria Railway Company (S.M.R., organized by the Japanese government in 1906 and charged with tapping the great resource potential of this region) took over the operation of the coal mines. Fushun was the most important coal producer in Manchuria and well known as possessing the largest open-cut mine in the world, owing to its rich coal reserves and favourable exploitation conditions. Production rose from 0.49 million tonnes in 1908 to 7.2 million tonnes in 1930, accounting for three-quarters of the total Manchurian coal production. The other important coalfield is at Benxi. It was producing about 0.4 million tonnes annually, and was especially important as the best source of coking coal in Manchuria.

The discovery and exploitation of iron-ore resources for the purpose of building up a Manchurian heavy industry and of supplying Japan's iron furnaces, was given high priority by the Japanese planners. Although the bulk of Manchurian ore was low-grade, with an iron content of only 30-40 per cent and a high silica content, and was confronted with difficulties in securing an adequate supply of coking coal, two iron and steel plants, Anshan and Benxi, received much attention, particularly after the 1920s. In 1933, the Anshan Iron Works was reorganized into a new plant and provided with new equipment. In 1944, this plant had a production capacity of some two million tonnes of pig iron and 1.2 million tonnes of steel ingots. A similar expansion took place at the Benxi Iron Works, and its pig-iron capacity was increased from 0.15 million tonnes to 0.65 million tonnes in 1942.

The Japanese also expended considerable energy and capital in the location and exploitation of other minerals, such as the production of aluminum in Fushun, and the production of molybdenum, vanadium, lead, zinc and copper at Hulutao.

In general, the Japanese had very largely integrated Manchurian industry into that of Japan. In the main, Manchurian mineral and metallic products were exported for manufacture or for finishing in Japanese factories. While unskilled labour was drawn mainly from the Chinese coolie population of Manchuria and north China, the managerial and technician groups were exclusively Japanese. Thus the collapse of Japan would in any case have largely disrupted Manchurian industrial economy since China at that time had neither the technical personnel to take their place nor the desire to maintain a contractor role for Japanese home industry.

CHAPTER VI

MINING-BASED DIVERSIFICATION

6.1 Introduction

Regional development is a long process of accumulation and redistribution of national endowments and social wealth. The forces that push the process forward come from the transformation of the economic structure. Mining activity, as discussed in the last chapter, can only play a dominant role at the early stage of regional growth when the society changes from an agricultural base to one rooted in industry. For the successive stages, the push power of the structural change should be handed over from mining to manufacturing, including mineral processing, and service industries. Such changes are inevitable, even for the mining industry itself. An expansion of mining industry is determined not only but by an increasing demand for mineral consumption, but also by a successful transition to a growing independence of economic activity from a single resource base to a diversified manufacturing and service one.

Generally, mineral production is a sequential value-added process. Once the industry is set up in a region, it always attracts some sequential businesses into its operation through the development of forward and backward linkages. Such an integration can greatly improve the local prosperity engendered in the national market. Consequently, the internal structural change (steadily augmenting the proportion of employment in manufacturing and services) can lead to expansion of local production and changes in the export-import structure.

The reasons for changes at the regional level which have major implications for economic development are often quite complex. In order to explain such changes thoroughly, the concepts of the economic base and the multiplier were developed from the 1940s (Richardson, 1985). Both of these have roots in economic theory; the economic-base concept is derived from the export-base model used to account for national development whereas the multiplier is commonly associated with Keynesian economics.

Resort to economic-base theory can help us gain an understanding of why some regions or countries have been growing or declining faster than others. For example, Berry and Dahmann (1977) examined the relationship between the growth of population and the composition of the economic base in the United States. In this study, they found that lower population growth rates were experienced by those regions with an economic base highly dependent upon primary economic activities such as agriculture, and high population growth rates were realized by those regions with an economic base highly dependent on government services and defence-procurement programmes.

As Isard (1974) points out, a major limitation of the basic-nonbasic concept (the core of the economic-base theory) is its emphasis on the aggregate effects of increases in regional economic activity at the expense of detailed, structural considerations. Moreover, although conceptually the notion relates to income changes, its practical application has largely been confined to changes in employment. Another disadvantage of the basic-nonbasic concept is that, with its emphasis on the sale of exports as a return from money flows into a region, the concept does not recognize other ways by which income may flow into a region or country; for example, through investment inflows and government spending. At the same time, money flows out of the region or country in the form, for instance, of wages paid to commuters, and, more importantly, the outflow of money connected with the purchase of imports of goods and services. This last hints at the notorious "leakages" issue.

An alternative technique that incorporates the real-world pattern of money flows is regional input-output analysis (Isard, 1974). The intellectual development of this technique occurred in the 1950s with the contributions of Isard (1951) in respect of the ideal interregional model and the more empirically-oriented applications of Leontief (1953). A major advantage of this technique is that it explicitly considers individual sectors in the regional economy, or measures the impact of expansion in a major industry on a region or country.

Addressing the fifth of the six targets earmarked for the consideration in the thesis, this chapter is designed to examine the regional impact of mining-based diversification, and that object is met by the use of input-output analysis and regression analysis.

6.2 Mining Impacts: the Evidence of Input-Output Multipliers

Some important concepts. Before discussing the output, income and employment multipliers in some detail, it is necessary to review some important concepts relative to input-output models.

First of all, an input-output table represents the economy to be studied in terms of aggregated industrial or commodity groups or sectors. The table sets forth in great detail the transactions in Yuan (Chinese dollar) terms between the sectors for a given year. Industries sell goods and services to other industries and primary 'final demand' and buy their input from other industries and primary sources. The transactions table summarizes the inter-sectoral flows in a given period and is conventionally presented in matrix form. The transactions table provides not only a concise, descriptive snapshot of a particular economy at a point in time, but it also presents a disaggregated and consistent accounting system for an economy. The final demand components (minus imports) are considered to indicate the equivalent of GNP measures on the expenditure side, and primary inputs (minus imports) are the same on the receipts side. In the regional policy context, the transactions table gives both a general understanding of the economy of a particular region and important information on particular aspects of the region's economy. Only when the transactions table has been compiled, can simple mathematical procedures be applied to derive output, income and employment multipliers for each sector in the economy.

Secondly, it is important to distinguish between 'open' and 'closed' input-output models. In open input-output models, household personal consumption is located as a column vector in the final demand portion of the table, and the row vector comprising wages, salaries and other household income is included in the primary inputs quadrant. Alternatively, the input-output table may be closed with respect to households by incorporation of the household row and column into the endogenous matrix. This distinction is critical because the range and relevance of regional multipliers vary according to which branch of the input-output framework is favoured.

Thirdly, there are two types of multipliers in input-output analysis, namely Type I and Type II. They can be described as:

Type I multiplier = direct and indirect effects / direct effects.

Type II multiplier = direct, indirect and induced effects / direct effects.

It is important to be aware at all times of the different properties pertaining to the types of multipliers which have been mentioned. For example, the income multipliers described in the sections above measure the direct and indirect effects, or direct, indirect and induced effects of a change in sales of one dollar of the output of a sector in question to final demand. Type I and Type II income multipliers measure the income generated following a Yuan (dollar) change in household payments as a result of a change in final demand for the relevant sector. In other words, the regional income multipliers measure the income impact of a change in sales to final demand, while the Type I and II income multipliers measure the income impact of a change in income. Similarly, the regional employment multipliers measure the employment impact of a change in sales to final demand, and the Type I and II employment multipliers measure the employment impact of a change in employment. A summary of input-output multipliers is presented in Table 6-1. For the sake of comprehensiveness, I have undertaken to calculate the full range of multiplier types, as the forthcoming discussion makes clear.

Table 6-1 Types of Input-Output Multipliers

Output		
	Simple	$Oj = \sum_{n+1}^{n} Zij$
	Total	$\bar{O}j = \sum_{i=1}^{n+1} \bar{Z}\,ij$
Income		
	Simple Household	$Hj = \sum_{i=1}^{n} a_{n+1,i}\ Zij$
	Total Household	$\bar{H}j = \sum_{i=1}^{n+1} a_{n+1,i}\ \bar{Z}ij$
	Type I	$Hj^{Y1} = Hj \,/\, a_{n+1,\ j}$
	Type II	$Hj^{Y2} = \bar{H}j \,/\, a_{n+1,\ j}$
Employment		
	Simple Household	$Ej = \sum_{i=1}^{n} w_{n+1,\ i}\ aij$
	Total Household	$\bar{E}j = \sum_{i=1}^{n+1} w_{n+1,i}\ \bar{a}ij$
	Type I	$Ej^{Y1} = Ej \,/\, w_{n+1,\ j}$
	Type II	$Ej^{Y2} = \bar{E}j \,/\, w_{n+1,\ j}$

symbols: n sectors (i,j...); z regions (r,s...),
Zij = element of Leontief inverse (open model), $B = (I-A)^{-1}$,
aij = household row coefficient of sector i,
wij = employment row coefficient of sector i,

$\bar{Z}ij$ = element of Leontief inverse (closed model with households endogenous),

$\bar{a}ij$ = household row coefficient of closed model (households endogenous).

Input-output multipliers at the national and the provincial levels. An examination of the matrix of calculated input-output multipliers (see Table 6-2) provides important information with respect to the input and output responses of each sector on a national basis. To prevent obfuscation, the essentials may be summarized in the manner stipulated below.

1. Generally, it would be expected that industrial sectors or groups in China would display an overall pattern in the size of input-output multipliers commensurate with their ranking in the overall economy. In other words, the 'large' groups would be expected to be more diversified and therefore would be expected to contain stronger linkages which, in turn, would contribute to higher input-output multipliers. When the 'size' of a sector is measured in terms of the total output of all sectors there is a close correspondence between the ranking of the sectors and the size of the input-output multipliers. For example, the agriculture sector is the 'largest' group, ranking first in the size of the output multipliers to boot (see Table 6-2).

However, this supposition is not always true, particularly when the multipliers are examined at the provincial level (Tables 6-3 and 6-4). The primary metal manufacturing industry, for instance, looms large in terms of its contribution to the total output of all sectors in Liaoning (10.59 per cent of the total output) but has a rather smaller stature on the output multipliers (both Type I and Type II; see Table 6-4). More importantly, it could be found that, by and large, the size of the output multipliers of Liaoning

Table 6-2 Output, Income and Employment Multipliers for Selected Industries: China, 1987

Sector	Output multipliers		Income multipliers		Employment multipliers	
	Type I	Type II	Type I	Type II	Type I	Type II
01. Agriculture	5.28	19.76	1.28	3.21	1.36	3.96
02. Coal mining	4.75	11.28	1.35	3.39	2.24	7.63
03. Crude oil & natural gas Ind.	6.02	8.04	3.58	9.01	6.58	15.02
04. Metal ore mining	4.28	7.75	1.92	4.83	3.87	10.80
05. Non-metal mining	4.69	8.96	1.84	4.62	3.24	8.97
06. Food Ind.	3.15	7.01	12.48	31.39	25.92	66.61
07. Textiles Ind.	3.62	6.89	5.96	14.97	14.22	32.96
08. Wearing & Leather Ind.	3.76	7.18	4.12	10.35	10.80	25.10
09. Wood & wood products Ind.	3.77	6.74	3.04	7.42	7.61	18.82
10. Paper & cultural articles Ind.	3.78	6.96	3.82	9.60	9.15	22.08
11. Power & heating supply Ind.	4.23	6.41	3.14	7.88	3.26	14.11
12. Petroleum refining Ind.	4.46	4.57	6.17	15.52	15.86	32.90
13. Coking Ind.	3.11	5.72	4.34	10.90	13.43	38.30
14. Chemical Ind.	3.83	6.47	5.23	13.14	13.69	31.92
15. Building materials Ind.	3.70	6.80	2.17	5.46	4.54	12.37
16. Primary metal Manu. Ind.	3.75	5.79	4.47	11.23	11.01	26.07
17. Metal products Ind.	3.89	6.40	2.85	7.18	7.82	19.07
18. Machinery Ind.	3.98	6.53	2.80	7.04	7.17	17.27
19. Transport equipment Manu. Ind.	3.87	6.13	3.40	8.55	6.43	14.46
20. Electric machinery Manu. Ind.	3.87	6.09	3.83	9.62	11.19	25.47
21. Electronic equipment Manu. Ind.	4.00	6.08	4.20	10.56	12.85	27.69
22. Instruments & meters Manu. Ind.	4.18	7.02	2.42	6.08	4.94	11.95
23. Machinery maintaining & repairing	4.05	7.07	2.21	5.57	11.96	33.29
24. Other Inds.	3.90	6.79	3.15	7.92	12.71	30.32
25. Construction	3.63	7.00	2.02	5.07	5.14	14.86
26. Transport & communication	5.40	10.39	1.37	3.44	1.86	4.98
27. Commerce	6.29	17.42	1.23	3.10	1.07	1.44
28. Restaurants	3.47	8.13	3.52	8.85	6.00	15.26

This table is calculated by the author.

Table 6-3 Output, Income and Employment Multipliers for Selected Industries: Shanxi Province, 1987

Sector	Output multipliers		Income multipliers		Employment multipliers	
	Type I	Type II	Type I	Type II	Type I	Type II
01. Agriculture	4.96	10.66	1.36	2.26	1.27	1.92
02. Coal mining	4.84	7.88	1.59	2.64	1.65	4.74
03. Crude oil & natural gas Ind.	4.09	8.94	1.21	2.01	0.00	0.00
04. Metal ore mining	4.18	6.08	2.13	3.54	3.76	12.32
05. Non-metal mining	4.48	8.90	1.34	2.22	2.42	12.50
06. Food Ind.	3.32	5.22	9.27	15.38	24.35	39.31
07. Textiles Ind.	4.59	7.00	6.34	10.51	9.77	17.39
08. Wearing & leather Ind.	4.36	5.92	4.95	8.22	6.26	11.89
09. Wood & wood products Ind.	3.97	5.18	2.87	4.77	3.42	9.55
10. Paper & cultural articles Ind.	4.03	6.07	3.32	5.52	2.79	5.63
11. Power & heating supply Ind.	4.07	4.18	4.74	7.87	4.38	11.06
12. Petroleum refining Ind.	4.07	7.58	7.77	12.90	4.33	12.32
13. Coking Ind.	3.60	4.65	3.45	5.72	3.28	8.33
14. Chemical Ind.	3.88	5.77	4.00	6.63	4.28	9.24
15. Building materials Ind.	4.19	5.07	1.91	3.17	2.74	8.92
16. Primary metal Manu. Ind.	3.74	6.57	3.76	6.24	4.16	11.85
17. Metal products Ind.	3.89	5.27	2.71	4.49	2.86	7.80
18. Machinery Ind.	3.93	5.69	2.66	4.41	2.55	6.68
19. Transport equipment Manu. Ind.	3.89	5.67	3.14	5.20	2.35	5.51
20. Electric machinery Manu. Ind.	3.83	5.20	3.45	5.67	3.43	8.60
21. Electronic equipment Manu. Ind.	4.06	5.65	3.18	5.27	3.12	7.47
22. Instruments & meters Manu.Ind.	3.36	6.59	1.89	3.13	1.77	4.34
23. Machinery maintaining & repairing	4.01	5.97	2.18	3.62	14.80	54.10
24. Other Inds.	3.65	5.32	4.39	7.28	8.89	18.40
25. Construction	3.75	5.70	2.24	3.72	2.23	6.25
26. Transport & communication	4.92	6.82	2.11	3.49	1.37	2.46

This table is calculated by the author.

Table 6-4 Output, Income and Employment Multipliers for Selected Industries: Liaoning Province, 1987

Sector	Output multipliers		Income multipliers		Employment multipliers	
	Type I	Type II	Type I	Type II	Type I	Type II
01. Agriculture	3.97	37.77	1.36	8.36	1.34	7.96
02. Coal mining	3.76	27.11	1.32	8.07	1.33	9.09
03. Crude oil & natural gas Ind.	5.94	13.01	2.70	16.55	1.98	9.82
04. Metal ore mining	4.34	15.37	1.85	11.33	3.06	28.83
05. Other mining	4.61	20.58	1.45	8.89	1.68	14.32
06. Food Ind.	3.40	17.61	10.94	67.17	11.84	71.77
07. Textiles Ind.	3.78	12.58	4.52	27.76	3.36	17.74
08. Wearing & Leather Ind.	3.95	12.80	3.28	20.15	2.87	15.57
09. Wood & wood products Ind.	3.61	12.37	2.99	19.59	2.99	20.60
10. Paper & cultural articles Ind.	3.75	12.07	3.45	21.11	2.64	14.71
11. Power & heating supply Ind.	3.88	13.33	7.35	45.12	5.40	34.82
12. Petroleum refining Ind.	3.71	6.37	6.44	39.54	4.24	22.43
13. Coking Ind.	3.11	16.05	11.32	69.49	10.04	67.95
14. Chemical Ind.	3.86	11.43	3.98	24.46	3.14	18.22
15. Building materials Ind.	3.88	13.70	2.39	14.67	2.31	15.56
16. Primary metal Manu. Ind.	3.92	11.16	4.50	27.62	3.39	22.33
17. Metal products Ind.	3.74	10.81	3.07	18.85	2.59	15.97
18. Machinery Ind.	3.93	12.05	2.38	14.62	2.16	12.76
19. Transport equipment Manu. Ind.	3.77	10.54	3.24	19.87	2.81	17.07
20. Electric machinery Manu. Ind.	3.75	9.96	3.59	22.04	2.62	14.56
21. Electronic equipment Manu. Ind.	3.97	10.36	3.36	20.63	2.67	13.28
22. Instruments & meters Manu.Ind.	4.05	12.39	2.31	14.17	1.73	8.23
23. Machinery maintaining & repairing	4.10	14.94	1.82	11.15	2.95	26.59
24. Other Inds.	4.41	15.92	1.80	11.02	4.73	54.38
25. Construction	3.71	13.93	1.96	12.06	1.90	12.35
26. Transport & communication	5.47	17.11	1.42	9.03	6.10	92.71

This table is calculated by the author.

are much larger than those of the country as a whole, while the size of the output multipliers of Shanxi (replicated in Table 6-3) are appreciably smaller than those that apply for the whole country.

2. For commodity groups falling within the mining industry, the output multipliers of Type I kind at the national level record values of 6.02 for the crude oil and natural gas sector, 4.75 for coal mining, 4.69 for non-metal mining and 4.28 for metal minerals. By comparison, the multipliers emerging for the range of activities comprising the whole manufacturing industrial group are generally lower, varying from 3.11 for the coking industry to 4.18 for the instruments and meters manufacturing industry. Only agriculture and the services' industries (with the exception of the restaurant sector) can compete with the mining industries in the magnitudes obtaining for output multipliers. This situation is repeated in reference to the size of the Type II multipliers. The mining industry continues to occupy "top" place in the sizes of the Type II multipliers when the whole system is the centre of interest. Indeed the sizes of the Type II multipliers--as one would expect--are substantially larger than those thrown up for the Type I situation (see Table 6-2). At the regional level the situation virtually duplicates that of the whole country. The high values of the output multipliers (Type I and Type II) for almost all mining industries in Shanxi and Laioning stand out in comparison with those obtaining for manufacturing industries.

3. There is a singular occurrence, placing mining at an

apparent disadvantage, which can be elicited from the analysis of income multipliers. For the mining industry, a range of multipliers can be found, from 1.35 for coal-mining to 3.58 for the crude oil and natural gas industry at the national level and from 1.34 for non-metal-mining (in Shanxi) to 2.70 for the crude oil and natural gas industry (in Liaoning) at the provincial level (Type I; see Tables 6-3 and 6-4). In other words, for each Yuan's (dollar) worth of mineral ore production, a total of C¥1.35-3.58 and C¥1.34-2.70 in income is respectively injected into the whole country as well as into the Shanxi and Liaoning economies. By way of contrast, the sizes of the multipliers for all other groups are higher, most noticeably in respect of the food industry which records values from 12.48 for Type I to 31.39 for Type II: the latter holding title to the largest multiplier in the whole economy. Similarly, the food industry is the largest group in laying claim to the highest income multipliers of Shanxi and Liaoning provinces.

4. A similar occurrence is discernible in the size of the employment multipliers. Among the 28 industrial sectors of China, the food industry exceeds all the others in the size of employment multipliers. The magnitude of employment multipliers referring to the mining industry as a group, in contrast, is the lowest; and this is particularly the case for coal mining where multipliers range from 2.24 for Type I to 7.63 for Type II. At the provincial level, the employment multipliers of the coal-industry score even lower magnitudes than those applying to the whole country. In Liaoning, for instance, the sizes range from 1.48 for Type I to

2.92 for Type II; that is, they emerge at a level smaller than all the other sectors.

5. Not only can we find remarkable distinctions between the mining industry and other industries in the sizes of input-output multipliers, but we can also discover them within the mining industrial group. In China, the metal-mining industry has a set of small output multipliers but substantially higher values for both the income and employment multipliers. Conversely, all the multipliers engendered by the mineral-fuels industries appear sizeable, suggesting that they have a profound effect on national economic development. The crude oil and natural gas industry figures prominently in this respect.

6. Examining the overall patterns of the input-output multipliers at the provincial level, we find that the sizes of the output, income and employment multipliers for Type I in Shanxi are always larger than their equivalents in Liaoning (see Tables 6-3 and 6-4), while the sizes of all three kinds of multipliers for Type II are far lower than those applying in Liaoning. This situation could be attributed to the level of industrialization or economic structure. Since the economic structure of Liaoning, one of the four largest industrial bases of China, is more advanced than that of Shanxi, and the level of its industrialization is much higher than most parts of the country (see Table 6-5), it is not surprising that this distinguishing feature emerges among the multiplier patterns.

Table 6-5 General Patterns of Economic Structure, Shanxi and Liaoning, 1987 (%)

Province	Agriculture	Mining	Manufacturing	Construction	Services	Total
Shanxi	10.97	12.04	42.31	12.44	22.24	100.00
Liaoning	10.49	4.03	60.70	8.09	16.69	100.00
The country	20.04	3.68	56.96	10.61	8.71	100.00

Source: 1. China's Statistics Bureau (1991) Chinese Input-Output Account, 1987.
2. Shanxi's Statistics Bureau (1992) Shanxi's Input-Output Account, 1987.
3. Liaoning's Statistics Bureau (1992) Liaoning's Input-Output Account, 1987.

6.3 Mining Impacts: the Development of Forward and Backward Linkages.

Indirect impacts occur in those industries that supply inputs to the industries directly stimulated and also embrace the subsequent impacts of supplying these industries. There are broad relationships between mineral and other industries through which the activity of mineral industry can make its contribution to regional development. Since considerable variation in such relationships occurs depending on the geographical scale of enquiry, it is preferable to emphasize the indirect impacts over the direct concept when focusing on the nexus linking mineral industry and regional development. The following discussion sets out the basic elements of a framework provided by linkage analysis.

Backward Linkages. A backward linkage exists when an industry purchases intermediate inputs from suppliers. The mining industry, for example, buys machinery and equipment, business services, chemical products and the like from other industries. Such measures of backward linkage from the mineral industry to other industries in the Chinese economy and selected regions can be constructed from the 1987 input-output tables, the most recent available. Backward linkage coefficients, as measured by percentage of intermediate goods and services' inputs purchased from domestic industries, are relatively smaller for mining and mineral-manufacturing industries than they are for other classes of activity. Among the 15 commodity groups examined in Table 6-6, the crude oil and natural gas industry and the non-metal-mining industry ranked lowest and fourth lowest, respectively.

Increasing the degree of integration of mineral industry into the economy of the country is a lengthy process best accomplished by gradual exposure over time. This process must begin with the implantation of scientific concepts at an early stage and then

Table 6-6 Impact Coefficients for Selected Industries, 1987

	Backward Linkage			Forward linkage		
	China	Shanxi	Liaoning	China	Shanxi	Liaoning
Mining Industry						
Coal mining	0.42	0.41	0.68	0.79	0.29	1.95
Crude oil & natural gas Ind.	0.27	0.61	0.29	0.84	1.00	1.79
Metal ore mining	0.50	0.57	0.49	1.21	1.92	2.69
Non-metal mining	0.40	0.51	0.45	0.98	1.75	1.18
Mineral Manufacturing						
Petroleum refining Ind.	0.58	0.71	0.49	0.86	54.33	0.52
Coking Ind.	0.79	0.65	1.00	0.76	0.58	1.08
Building materials Ind.	0.59	0.55	0.60	0.96	0.62	0.84
Primary metal Manu. Ind.	0.68	0.69	0.58	1.12	1.03	0.74
Metal products Ind.	0.67	0.67	0.70	0.72	1.22	0.62
Other Industries						
Agriculture	0.31	0.38	0.50	0.46	0.49	0.49
Food Ind.	0.74	0.74	0.77	0.32	0.31	0.28
Textiles Ind.	0.74	0.74	0.81	0.62	0.26	0.28
Chemical Ind.	0.67	0.69	0.62	0.83	0.83	0.68
Machinery Ind.	0.65	0.69	0.64	0.51	0.46	0.39
Transport & communication	0.30	0.43	0.29	0.55	0.69	0.43

Source: see Table 4-5.

across the full society. On this fundamental level, the country in which mineral development takes place must be prepared to undertake more fundamental industrialization based on its strong and diversified mining foundations. In fact there is evidence to suggest that China's situation has followed such a course since the 1950s, particularly during the last ten years. For instance, the magnitude of backward linkages for coal and metal-mining increased, respectively, from 0.31 and 0.38 in 1981 to 0.42 and 0.50 in 1987. This result indicates not only that the mining industry now buys a wider variety of commodity inputs from other domestic industries than was the case formerly, but also--and more importantly--that the links represent a larger proportion of the input of the supplying industry; that is to say, the commodity purchased by mining industry has a stronger influence on the domestic economy.

It should be said, however, that the supply of equipment to the mineral industry in China has not developed to the extent of being able to meet the needs of the local industry. According to the Chinese Input-Output Account, the mineral industry purchased a wide variety of equipment, totalling over C¥ 20 billion in 1987. These equipment purchases are made from a broad cross-section of both general and mineral-specific equipment suppliers. There were 41 state-run firms, largely concentrated in the North and the Northeast of China, altogether employing about 320,000 people directly in the production of these pieces of equipment in 1985. Even so, import of machinery for mineral production in 1985 still captured more than 30 percent of China's market share.

Forward Linkages. An industry is forwardly linked when its output is used as an input by one or more other industries in the economy. This suggests, then, that the mineral industry's forward linkages can be measured by:

i the number of other industries to which it sells;

ii the share of the total output of mineral products which is used by others;

iii the importance of mineral products among all the inputs used by the purchasing industry.

Such measures of forward linkage from the mineral industry to other industries in China's economy can also be constructed from input-output tables. Forward linkage coefficients of the mineral industry, expressed in percentage form, are set out in Table 6-6 for the mining industry and the mineral-manufacturing industry. Two features of the construction of the linkage coefficients should be kept in mind when interpreting this table. In the first place, linkage coefficients would ideally be derived for policy purposes by tracing the interindustry flows of mineral commodities of domestic origin only. However, this is not possible in practice because the input-output tables do not distinguish between domestic and foreign sources of a single aggregate supply. Secondly, the size of forward linkages will be affected by the level of industry and commodity aggregation utilized in the input-output tables. The higher the level of aggregation, the larger will be the size of linkages.

Generally speaking, when we use the 1987 input-output tables to analyze the coefficients of the forward linkages, we find that there are relatively larger forward linkages from mining and mineral production to other industries, particularly in respect of the metal-mining and manufacturing industry, than is prevalent with other sectors of the economy. While more than 100 per cent of the total supply of metallic ores and metal products is used by domestic industries (see Table 6-6), some 80 per cent of the total supply of mineral-fuel products is absorbed by the whole industrial system. By way of contrast, the forward linkages from other industries, such as machinery and chemical industries, are weaker. The largest coefficients occur in those mineral industries where the domestic production is insufficient to meet its needs. In metal-mining, for example, one-eighth of the total supply of iron ore was imported from foreign countries in 1987. Conversely, the smaller coefficients for the mineral-fuel industry indicate that this industry has a stronger competitive capacity not only to serve the whole country but also to export around 20 per cent of its total products to the world market. Similarly, the large sizes of forward linkages for the mining industry in Liaoning implies that the large scale attaching to the primary metal and petroleum-refining industries in that province is the major factor accounting for the large import of mining products.

What is more striking upon examining the linkage coefficients of the mining industry is the remarkably strong tendency in the size of the coefficients to decline from the forward linkages to backward linkages. This result can be ascribed to the supposition that the forward linkages render a much greater contribution to the larger sizes of input-output multipliers except for those applying to output multipliers. In other words, the strong forward linkages can be seen as chief determinants of the greater impacts of income and employment arising from the industry. Similarly, the higher forward linkage coefficients for the mining industry indicate that this production is mainly for domestic consumption, and that the diversification of both national and regional economies is a result of the expansion of mineral-resource processing, especially the branches of metal-fabricating manufacturing and petrochemical processing which have grown rapidly during the past 40 years. The full impacts of the mineral industry can be captured, therefore, by looking beyond the direct impacts to effects induced by rounds of consumer spending (that is, to embrace the indirect and, more significantly, the induced effects of the mining industry).

This apart, the smaller sizes of the backward linkage coefficients only show that the Chinese mining-services industries, for example the manufacture of mining equipment, have not developed sufficiently to meet the needs of local mineral production.

Two reasons present themselves in accounting for the small income and employment impacts of the mining industry, or expressed alternatively, in explaining why the development of mineral industry needs more capital input rather than labour input. First, mining activity is usually regarded as a capital-intensive business, and with good reason. For instance, according to *China's Statistics Yearbook 1990* the capital expenditure by the mining industry in 1987 was C¥ 30 billions, or 21.5 per cent of that of

China's industry as a whole. It is obvious that such a huge magnitude of capital input will have a strong influence on the size of income and employment multipliers if the worker-capital ratio, expressed by yuan per worker in capital investment, for the mineral industry is constant. Second, in fact, the ratio of capital investment per worker for the mineral industry has grown rapidly since 1980. According to China's Statistics Bureau, the worker-capital ratio of the mining industry increased 4.7 times between 1980 and 1987 while textiles and food industries registered an increase of only 1.5 times for the equivalent period.

Like other forms of mineral production, the non-metal-mining activity is scattered all across China. By way of contrast, the mineral-fuel industry is concentrated in only a few provinces, led by Shanxi in coal production and Heilongjiang in crude oil extraction. With its ubiquitous type of mineral resources and the final products mainly used in the local construction industry, the non-metal-mineral industry is considered as region-serving rather than region-forming, and its development rests on a limited local market which conforms to relatively small scale of operations. It is fair to surmise, then, that the non-metal mineral industry would be responsible for generating few impacts on national economies.

Whether corroborated in theory, for example, through Thompson's model of economic linkages (recollect Chapter I), or whether vindicated in practice, mining activity can play a more important role in regional development if it can successfully expand the resource-based business and manufacturing operations by means of forward and backward linkages into a diversified local economy. It is the promise inherent in such transformation that moved China and other LDCs to espouse resource-based industrialization as the principal plank in national planning. Generally speaking, the magnitude of the effect of the diversification at the regional level depends not only on which stage of industrialization the society finds itself within, but also on various internal and external development conditions obtaining within each region, such as the types, qualities and configuration of resources as well as other economic and natural factors.

Some conditions augment a region's prospects for successfully capturing the potential benefits of resource-based industrialization. First, among the major mineral resources enjoying proven reserves, there are high proportions of poor quality ores or ores that are difficult to dress and smelt. This is the case with iron, manganese, lead, zinc, sulphur, and phosphorus. Iron ores that can go directly into furnaces amount to only two per cent of the total extracted. Therefore the setting up of processing plants is likely to occur in mining areas in order to reduce operational costs. Second, coal is the dominant fuel resource in China, but only a small proportion of coal is washed to remove rock and impurities (around a fifteenth of the output, mainly from mines run by the central government), and therefore industries for the most part are relatively inefficient in transporting and using it. This has persuaded the energy-intensive industries, among them large-scale modern power stations and alumina-refinery plants, to locate at the sites of major coal mines. Third, not only because of the heavy pressure of the domestic demand for mineral products but also because of the strong tendency of concentration in heavy industry itself, the mineral-based diversification can be developed on a large scale. For example, the central area of Liaoning province with an urban population of 9 millions in 1987 was already easily one of the largest metropolitan areas in China. Yet, it would be hard to imagine this area's growth without iron, coal and crude oil exploitation and the resource-based industrialization which it has engendered (Table. 6-7 and Figure 6-1). Fourth, the development of mining industries can effect fundamental changes in the spatial pattern of economic activity. This has important implications for infrastructural development, especially transport. The heavy traffic flows generated by localized mining can sustain investment in transport facilities much more easily than the

Table 6-7 Mineral-based Industrialization in the Central Area of Liaoning Province, 1987

	The Central Area	% of the province	% of the whole country
Urban population (million)	9.0	49.0	3.4
Area (000 km)	6.8	5.0	0.1
Industrial output (billion yuan)	92.8	60.1	4.2
Iron ore (000,000 tons)	200.0	90.1	25.0
Crude oil (000,000 tons)	134.5	100.0	9.7
Coal (000,000 tons)	408.0	81.9	3.8
Pig iron (000,000 tons)	98.1	86.3	16.8
Steel (000,000 tons)	110.7	91.7	18.0

Source: Li Wen-yan (1990) China's Industrial Geography.

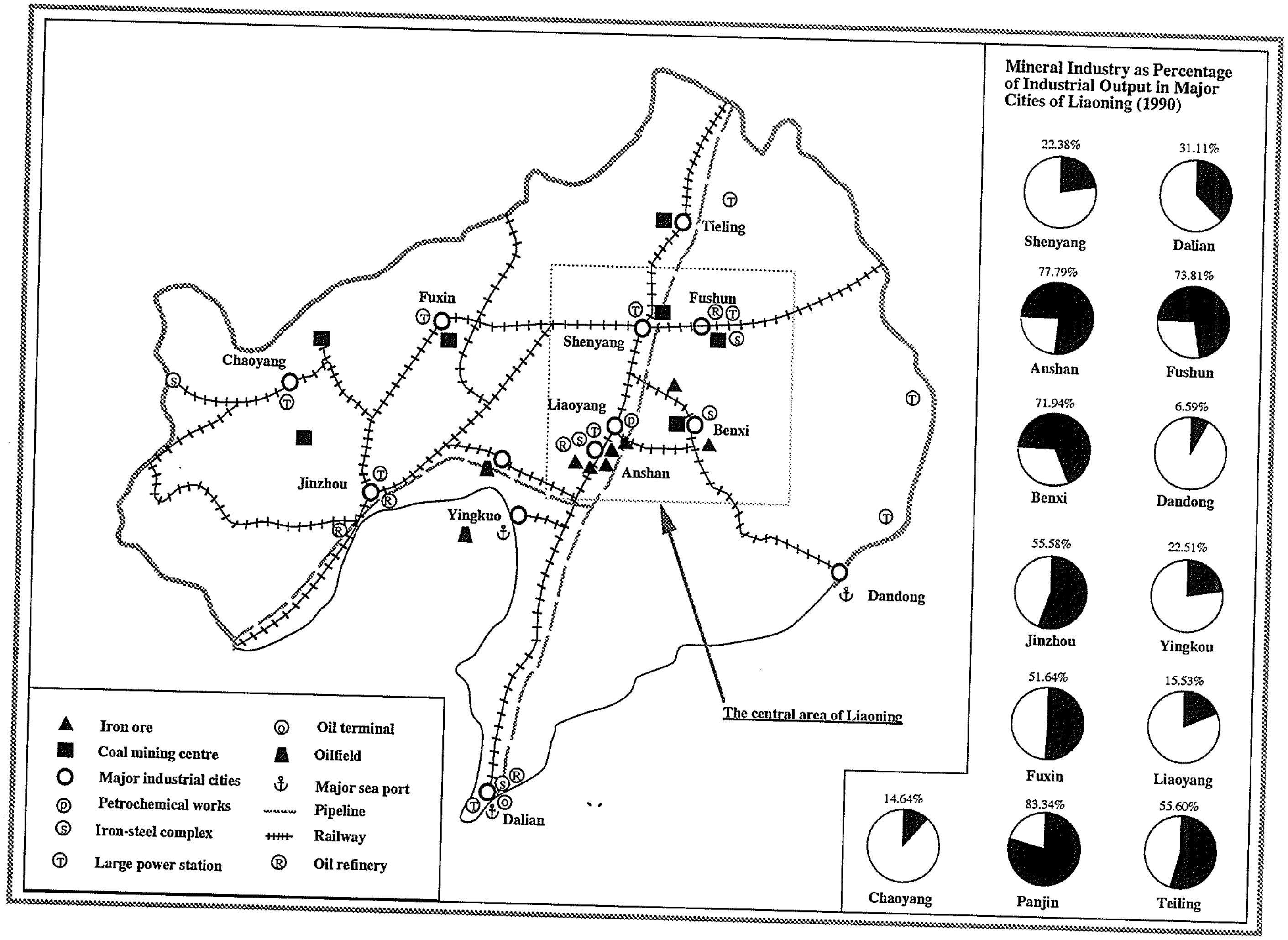


Figure 6-1 Mineral-Based Industrialization in Liaoning

diffused areal production associated with exploitation of biological resources. In fact, the regional distribution of the railway network in China is highly correlated with the expansion of mining activity. Using Eastern China as a benchmark (Figure 6-2), it is evident that the rail network is intimately involved with linking mine to power station, mine to port, mine to smelter and so on. What is more, leading trunk lines owe their existence to measures taken to effect these links. The reconstruction of Beijing-Xugezhang (Tangshan) railway line in the 1970s, for instance, secured an adequate iron- ore supply for a large expansion of the Shoudu Iron and Steel Company. The 40-km length of railway line, conveying coal from Tangshan mines to the newly-built Douhe Power Station (northwest of Tangshan), was brought to completion in 1978. Since the early 1980s, most parts of the country have suffered from a great increase in energy demand, particularly in the coastal areas. In order to relieve the energy shortage, a large-scale railway construction has begun. The most important single project of this initiative is the Datong-Qinhuangdao line (960 km), connecting the largest coal producer in the country--Datong coalfield in Shanxi with the largest coal-export port--Qinhuangdao Seaport in Hebei, and it was completed in 1991. Another important railway is the Yanzhou-Shijiusuo line (291 km), linking the important Yanzhou coalfield with the second specified coal-export port, Shijiusuo Seaport in Shandong. It was finished in 1990.

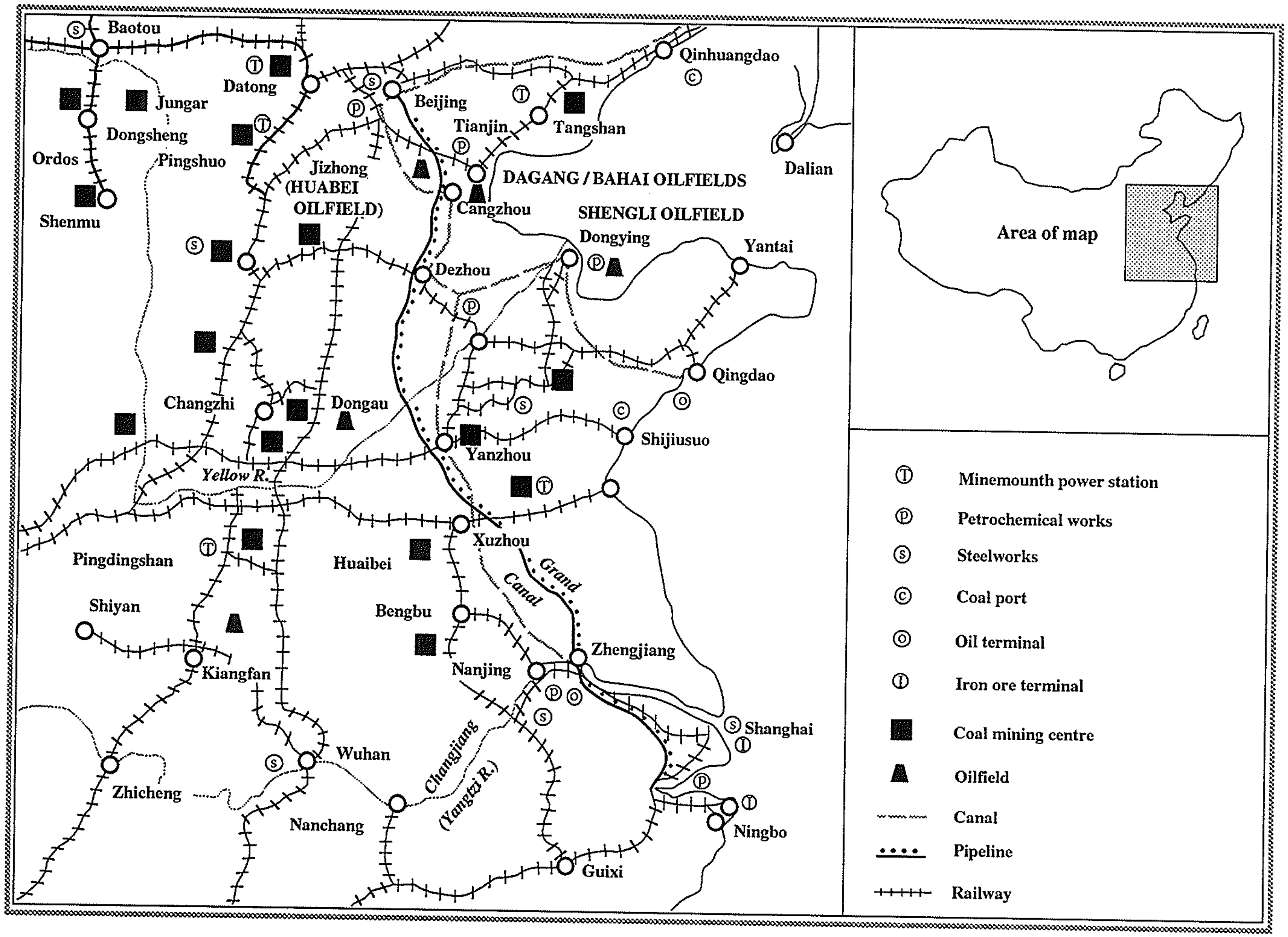


Figure 6-2 Energy Production and Transport in Eastern China

6.4 Obstacles to Mining Area "Conversion": Environmental Impacts of Mining Activity

There is another perspective concerning the contribution of the mineral industry, and that concerns the grave implications for the environment. For example, Harry Caudill (1962) in his study of the Cumberland mountains of Kentucky pointed out that "Coal has always cursed the land in which it lies.... It is an extractive industry which takes away all and restores nothing". Also from the experience of Appalachia in the United States and cases that have cropped up in many other parts of the world, mining companies are frequently regarded as environmental vandals. These negative images always encourage conflict between economic and environmental interests, especially in developed countries.

If the mineral industries have invited a poor image in developed countries in regional development terms, the same can be said for China in the context of environmental impacts and resource management. It follows, then, that discussion of the contribution of mineral industry to regional development cannot be divorced from a consideration of the environmental problem incident to the industry. The following discussion examines the circumstances as they bear on China.

Environment pollution in historical perspective. For thousands of years pollutants in Chinese rural societies consisted of only human and animal manure and fuel ash. There is a long history recording the utilization of manure and ashes from grass and wood as fertilizers which can be traced back to the remote Yin and Shang Dynasties (1766-1222 BC) (Huang Yuan-jun and Zhao Zhong-xing, 1987). This proper and traditional use of wastes meant that the three elements in organic fertilizer, nitrogen, phosphorus and potassium, were continually recycled within the biological sphere and thus provided China's farmlands with long-term soil fertilizer, to say nothing of protecting rivers and lakes from eutrophication. The ecosystem maintained its fundamental *status quo* of ecological equilibrium without the occurrence of any apparent anthropogenic pollution phenomena.

Following the gradual increase in population growth and the development of industrial production, environmental pollution became evident, initially in the urban areas. These were 20th century phenomena and so, therefore, was the attendant pollution. In particular, the latter half of the century was afflicted with the problems that arose following the birth of New China. Prominent among them were the population explosion; the lopsided development of heavy industry, which lacked a preformed concept of environmental protection; underdeveloped scientific resources and technology; and ten years' political turmoil. As a consequence, environmental pollution became a major problem accompanying China's urban development. Air pollution, for example, was becoming palpably worse in many large industrial cities, such as Shenyang and Fushun, not to say the national capital city, Beijing (see Table 6-8 and Figure 6-3). It was not until 1978 that the importance of environmental protection was recognized and incorporated in the process of economic development. In 1979 the Fifth National People's Congress adopted the Environmental

Table 6-8 Data on the Air Quality of Chinese Cities in the Late 1970s

City	SO^2 (mg/cm*)	Dustfall (t/km^2)	Dust concentration (mg/cm)	Type of data
Beijing	0.20	38	0.87	Average for the heating period in 1978
Shanghai	0.08	44	0.28	Yearly average for 1977 in different parts of town
Shenyang	0.09	39	0.51	Yearly average for 1978
Chongqing	0.21	14	0.46	Daily average for february and March in 1978
Lanzhou	0.25	36	1.32	Average for the heating period in 1978
Taiyuan	0.24	35	0.20	Yearly average for 1976
Nanjing	0.09	63	0.11	Daily average for 1976
Xuzhou	0.15	47	1.26	Average for the heating period between 1975 and 1978
Fushun	0.05	48	0.96	Daily average for 1974
China	0.15	6-8	0.15	Standards Long-term exposure (daily average)

Note; *cm=cubic metre.
Source: Glaeser (1990) The Environmental Impact of Economic Development: Problems and Policies.

Protection Law of the People's Republic of China for trial implementation. Two years later, an adjustment policy was announced and environmental protection was made a mandatory part of development policy.

Recent Situation. According to *the 1990 China Environmental Report*, environmental conditions in that year held steady. Improvement, if improvement there was, came in the wake of a series of measures taken by the state; measures geared to the rapid economic development under way that year. Environmental pollution and ecological destruction were still rampant, but, in some areas, pollution was brought under control, and in some rural areas, ecological conditions were seen to be actually improving.

In 1990 some 8,500 billion cubic metres of waste gas were discharged in the country. Of this figure, soot accounted for 13.24 million cubic metres, a 5.3 per cent decrease from the previous year; sulphur dioxide made up 14.94 million cubic metres, down 4.5 per cent; and industrial dust comprised 7.81 million cubic metres, a 7.0 per cent decrease.

National discharge of waste water was 35.37 billion tonnes in 1990, a level equal to that of 1989. Of this total, the discharge of industrial waste water stood at 24.87 billion tonnes, a drop of 1.1 percent from 1989. The water quality of the major rivers was beyond reproach, save in sections flowing through towns and cities where pollution was endemic. Ground water in most cities was seriously polluted, while 85.7 per cent of indicators used in monitoring projects of urban rivers showed water quality below standard. Lakes were contaminated by minerals such as nitrogen and phosphorus, suffering from a cycle of over-enrichment brought on by them. Much of the coastal area escaped pollution, but the same could not be said for some estuaries and bays, which experienced grave environmental damage.

As to solid waste, discharge of solid industrial waste in 1990 amounted to nearly 578 million tonnes, an increase of one per cent over the previous year. Accumulated discharge during the past few years was 6.48 billion tonnes, taking up 58,390 hectares of land, a drop of 2,986 hectares from 1989.

Generally speaking, it is rapid industrial development which constitutes the major factor affecting the national environment and

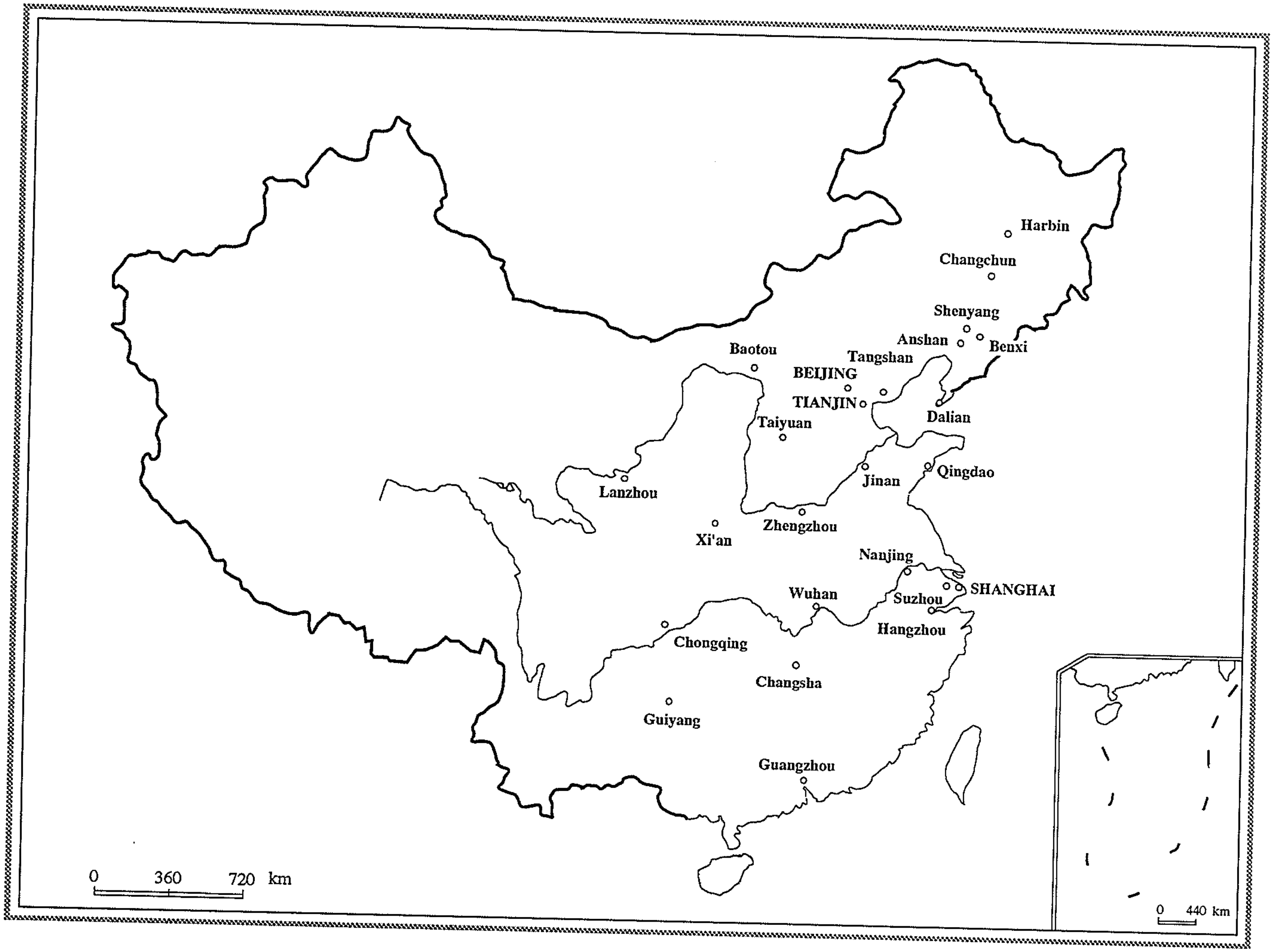


Figure 6-3 Main Polluted Cities in China , 1990

it is this phenomenon which serves as the key link in establishing urban and rural ecological equilibrium. Since 1949, a comparatively complete category of industrial production systems has been developed in China. By the end of 1990 industrial output accounted for about 45 per cent of national product (GNP). However, an incompatibility between technical aspects and management, as well as outdated technical processes and equipment, have caused losses in energy and resources and, as a consequence, have brought about a whole series of pollution problems.

The national average rate of energy utilization is only 30 per cent, which is equivalent to the level of the developed countries in the 1960s. Coal accounted for over 70 per cent of the energy utilized and annual industrial consumption has reached more than 800 million tonnes. Under these circumstances, that is to say, huge coal consumption rates and low effective utilization rates, atmospheric pollution will mainly consist of smoke-dominated contamination. According to statistical data, 60 per cent of the nationwide emission of pollutants into the air were in the form of dustfall. Among the pollutants detected were nearly 1500 million tonnes of sulphur dioxide, the agent which leads to acid precipitation. These were emitted over sizeable areas in twenty provinces, municipalities and autonomous regions. The rate of recycling of industrial water for reuse is very low compared with the consumption rate and many industrial cities recycled less than 40 per cent. This figure is far below the world level. In 1990, industrial liquid waste accounted for 70 per cent of the total liquid waste, most of which was discharged directly into river systems without prior treatment. This is the main source of the surface-water pollution that occurred near the outlets of trunk rivers close to large- and medium-sized cities (see Figure 6-3). In the meantime, about 80 per cent of China's total solid waste was produced by industry and amounted to nearly 570 million tonnes. Solid waste is mainly in the form of ash and slag products from coal combustion and coal gangue. This accounts for 55 per cent of the total. Other waste products include slag from smelters, chemical waste and industrial soot and dust.

Environmental impacts of mineral industry. Many of the most obvious, and some of the most severe, disruptions of the natural environment come from the development of mineral industry. Mining, quarrying, dredging, exploitation and extraction from wells, are activities that have marked impacts on the landscape and natural environment. Directly linked to these activities are problems concerned with the disposal of waste products that are often produced by them. More importantly, once resources have been extracted from the earth and processed, further disruption of the environment may be caused by their actual use. The principal example is the burning of fossil fuels in power stations, homes, and engines, particularly automobile engines, that results in emission of gases, particles, and in some cases, excess heat, into the environment.

In order to gain an insight into the manner in which the development of China's mineral industry influences regional

Table 6-9 Environmental Impacts of Mineral Industry: China, 1990

Region	b	R squared	F	t
Air Pollution				
The Country				
Mineral Processing Ind.	0.004	0.876	203.646	14.281
Hebei				
Mineral Processing Ind.	0.004	0.913	240.302	15.502
Liaoning				
Mineral Processing Ind.	0.002	0.931	256.555	16.017
Shandong				
Mineral Processing Ind.	0.002	0.862	214.391	14.642
Water Pollution				
The Country				
Mineral Processing Ind.	0.156	0.825	136.472	11.862
Jiangsu				
Mineral Processing Ind.	0.108	0.907	244.856	15.648
Hubei				
Mineral Processing Ind.	0.073	0.956	625.368	25.007
Sichuan				
Mineral Processing Ind.	0.052	0.826	104.469	10.221
Industrial Solid Wastes				
The Country				
Mining Ind.	0.003	0.589	40.038	6.328
Mineral Processing Ind.	0.003	0.750	87.043	9.330
Hebei				
Mineral Processing Ind.	0.003	0.881	170.056	13.041
Liaoning				
Mineral Processing Ind.	0.001	0.833	95.069	9.750
Sichuan				
Mining Ind.	0.014	0.852	120.546	10.979

environmental conditions, I have resorted to the use of regression analysis. Application of this form of analysis entails, first, compiling a proxy for the latter from the dependent variables of water, air and solid wastes and, secondly, relating these to the independent variables of mining and mineral-processing industries. Data are amassed for 1990 referring to each of the three most polluted regions together with the country in aggregate. Beginning with the most overriding result, it is evident from Table 6-9 that a substantial direct relationship exists at both the national and the regional levels between mineral-processing industry and environmental pollution. The mining industry, to the contrary, records a direct relationship only in one instance at the regional level (Sichuan) and, again, at the national level. Since all the provinces at issue record statistically significant equations (inferred from F values) and 'b' parameters (manifest in the t values) and granted that the 'explanation' (R squared x 100) attending the country and each provincial equation consistently exceeds 58 per cent, this relationship must be treated with respect. Thus the regression analysis leads me to conclude that the serious environmental problems caused by the mineral industry at the national and provincial levels are mainly attributable to the rapid development of mineral-processing industries whereas, in marked contradistinction, the mining industry has a comparatively much smaller impact on its surroundings.

6.5 Conclusion

In the light of the weaknesses attending export-base or economic-base theory, input-output analysis is introduced to provide us with insights into the overall level of regional economic activity based on mineral industry.

Input-output models have been developed which use the transaction accounts to capture the primary impact (direct plus indirect effects) and the total impact (direct and indirect plus induced) of a change in final demand for the mineral industry of China. Findings affirm that the latter mechanism plays a more important role than the former because the overall impact of the mineral industry extends far beyond mere direct effects.

It should be noted that such models necessarily ignore a number of factors which may be critical to industrial performance, such as supply scarcity, foreign competition and technological change as well as price changes.

Despite the limitations impinging on input-output analysis, the fact remains that impact analysis based on input-output models is a highly useful exercise in one important respect; namely, it allows the application of a uniform methodology to a data base consistently derived across industries. Nickel *et al* (1978) have observed that multipliers derived from other techniques are not generally as amenable to interindustry comparison as those rooted in input-output analysis, and are thus somewhat limited in their usefulness for policy purposes. It is clear that to a certain extent the analytical technique chosen depends on the type of study being conducted; for example, the interregional and regional input-output models can be used to assess the impact of specific mining projects as well as the mining industry at large. The format of the models can be adjusted to reflect the variations in scale.

It is possible to generalize to some extent about the impact of the mineral industry on China's economies. The input-output multipliers of the mineral industry, for the most part, are quite low for the mining industry and remarkably high for the mineral-processing industry in comparison with those of other industries. To be specific:

(1) the total income generated in the economy (GDP) resulting

from a million-yuan increase in demand for mineral products is well within the range calculated for other industries; the multipliers for mining range from 3.39 to 9.01; at the same time, the multipliers for mineral processing activity register from 5.46 to 15.52 (see Table 6-2);

(2) one job in mining industry creates one to fourteen other jobs, while in mineral-processing industry an incremental job introduces thirteen to thirty-seven others in the national economy;

(3) per million yuans of input, the amount of output created by mining is remarkably higher than other industries, but by mineral-processing activity it is neither remarkably high nor remarkably low;

(4) the development of the linkage effects for the mineral industry, especially the set of forward linkages, has become a determining factor in the size of its input-output multipliers.

After examining the positive effects of mineral industry, I turned to discuss the negative impacts on the economies; that is, the bundle of environmental impacts. Indicators have shown that the situation of air, water and land pollution in the major urban areas of China, especially in the urban areas developed mainly on mineral-based activities, became steadily worse until the early years of the 1980s, although the Chinese government had acknowledged the existence of these problems from the mid-1970s. Regression analysis intimates that the development of the mineral-processing activity has a very close relationship with environmental disruptions, particularly in urban areas, while the mining industry disseminates limited effects on its surroundings.

It has been recognized that the resource and environmental problems in China are intercorrelated to a greater degree than in many other countries. First, the huge population intensifies the effects of land, mineral resource, water, and climate constraints. Second, economic development in China places heavy reliance on coal as its prime industrial and domestic fuel. Third, the backwardness of China's industry and infrastructure makes it very difficult to design and implement modern, technology-based strategies for pollution control and resource management.

Hitherto, this study has examined China's mineral industry in terms of its performance in both national and regional development. It is clear that the country possesses a rich and varied mineral resource base along with the variables that tend to impact on production, utilization and location of industrial minerals: a large, growing population, rapidly increasing living standards, an expanding industrial base, growing needs for export earnings and technology introduction, a vast unmet demand for infrastructure, abundant low-cost labour and an increasing concern for environmental protection. These variables, and the intricacies of their interaction, are best explored with the aid of a standard statistical methodology. To that end, the study will direct our attention in the next chapter to multivariate techniques--factor analysis and cluster analysis--in order to arrive at a measure of the independent contribution of mineral production to the national socio-economy in general, and its impacts on the national centre-periphery structure in particular.

CHAPTER VII

METHODOLOGY AND APPLICATION

7.1 Introduction

A theme running through this thesis and one that has been emphasized in the last two chapters maintains that the development of large-scale mineral resources and mineral-based industrial projects in China in recent decades has been instrumental in moulding the country's regional development. Such a development has promoted structural transformation and, thereby, stimulated economic, social and demographic growth in the affected areas. However, assessments of mineral production and its impacts on regional development are often quite complex not only because of the uneven distribution of mineral resources but also because of spatial aspects of mineral production being viewed broadly as the whole process of change brought about by the creation and expansion of an interdependent national economic system. Regional development is not simply economic growth; it has broad causation linkages between economic and social activities. Indeed, in the context of mineral exploitation in China, while economic growth has been of primary concern, it does not mean that social consequences must be overlooked. Nor is development exclusively measured by economic criteria such as GDP per capita or industrial output; criteria of social welfare and infrastructure are increasingly important. Discussion of the contribution of mineral production to regional development, therefore, cannot be divorced from a consideration of social and other economic factors.

It is equally important to be mindful of the fact that development is fundamentally about correcting inequality, and this is a spatial as well as social, demographic and occupational problem. A basic concept about it is cumulative growth. As already mentioned in Chapter I, once a region (for whatever reason) gains an initial advantage over others, various forces tend to widen rather than reduce the gap between them; once triggered, growth proceeds by 'circular and cumulative causation', while spatial interaction with other regions tends to heighten the regional disparities by the process of 'backwash' (Myrdal, 1957). Although eventually counteracting 'spread' effects can develop, these tend to be weaker, and cannot prevent the development of a 'centre-periphery' structure. The peripheries of a nation develop a dependent relationship to the industrial centre, supplying it with resources' inputs, and lagging behind it in development. When economic growth is sustained over long periods, some equilibrating tendency may occur and progressive integration of the space economy may result, through outward flows of growth impulses down the regional hierarchy and catalytic impacts on surrounding areas (Berry, 1973).

In view of all these factors, anyone desirous of grasping a comprehensive appreciation of development should pay heed to two basic questions. First, are there any independent contributions of mineral production to regional development once the overall patterns of socio-economic change are taken into account and, if so, how great are they? Second, and following from the first, what is the influence of mineral development on the national centre-periphery structure? To answer these questions adequately, it is necessary to rely on statistical analysis. The main research objective of this chapter, therefore, is to arrive at an adequate means of modelling the intricacies of the stimuli afforded to regional development by mineral production. In so doing, it fulfils the sixth and the last target outlined in Chapter I; a target which, like the others, is put forward to reveal the extent by which development stems from mineral activities.

7.2 The Modelling System and Data: Description Progressing to Explanation

Like most other research contexts, the relationship between mineral production and regional development can be examined by making use of a large number of variables. Yet since many of these variables are interrelated, information is duplicated and the essential structure of the system is obscured. In order to eradicate the obscurity and discover underlying structure, it is essential that the statistical tools provide a means of deducting redundancies from a set of interrelated variables so that what remains is a 'simple structure' consisting of a small number of composite indicators (variables). Certainly, one would expect *a priori* that mineral production would influence several development indicators across the spectrum of socio-economic phenomena in a roughly even fashion. The set of indicators (variables) constitutes a multivariate system, one couched in this instance to represent the nature of regional development. The corresponding influences of mining on the variables within the multivariate system are uncovered initially by means of correlation analysis. Combining bivariate correlations in a manner which dispenses with redundancies calls for multivariate techniques, and in particular, factor analysis. Quite simply, this is a methods of investigating the correlation structure of a multivariate system. In essence, it is designed to uncover causal order, explain uniformities, or classify correlation. The nature of the factors, as well as the relationships between the factors, can allow one to summarize the basic characteristics and patterns of the research perspective. Considering the general pattern of regional development in China, there are, at least, two common factors expected to occur, one which could be denoted as a social development factor leaving the other to be interpreted as the mineral-industry-led growth factor. It is also important to realize that, in the first place, regional development in China is the consequence of a long process of accumulation, redistribution of natural endowments and social wealth, and, in the second, that mineral activities have played a dominant role in regional growth only in the last four decades when the country has changed from an agrarian society to one rooted in industry. In this sense, therefore, the social development factor could be expected to be the leading dimension emerging from the mass of development strands leaving the mineral-led-growth factor to have a less significant role in China's regional development.

Once the common factors are identified, the next step in the study is to classify the set of observations into groups so that the spatial consequences of mineral development in China can be tested. I maintain that there should be two single groups with large dissimilarities or statistical distances separating them if there is a centre-periphery structure embedded in China: one of these should collect together the observations constituting the "centre" portion of the country whereas the other should assemble those observations composing the "periphery". Should this not be the case, it cannot be claimed that mineral production has any significant and stable effects on the development of a centre-periphery structure. This would conflict with the "regional" aspect of the general hypothesis which holds that the centre-periphery structure, if anything, should be reinforced as a consequence of substantial mineral developments. Cluster analysis can be employed to test this hypothesis. Not only can cluster analysis provide for the extraction of discrete groups by hierarchical plot to show an overall pattern of the centre-periphery system but also it can test the general hypothesis without requiring any changes in the nature of the original input data used for factor analysis.

Factor analysis and cluster analysis can be valuable tools in the exploration of multivariate data. By organizing such data into common factors and clusters, factoring and clustering can help us discover the characteristics of any structure or pattern present. Both techniques are often compared to each other, and much has been written concerning the relevant advantages and disadvantages of each technique (Everitt, 1974 and 1980). Often, the methods are distinguished from each other by suggesting that factor analysis is mainly concerned with grouping the columns of a matrix X (i.e. the variables), while cluster analysis is preoccupied with grouping the rows of a matrix X (i.e. the observations or individuals). A more fundamental difference, perhaps, is the explicit linear model assumed in factor analysis (McDonald, 1985). However, the purpose of this chapter is not to consider the claims and counter-claims made by the proponents of the two classes of techniques. Here, it should suffice to say that both factor analysis and cluster analysis should be considered for the exploration of complex multivariate data. Figure 7-1 outlines the different steps inherent to both techniques as applied in this study.

In order to empirically apply the foregoing modelling system (see Figure 7-1), data on China's economy of 1990 are collected. The observed regions in this study cover 27 provinces and Autonomous Regions and the three municipalities of Beijing, Shanghai and Tianjin. All the data for this study are compiled from information contained in the *Statistics Yearbook, 1990*, the only reliable official information in China. Table 7-1 lists these data when couched as variables.

In terms of the intention of this study, 25 variables are selected, each of which can be classified as bearing on mineral industry, or social, economic and environmental development. The group representing mineral industry consists of seven variables (COALOUT, OILOUT, PIGIRON, STEEL, MINASS, RAWMASS and MIORALL). The reasons for choosing these variables to stand for mineral industry are self-evident. Coal and crude oil are the two primary energy

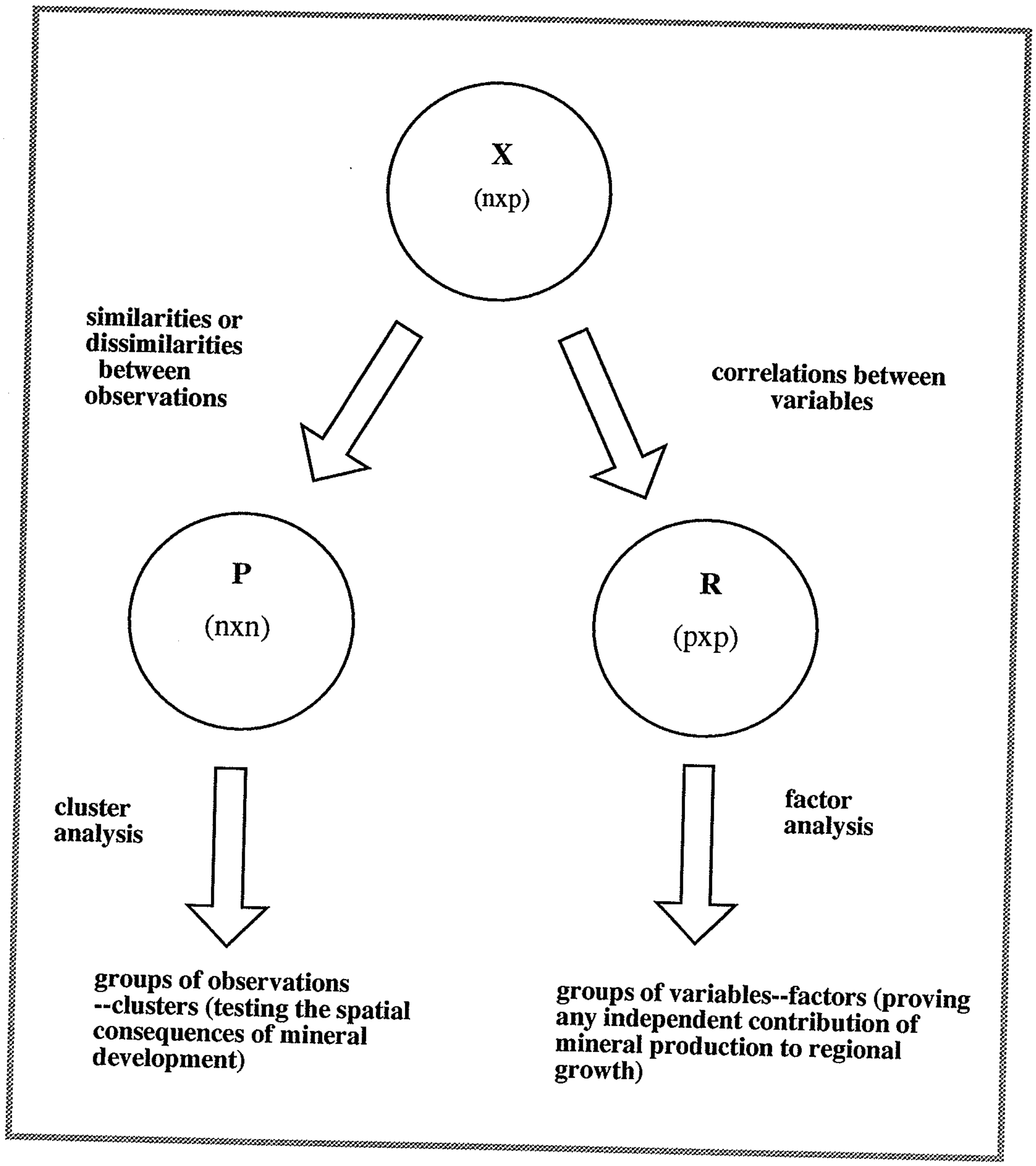


Figure 7-1 Modelling Framework of Factor Analysis and Cluster Analysis

Table 7-1 Variable Explanation

Variables	Contents
COALOUT	output of coal products (mlt) (1990)
OILOUT	output of crude oil (mlt) (1990)
PIGIRON	output of pig iron (mlt) (1990)
STEEL	output of crude steel products (mlt) (1990)
CAPINVE	capital investment per capita (1952-90 Yuan/p)
GDP	GDP per capita (Yuan/p) (1990)
TERTVAL	total value of tertiary industry per capita (Yuan/p) (1990)
INDASS	industrial fixed assets per capita (Yuan/p) (1953-1990)
MINASS	fixed assets of mining industry per capital (Yuan/p) (1990)
RAWMASS	fixed assets of raw material manufacturing per capita (Yuan/p) (1990)
STUDENT	number of university and college students per thousand persons (p/tp) (1990)
SCIENT	number of scientists and technicians per thousand persons (p/tp) (1990)
HOSPBED	number of hospital beds per thousand persons (p/tp) (1990)
INDEMP	number engaged in industrial employment per thousand persons (p/tp) (1990)
INCOME	per capita income (Yuan/p) (1990)
INDVAL	output value of industry per capita (Yuan/p) (1990)
AGRVAL	output value of agriculture per capita (Yuan/p) (1990)
URBANP	ratio of urban population at provincial level (percent) (1990)
ENECOS	total energy consumption per capita (tce/p) (1990)
WASWAT	discharge of waste water per capita (cm/p) (1990)
WASARI	discharge of waste air per capita (sm/p) (1990)
MIORAIL	proportion of mineral products in freight traffic volume of railway system per capita (t/p) (1990)
FREIGHT	freight traffic volume per capita (t/p) (1990)
POPUL	density of population (p/sm) (1990)
FOREIGN	total value of foreign trade per capita (US$/p) (1989)

Note: (1) mlt=million tonnes; t=tonne; p=person; mlp=million persons; tce=tonnes of coal equivalent; cm=cubic metre; sm=square metre.
(2) see Appendix 7-1.

sources, and pig iron and steel are the two basic metal products for the national economy. The output of the four mineral products as well as fixed assets in mining and raw-material manufacturing can be regarded as powerful indicators of the development of the mineral industry. For its part, the last variable could indicate the dependence of local economy, either mineral exporter or importer, on the mineral products.

The social group is composed of five variables. These are, in no particular order: the ratio of urban population at the provincial level (URBANP), the number of hospital beds per thousand persons (HOSPBED), the number of university students per thousand persons (STUDENT), the number of scientists and technicians per thousand persons (SCIENT), and the density of population (POPUL). Clearly, they evince the general pattern of regional advantages in urbanization, social wealth, education, scientific and technological development. Considering that China now implements a policy of nine-years of compulsory education and that enrolment in high school for all parts of the country has reached more than 80 per cent of the total eligible young people, the numbers of primary-school pupils and high-school students per thousand persons have, therefore, little value as indicators of spatial variation in development patterns. They are not used for that reason.

The economic group is the largest, containing GDP per capita (GDP), per capita income (INCOME), outputs of agriculture (AGRVAL), industry (INDVAL) and tertiary industry (TERTVAL), industrial fixed assets (INDASS), industrial employment (INDEMP), total energy consumption (ENECOS) and foreign trade (FOREIGN). The first two variables can be regarded as a mirror to the general development of regional economy, while the outputs of agricultural, industry and tertiary activities can be employed for measuring the structural change that has occurred in the local economy. The last four variables can be used to shed light on the development of industrialization.

The last group, the environmental development group, consists of six variables. Capital investment (CAPINVE) is a key factor coming to bear on the overall regional development environment, and it reflects the regional preference or bias in the process of national industrialization during the past forty years. The freight traffic volume (FREIGHT) and total value of foreign trade (FOREIGN) represent the development of regional infrastructure, while the discharge of waste water and waste air indicate the degree to which the regional physical environment is polluted.

7.3 Application and Results: the Model's Veracity

The results of factor analysis applied to the multivariate structure are presented in Table 7-2 [1]. As explained, the factor loadings indicate the net correlations between each factor and the observed variables. The communality represents the proportion of the total unit variance of variable *i* which is explained by all common factors *p* taken together; standing, for example, at 97.1026 per cent for per capita GDP. For the whole set of observed variables, the percentage of common variance, explained by the four

Table 7-2 Rotated Factor Loading Pattern

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Communality
SCIENT	0.96862	0.13941	-0.03043	-0.03422	0.959751
CAPINVE	0.93640	0.17610	-0.15473	-0.02524	0.932434
URBANP	0.90917	0.23280	-0.10854	0.15939	0.917966
STUDEN	0.89997	0.23405	-0.11657	-0.13925	0.897703
ENECOS	**0.87932**	**0.26158**	**0.20138**	**0.23304**	**0.936491**
TERTVAL	0.87322	0.31870	-0.32507	0.03539	0.971026
INDASS	0.86099	0.43373	-0.10069	0.17884	0.971552
HOSPBED	**0.85289**	**0.26464**	**0.18669**	**0.03240**	**0.833333**
FREIGHT	**0.84951**	**0.26243**	**0.20448**	**0.01796**	**0.832669**
GDP	0.83259	0.42915	-0.30455	0.01255	0.971026
INCOME	0.79450	0.47177	-0.33825	0.07318	0.973564
RAWMASS	**0.75469**	**0.61446**	**0.02104**	**0.05349**	**0.950425**
INDEMP	0.74349	0.51953	-0.20591	0.21998	0.913479
INDVAL	0.74288	0.51641	-0.35411	0.13899	0.963264
WASARI	0.70913	0.62471	0.03469	-0.18265	0.927688
STEEL	0.28212	0.87687	0.21763	-0.06606	0.900218
PIGIRON	0.16214	0.80913	0.45285	-0.01994	0.886454
WASWAT	0.49221	0.72453	-0.30013	0.02340	0.857839
FOREIGN	0.54569	0.66875	-0.31070	0.11144	0.853962
POPUL	0.40463	0.64481	-0.47702	0.09639	0.816347
MIORAIL	0.01006	-0.02601	0.71161	0.04891	0.509556
COALOUT	-0.10612	0.14177	0.66955	0.34928	0.601647
OILOUT	-0.03791	0.05888	0.12188	0.82251	0.696288
MINASS	0.52789	-0.21509	0.22035	0.61510	0.751830
AGRVAL	-0.05736	-0.10415	0.26782	-0.68995	0.563287
	**********	**********	**********	**********	
Eigenvalue	13.24478	2.45303	1.64276	1.32749	18.668060
	**********	**********	**********	**********	
% Variance explained	49.08	21.87	9.77	6.05	86.77

factors, is 86.77 per cent.

The technique for determining how many factors to extract in this study is *Kaiser's criterion* suggested by Guttman and adopted by Kaiser. The rule is very simple to apply. Only the factors having eigenvalues greater than one are considered as common factors. This method is particularly suitable for principal components' designs and probably most reliable when the number of variables is between 20 and 50 (Cattell, 1952). In terms of *Kaiser's criterion* only the four factors, in Table 7-2, have eigenvalues greater than unity--the fourth factor, indeed, just exceeds unity (1.32749)--while the others have too small eigenvalues (less than one) to be considered further.

Table 7-2 also provides the basis to group the variables into common factors. Each variable is assigned to the factor in which it has the highest loading. Once variables are assigned to common factors, the factors must be "identified"; that is, given a title descriptive of their contents.

It may be observed that there exists strong and positive correlation between Factor 1 and more than half of the observed variables, registering from a high of 0.96862 for scientists and technicians per thousand persons (SCIENT) to a low of 0.54569 for per capita foreign trade (FOREIGN). Factor 1 may be interpreted as the "Social Development Factor" characterized by a highly-developed urbanization: the results of highly-concentrated scientific, educational and public health services, capital and industrial investments (CAPINVE, INDASS and MINASS); urban population

(URBANP); a high consumption of energy (ENECOS); and a small population size as well as a low level of mineral production. The negative loadings for coal and crude oil mining (COALOUT and OILOUT) are in accordance with the centre-periphery relationship view that the mining frontiers have always poor images in social development because of their remote locations.

Factor 2 may appropriately be called the "Mineral-Processing-Led Growth and Regional Environment Factor", with highly positive loadings recorded for steel production (0.87687), pig-iron manufacturing (0.80913), water pollution (0.72453), international trade (0.66875), population size (0.64481), air pollution (0.62471) and raw-material manufacturing (0.61446). Such a factor loadings' pattern strongly suggests regional growth based on mineral production, leaning particularly on the presence of the iron and steel industry. Development of this nature is instrumental for occasioning a great increase in foreign trade and population on the one hand, and a serious damage of regional environments on the other hand. The negative loadings obtaining for the mining industry (MINASS and MIORAIL) reflect the fact that the development of mineral-based industrialization is a powerful medium of spatial organization, working to reinforce the national centre-periphery structure rather than to create new rivals to the original core.

Factor 3 may be regarded as the "Coal-Mining-Led Growth Factor". The two significant loadings, 0.71161 for coal movement (MIORAIL) and 0.66955 for its production (COALOUT), indicate that coal movements render greater contributions to regional development than does coal production. Through effecting great improvements in transport infrastructure, the former is critical to the formation of an integrated national transport system: in itself far more effectual in furthering regional or interregional development than mere coal production alone (recall Chapter V). The low and negative loadings applying to all other variables may point to the locational disadvantages of coal production when most coal mines remain in peripheral areas, which are always poor in socio-economic foundations.

Factor 4 may be labelled as the "Oil-Exploitation-Led Growth Factor", boasting as it does two significant loadings for crude oil production (OILOUT, 0.82251) and mining investment (MINASS, 0.61510). It could be argued that crude oil production is a capital-intensive business and that is demonstrably the case when it is recalled that more than 60 per cent of the total investment in mining activity in China during the past twenty years has been committed to this activity (also see Chapter III). Factor 4 should, therefore, be considered as centring on one loading; that is, crude oil production. The low and negative loadings for all other variables save the two highlighted imply that the location of crude-oil exploitation and mining investment are forthcoming with social disadvantages comparable to those associated with coal mining.

On the basis of the factor scores pertaining to the four factors, the 30 observed regions can be divided into four types: the highest group with factor loadings of more than 1.0; the higher group with factor loadings of between 1.0 and 0; the lower group evincing loadings of between 0 and -0.5; and finally, the lowest group with loadings of less than -0.5 (see Appendix 7-2). Figures 7-2 to 7-5 show the classification of all observed regions for each factor. For Factor 1, Shanghai, Beijing, Tianjin and Liaoning are identified as the leading regions enjoying privileges in social development. Liaoning, Shanghai, Hubei and Sichuan are the most important regions on the strength of mineral-based industrialization (Factor 2). Shanxi, Liaoning and Heilongjiang are the three key regions in coal movements and production (Factor 3), while Heilongjiang, Shandong and Tianjin dominate the scores pattern of Factor 4 (also see Appendix 7-2). For the leading regions, an "overlapped" pattern could imply that, if a region wants to surpass others in enjoying greater progress in economic development, it not only must register as high as possible in a factor loading on a single critical factor but also register high loadings throughout the factor pattern. It is obviously the case that a high factor loading is the most important for regional development and it can be taken as indicative of the advantages of regional resource endowments. It is also very important for a region to assume a leading position on several factors ostensibly unconnected with minerals; for it means more opportunities in economic growth for this region than for other regions. Therefore, it comes as no surprise to notice that Liaoning emerges prominently in the overall factor pattern three times (on Factors 1, 2 and 3) while Shanghai crops up twice (Factors 1 and 2), as does Tianjin

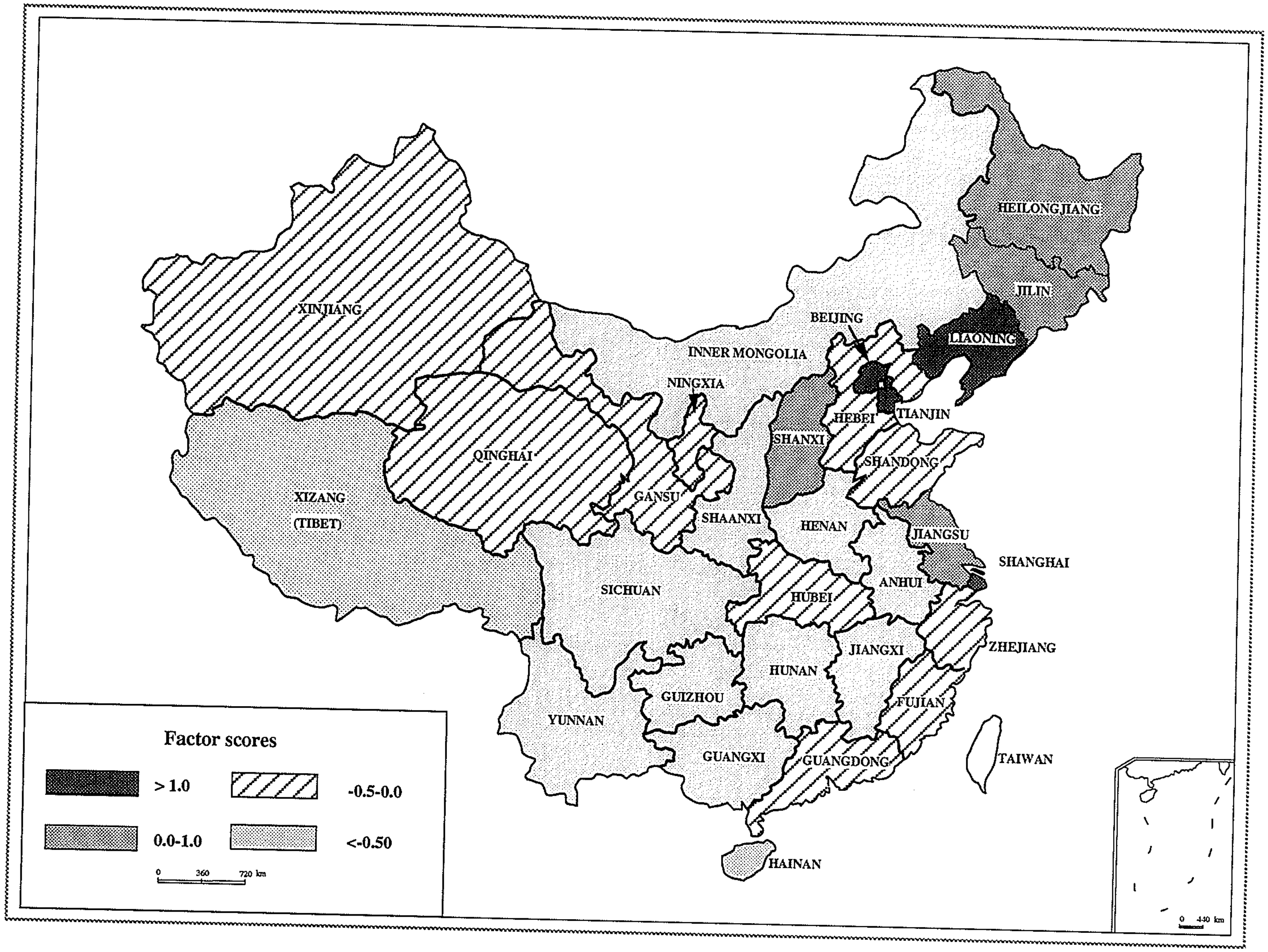


Figure 7-2 Socio-Economic Development Factor of China

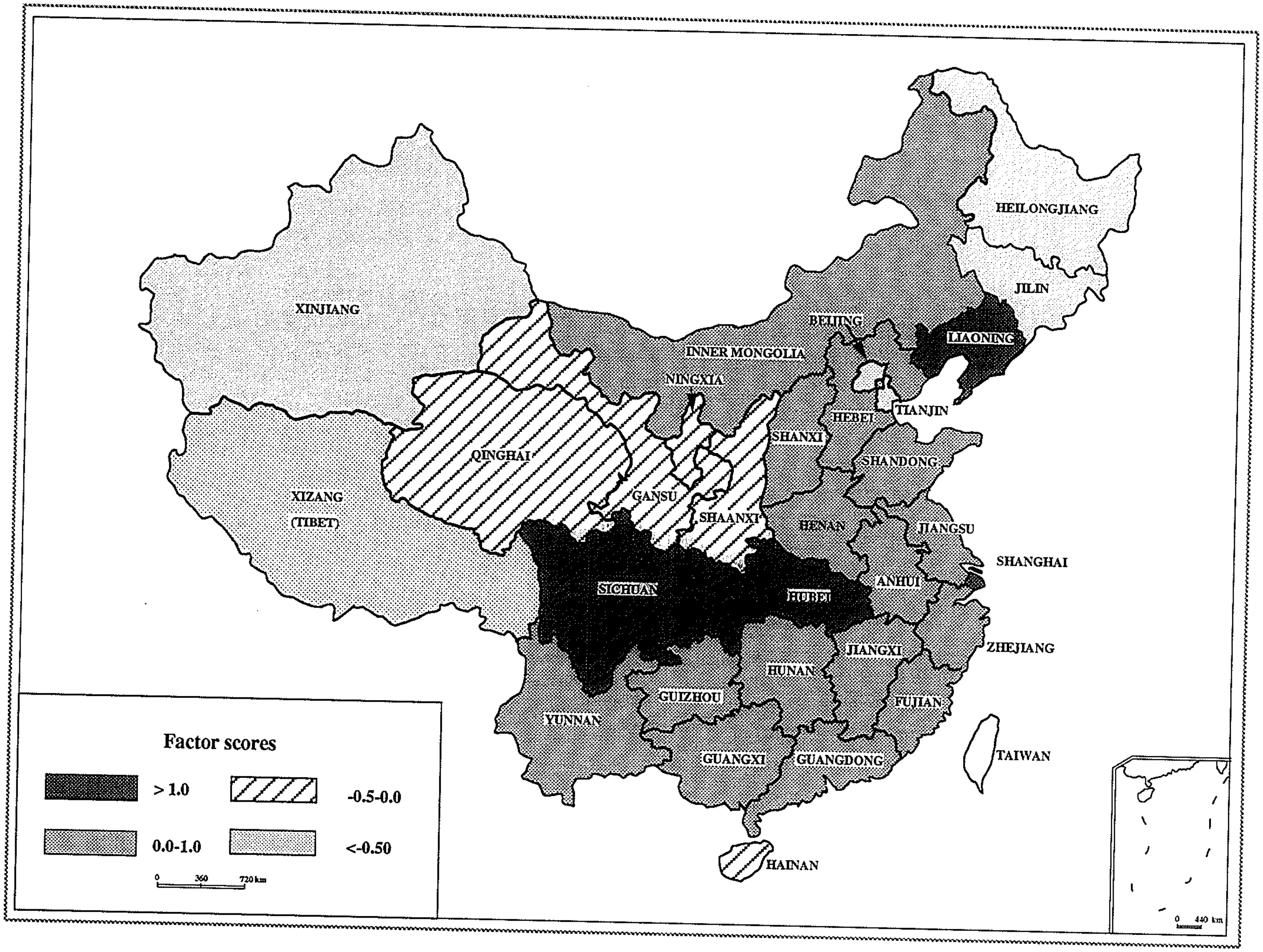


Figure 7-3 Mineral-Processing Development and Environment Factor of China

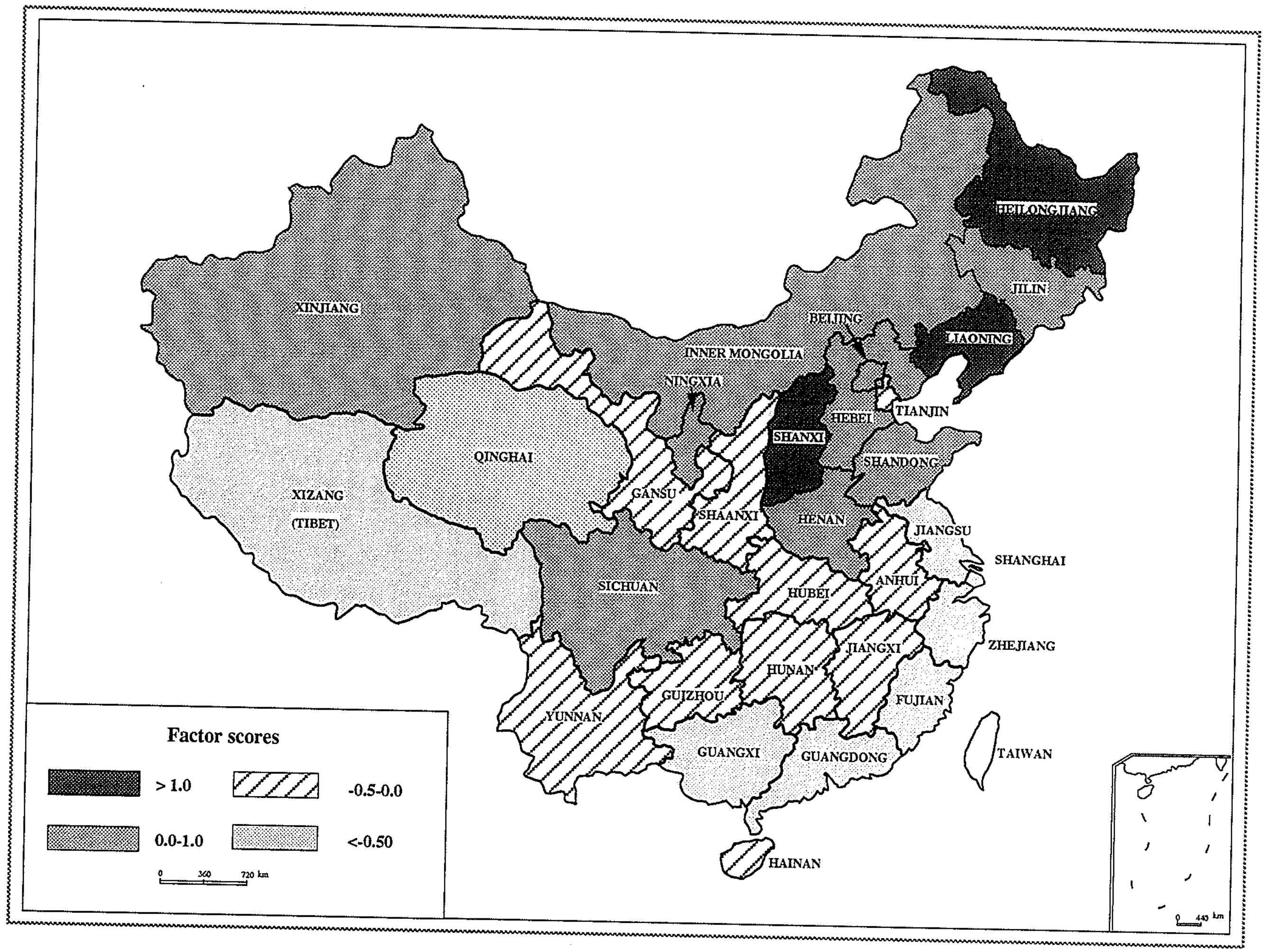


Figure 7-4 Coal-mining Development Factor of China

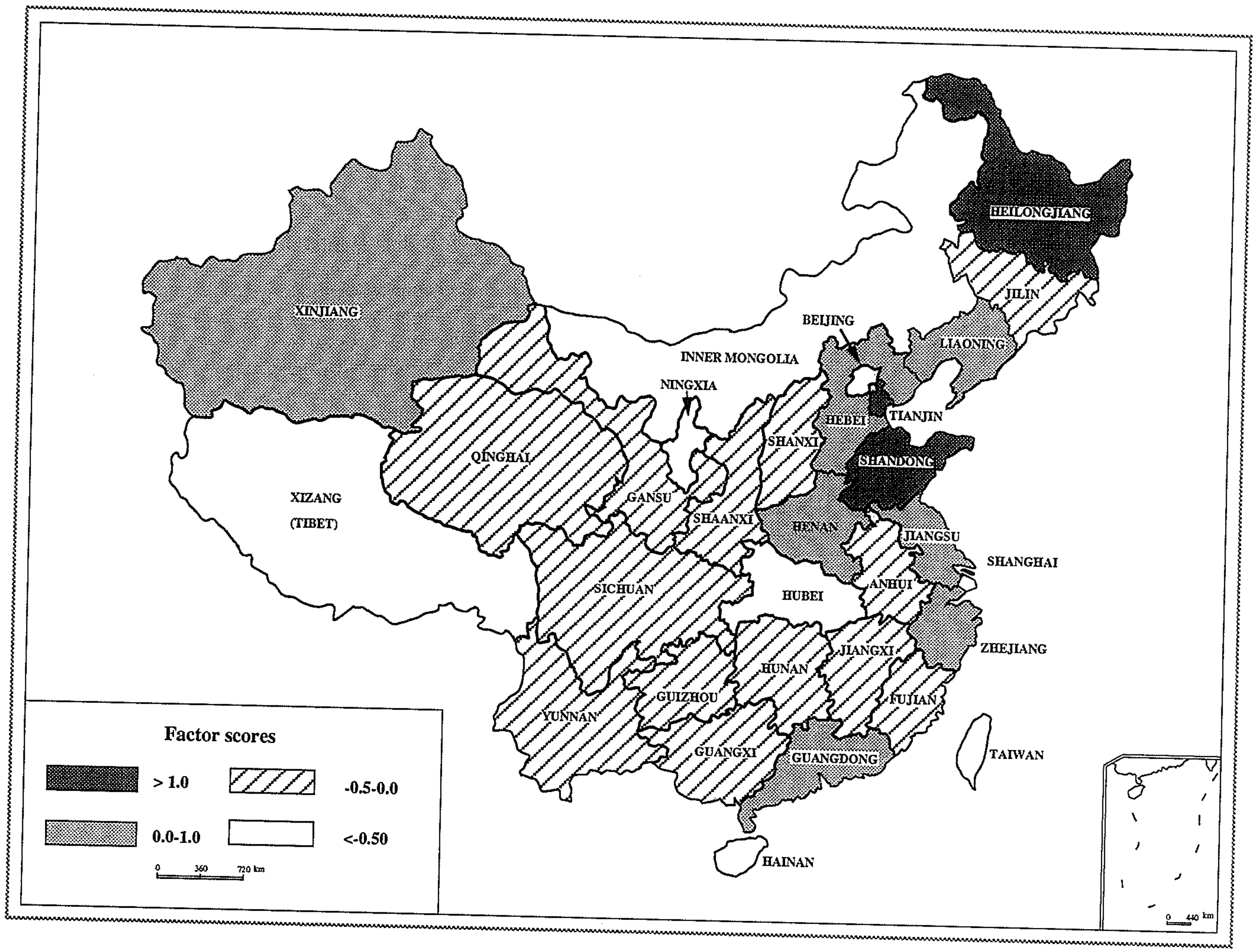


Figure 7-5 Crude Oil-mining Development Factor of China

(Factors 1 and 4). Of course, all three regions are already known as key industrial heartlands.

It is now necessary to focus on the classification of regional patterns of mineral production in China. For this purpose I shall resort to cluster analysis, the technique that computes mathematical distances and dissimilarities among all observations [2]. The results are expressed in Figures 7-6, 7-7 and 7-8. A coefficient of less than 10 between clusters is chosen as the distance limit in terms of combining rescaled distance clusters [3]. Based on this limit, five kinds of regional combinations are formed. They are each detailed in turn.

I. **The most advanced manufacturing centre category.** This category has only one case, Shanghai. After the Opium War, Shanghai was opened up as a treaty-port city, and became the largest port of Western economic penetration and the biggest harbour and industrial, commercial, and communications centre in the country before 1949. Since then, it has been listed as the centre of one of the key reconstruction regions by the government, although all mining products required by its industries must be moved in from other regions and countries. Great progress has been made since 1979 not only in aspects of economy, science, culture, transportation and communications but also in manufacturing industry, particularly in raw-material manufacturing industry (as evidenced by the construction of the Shanghai Baoshan Iron and Steel Complex, began in 1978). So, Shanghai remains the largest urban centre in China.

Figure 7-6 Vertical Icicle Plot using Ward's Method

(Down) Number of Clusters (Across) Case Label and number

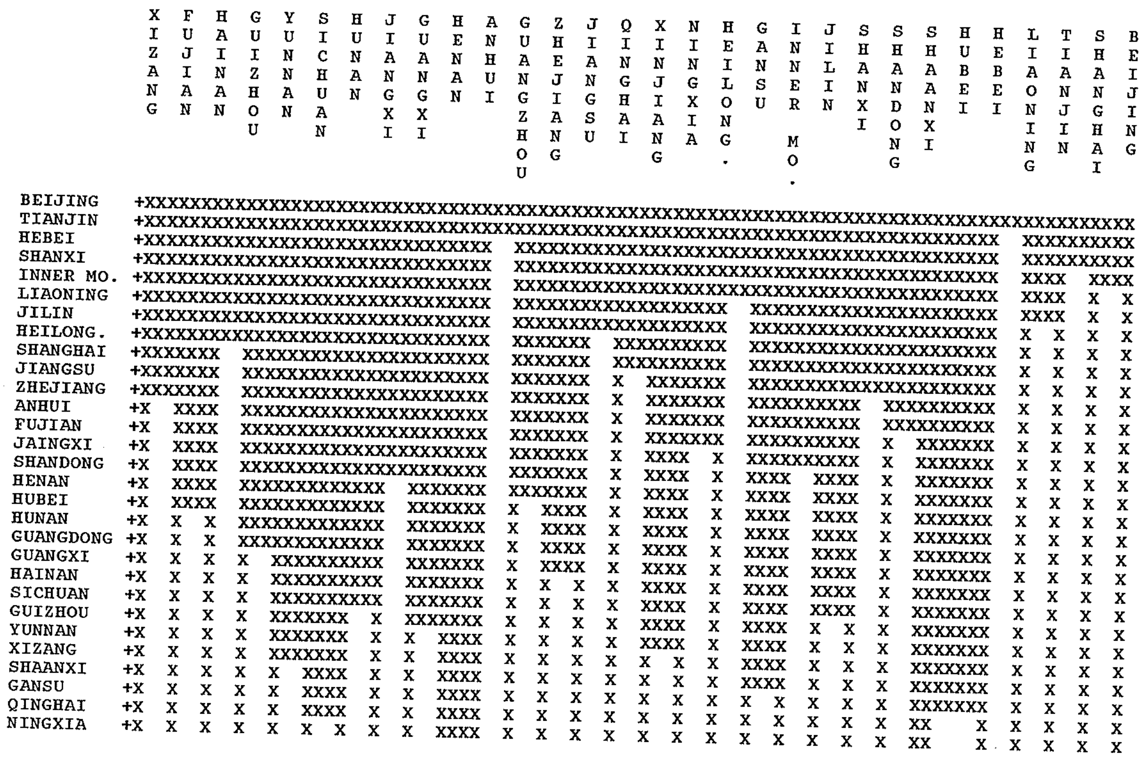
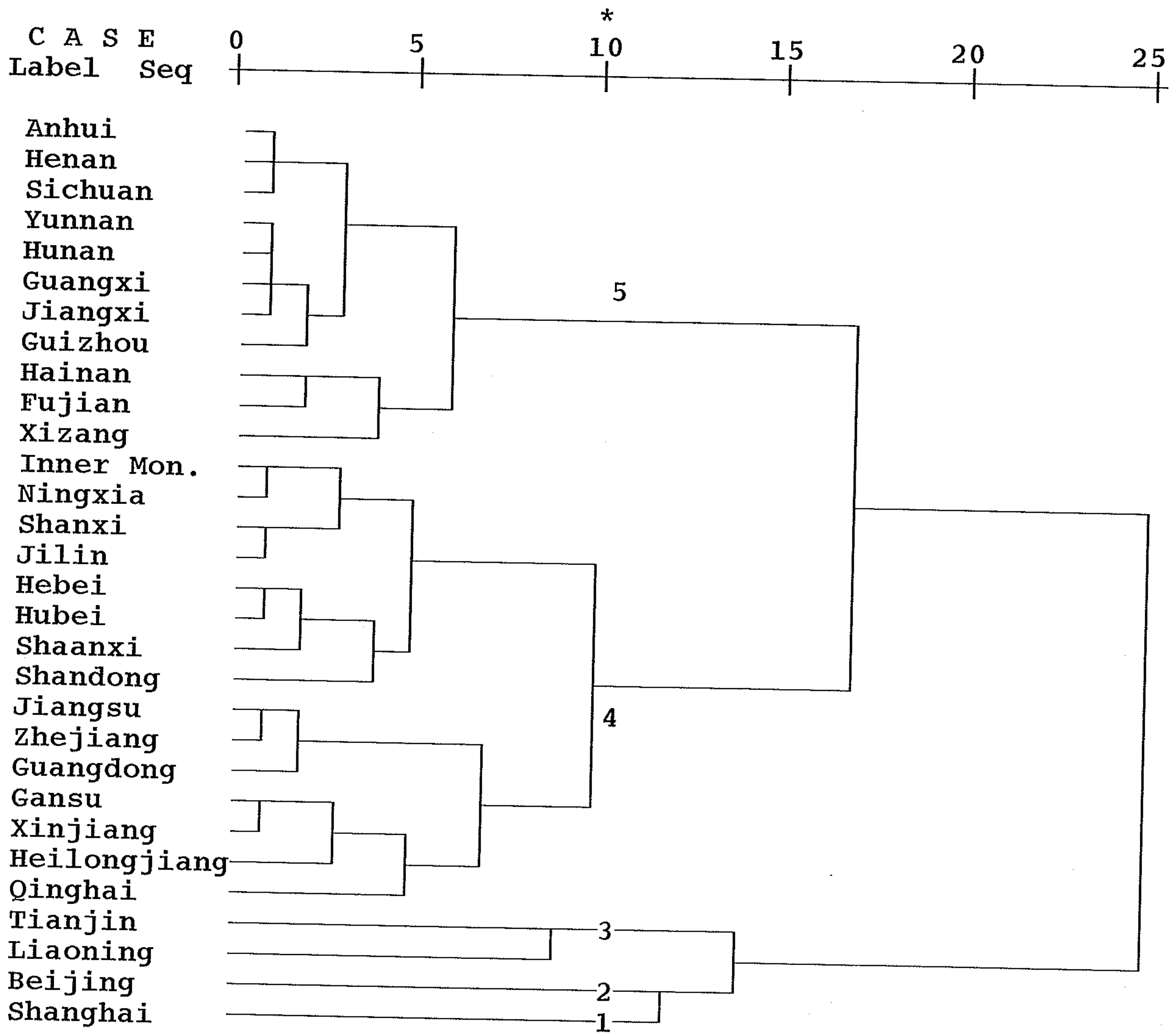


Figure 7-7 Rescaled Distance Cluster Combined by using Ward's Method



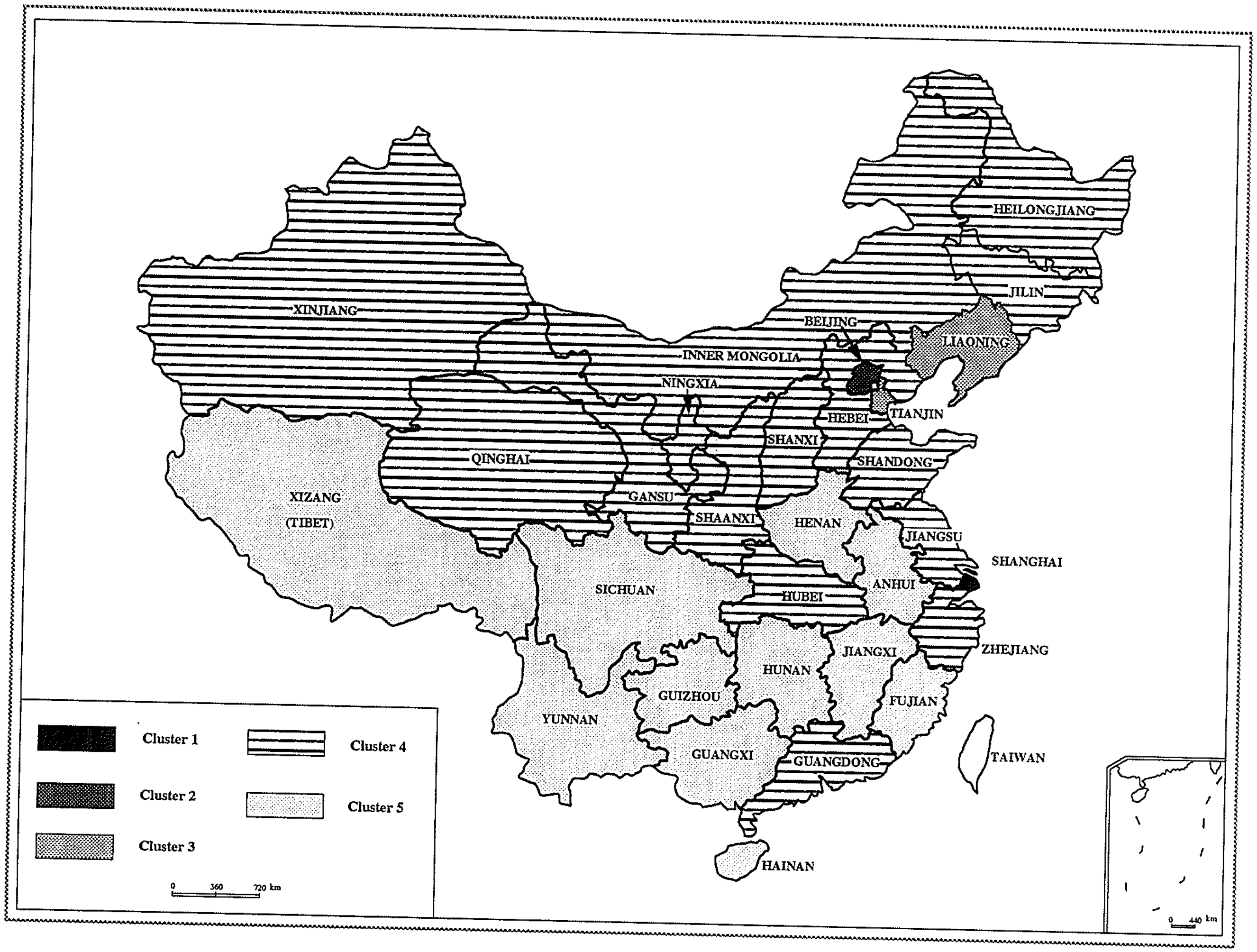


Figure 7-8 Cluster Analysis of China's Mineral Industry and Regional Development

II. The newly-developed metropolitan centre. Like the first category, this group is composed of just one case; although the case in point is now Beijing. Historically, Beijing has served for centuries as the political and cultural centre for the country. However, large-scale industrial constructions such as iron and steel, machine-building, petro-chemical and textiles industries have been initiated within its borders since the 1950s under the policy of 'transforming the city from goods consuming to goods manufacturing'. After the 1970s Beijing emerged as one of the most important industrial centres of the country. The development of Beijing owes much to the privileges that it has reaped both from its political position as the capital of the country and its geographical location as the nearest neighbour of energy-rich and ferrous-rich resources in Shanxi and Hebei provinces.

III. The highly-industrialized heartland. This group consists of Liaoning and Tianjin. They are the principal metallurgical and machine-building bases and the major oil producers in China. However, they fulfil different functions within this tendency. Greatly benefiting from its mineral resources, particularly metal minerals such as iron ore, Liaoning serves as the largest heavy-industry base of the country and has done so for years. For its part, Tianjin has gained a high reputation in the development of light industry and commercial services and is also the largest port in North China. Its ocean-chemical and textiles industries are of national significance.

IV. Fast-developing areas. This category is the largest group.

Composed of 15 provinces and Autonomous Regions, this group can be divided into four subsets. The first subset is constituted from Inner Mongolia, Ningxia, Shanxi and Jilin. Economic growth in these regions is characterized by the rapid development of mineral industries such as oil, coal, iron and steel and nonferrous industry. Shanxi, Inner Mongolia and Ningxia boast rich mineral resources while Jilin owes much to its geographical location in between Heilongjiang, one of the major coal producers, and Liaoning, one of the largest coal consumers in China. Emphasizing large-scale development of coal and outside coal movement, all of them have developed rapidly although their economic foundations were quite poor forty years ago. The second subset embraces Gangsu, Xinjiang, Heilongjiang and Qinghai. The major driving power of regional development for the four regions comes from mineral exploitation, particularly crude oil. Before 1949, almost no modern development was seen in these areas except for what occurred in a few large cities such as Harbin, the capital city of Heilongjiang, and Lanzhou, the capital city of Gangsu. Recent economic growth has been very fast, however. Gangsu and Xinjiang were the first crude oil centres of the new republic. Heilongjiang plays host to the largest oilfield of the country while oil exploitation in the 1970s in Qinghai greatly stimulated local economic growth. The third subset consists of Hebei, Hubei, Shaanxi and Shandong. Economic development in these regions during the past forty years relied not only on mining activity but also on mineral manufacturing. The large-scale expansion of the Wuhan Iron and Steel Complex in Hubei in the 1950s and the 1970s, and the constructions of large petrochemical, cement and themopower projects in Shandong and Hebei in the 1970s and the 1980s, for example, provided great opportunities for these regions to become the important producers and suppliers of raw materials and electricity of the country. Unlike the first three subsets, the last one, comprising Jiangsu, Zhejiang and Guangdong, captures the coastal regions with well-established educational, commercial, agricultural and industrial backgrounds, and they are important light industrial bases of the nation to boot. Nevertheless, mineral industry still plays an important role in their local economies, such as the rapid development of oil refining in Guangdong and petrochemical industries in Jiangsu based on importing crude oil from other regions since the 1970s. Benefiting from the 'Open Door' policy, industrial development in these areas has progressed rapidly in recent years, especially in the light aspects of manufacturing.

V. The developing areas. This group comprises Anhui, Henan, Sichuan, Yunnan, Guizhou, Hunan, Jiangxi, Guangxi, Hainan, Fujian and Xizang. These provinces and Autonomous Regions (A.R.) can also be separated into two subsets. Belonging to the first subset, Anhui, Henan, Sichuan, Yunnan, Guizhou, Hunan, Guangxi and Jiangxi are located in south and southwest interior parts of the country. They have poor socio-economic foundations, constituting the traditional agricultural regions. However, fair-sized modern mineral industries have been established in them since the First Five-Year Plan period, such as coal and aluminum industries in

Henan, Guangxi and Guizhou; iron and steel industry in Sichuan; and copper industry in Jiangxi. Because these areas are large in size, low in population density, and rich in mineral resources, they have a certain competitive edge where future development is concerned. The fact remains, though, that as a result of historical, physical and political constraints, agricultural activities and husbandry are the mainstays of their local economies, and industrial development is still in a beginning stage. Although Fujian and Hainan are coastal regions, the longstanding political tensions associated with the Taiwan Question have constricted their development prospects. Moreover, their sparse endowment of mineral resources has acted as a disincentive to both capital investment and the attracting of technical personnel. Consequently, they remain marked by a poor socio-economic setting compared with other coastal regions.

By dint of a comparison of the maps emanating from the factor analysis (Figures 7-2 to 7-5) and the cluster analysis (Figure 7-8), a few key findings can be elicited. First, the division line of Type I of Factor 1 (with factor loadings of more than 1.0) is exactly the line which separates Category I, II and III from other categories delineated in the cluster analysis. This spatial coincidence implies that the Socio-Economic Factor remains highly relevant to the regional pattern of China's modern development. Secondly, all other divisions associated with Factor 1-to-Factor 4 breaks are subsumed into two categories in the cluster analysis. Further, this indicates that the other three factors, namely the

'Mineral-Based Industrial Development Regional Environment Factor', the 'Coal-Mining-Led Growth Factor' and the 'Oil-Exploitation-Led Growth Factor', have played a very important role in consolidating the centre-periphery structure rather than the reverse. They have done this through reinforcing the leading positions of the centre areas. Two good examples of this tendency are the developments of heavy-industrial manufacturing in Liaoning in the first instance and nonferrous-metal manufacturing in Shanghai in the second. Thirdly, for most developing areas, the spatial distributions of social development attaching to the factor analysis and the cluster analysis together prove that mineral industry can only be developed on its mineral bases. In other words, mineral industry can act as an instrument for stimulating and sustaining regional development only if the regions own a good resource perspective. It testifies to the fact that the richer the mineral endowment of a developing region, the greater are the opportunities that it can grasp for engaging in mineral-based industrialization. Coal production in Shanxi and oil exploitation in Heilongjiang are the two classic instances of mineral resources spawning industrialization. The other side of the coin, of course, is the lot of many developing areas, one in which a patchy mineral endowment is not conductive to anything other than very limited industrial initiatives. Their overall form with respect to social development in consequence is uninspiring.

7.4 Conclusion

It is certainly a basic characteristic of the relationship between mineral production and regional development that isomorphism, or the existence of simple, one-to-one causal relationships, is rare, and extensive study of a complicated multi-faceted relationship is required for disentangling the effects of mineral developments on the aggregate regional growth pattern. By default, then, we are forced into an investigation of a series of causally-related variables for examining the configuration of this relationship. Such an examination may be made more rigorous and less time-consuming if our explanatory variables and observations can be considered simultaneously, rather than in a stepwise, "one-after-another" manner.

In order to accomplish this aim, the analysis uses two different techniques: factor analysis and cluster analysis. The first is a branch of multivariate analysis designed to explain the correlations or covariances among a set of variables in terms of a limited number of key unobservable, latent variables. The second is the modern statistical method of partitioning an observed sample population into relatively homogeneous classes, to produce an operational classification. The objective is to sort observations into groups called clusters so that the degree of statistical association is high among members of the same group and low between members of different groups.

The results of applying the two techniques in this study can be generalized in the manner presented below.

i The Socio-Economic Development Factor dominates the regional pattern of China's industrialization. This factor pattern implies that the present formation of regional disparities in socio-economic development in China is a part of its historical process, which can be traced back to early ages. The coastal zone is still the most favoured assemblage of regions in China's modern economy while the interior zone continues to lag behind it. The lag persists despite much attention directed to eradicating regional disparities over the period extending from 1949.

ii Moreover, the three later factors--the Mineral-processing-Led Growth Factor, the Coal-Mining-Led Growth Factor and the Oil-Exploitation-Led Growth Factor--change nothing regarding the original centre-periphery structure. On the contrary, they reinforce the structure through improving the leading position of core regions as a result of developments in raw-material manufacturings. It is, therefore, the case that the traditional economic division of China into a coastal belt and an interior land belt remains very much alive and retains its relevance for assessing regional development. In fact, if 20 is selected as the distance limit in the cluster analysis rather than the preferred 10, the number of clusters would be reduced from five to two. The upshot, once mapped, affirms the centre-periphery structure of China's regional development.

The central area, consisting of Shanghai, Beijing, Liaoning and Tianjin, concentrates on the development of manufacturing and mineral processing, while the peripheral area consisting of all the rest, relies on primary activities or less elaborate industrial sectors (Figure 7-9).

iii The spatial distributions of social development attaching to both the factor analysis and the cluster analysis indicate that for most developing areas rich mineral resources are the determinant factor not only to economic growth but also to social progress in developing areas in the mineral-based industrialization. In this sense, mineral industry can act as a key instrument to stimulate and sustain regional development in these areas only in terms of their resource perspective: plentiful resources equals good growth prospects; scanty resources equates with much poorer prospects.

iv. Another great contribution of mineral activity to regional development is afforded by transport infrastructure; a contribution strongly supported by the loading pattern of the "Coal Mining-Led Growth Factor" (Factor 3). This finding indicates that through effecting great improvement in transport infrastructure, the development of mineral industry is critical to the formation of an integrated national transport network: in itself far more effectual in promoting regional and interregional development than

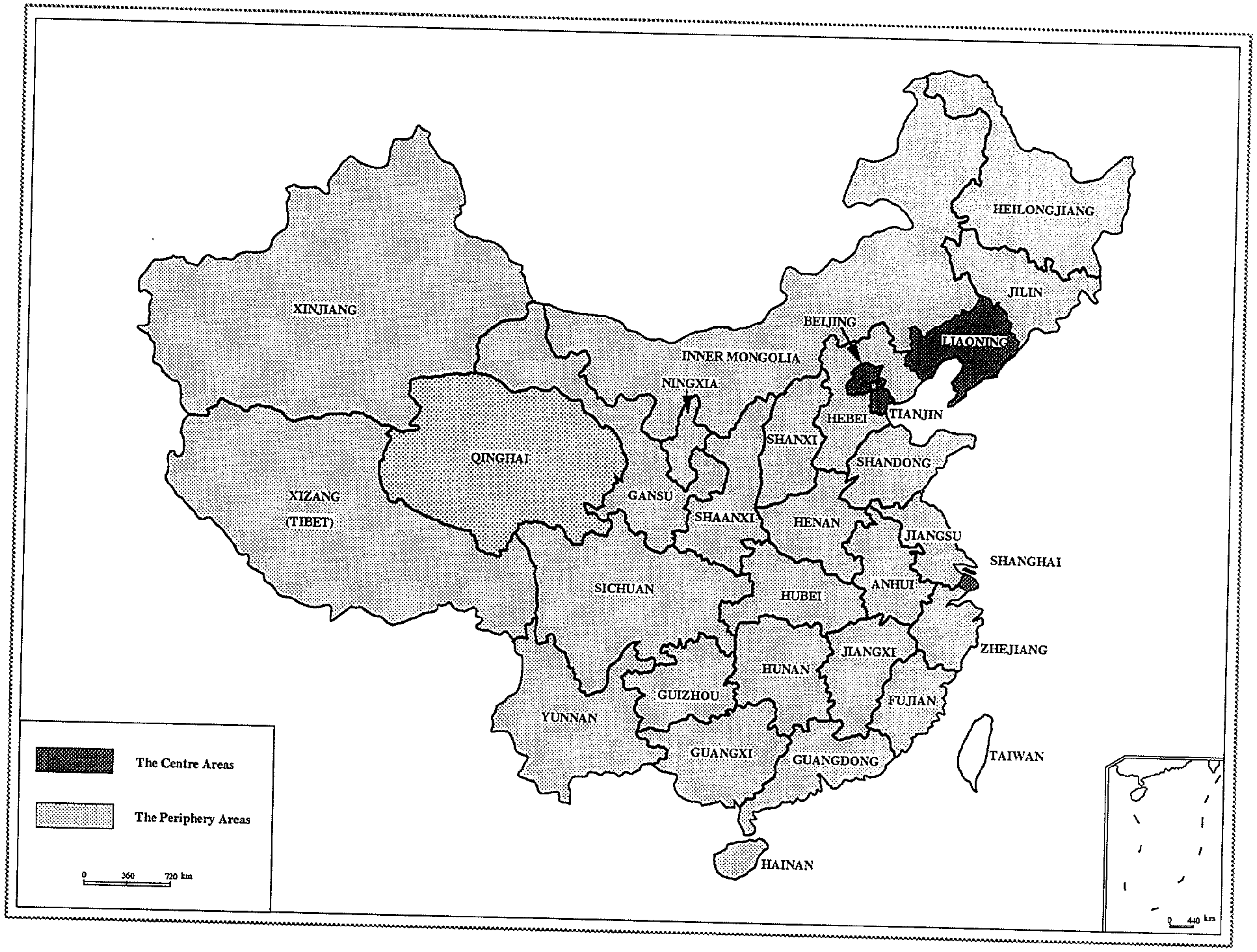


Figure 7-9 A Proposed Centre- Periphery Structure of China's Regional Development by Cluster Analysis at the Distance of 20

mineral production alone.

v. Finally, examination of the factor loading pattern (Table 7-2) reveals that there are only four variables, namely energy consumption (ENECOS), fixed assets of raw material manufacturing (RAWMASS), freight traffic volume (FREIGHT) and number of hospital beds (HOSPBED), which have positive loadings across all factors. These variables, few though they are, provide an insight into the characteristics of early industrialization in China. Firstly, the structural transformation from an agrarian society to one rooted in industry in a country can cause a great increase in mineral consumption (represented by ENECOS). Secondly, under this pressure, the system of production becomes heavily engaged in the development of mineral processing (indicated by RAWMASS). Thirdly, mineral development can further regional development through the inception of a national integrated transport system (demonstrated by FREIGHT). Finally, all the developments can provide the region with great opportunities for achievement of social well-being conductive with the "take-off' point (represented by HOSPBED).

NOTE

[1]. Using the factor technique, one could expect to define the minimum dimensionality (two key factors) of the data and a basis of the space (core versus periphery) in advance, like this study does, but the original factors matrix often turn out to be confusing. This means that grouping is virtually impossible either because of high loadings for most of the variables or high loadings on a number of factors. Such a restriction naturally leads to a unique solution: rotation. There are several rotation techniques to choose from, and in this study, the varimax solution, one of the procedures of orthogonal rotation, is employed. The reason is simple. The varimax solution seeks a solution where the variance is maximized across all factors in the matrix. The simple structure that results succeeds in eliminating factor complexity to a greater extent than other rotations.

[2]. The Ward's clustering method is based on statistical minimization of clustering "expansion". At any stage of an analysis the loss of information which results from the grouping of individuals into clusters can be measured by the total sum of squared deviations of every point from the mean of the cluster to which it belongs. At each step in the analysis, union of every possible pair of clusters is considered and the two clusters whose fusion results in the minimum increase in the error sum of square are combined. The distance between two clusters, therefore, has a real "geometrical" distance: a pure statistically-evaluated

parameter which can be easily seen from the linking values on the dendrogram. Ward's method is widely accepted as the best clustering technique of all grouping procedures. For this reason, I have elected to apply it to my data.

[3]. The algorithm developed by Ward also employs a hierarchical grouping procedure. The grouping process begins by considering *K* groups of subjects, one subject per group. The *K* initial groups are systematically reduced from *K* to *K - 1* to *K - 2* to...to *1* group in the course of this hierarchical grouping procedure. At each stage of the procedure the value of the objective function is assessed. Changes in this value from stage to stage provide an important clue for determining the number of "natural" groupings for the *K* subjects, and the number of groups can be calculated simultaneously by the computer when one uses the clustering computer programme. In my study, five groups (at the distance 10) are judged to be the most revealing in terms of empirical substantiation (recall Figure 7-7).

Appendix 7-1 Basic Socio-Economic Indices of China

Region	No.	COALOUT (mlt)	STEELOUT (mlt)	CAPINVE (y/p)	GDP (y/p)	TERTVAL (y/p)
Beijing	1	10.05	4.44	8746	4611	1941
Tianjin	2	0.00	1.67	5729	3397	1610
Hebei	3	62.43	3.84	1632	1331	399
Shanxi	4	285.97	2.39	2489	1374	481
Inner Mon.	5	47.62	2.73	1888	1325	498
Liaoning	6	51.01	12.16	3337	2432	891
Jilin	7	26.10	0.75	1997	1586	551
Heilongjiang	8	82.64	0.95	2780	1792	726
Shanghai	9	0.00	9.15	8170	5570	2254
Jiangsu	10	24.08	1.90	1764	1942	644
Zhejiang	11	1.37	0.86	1774	2008	711
Anhui	12	32.05	2.48	1035	1069	304
Fujian	13	9.25	0.52	1465	1534	503
Jiangxi	14	20.27	1.12	1003	1485	467
Shangdong	15	59.95	2.27	1493	1569	474
Henan	16	90.80	1.69	1065	1036	345
Hubei	17	9.24	6.29	1656	1457	373
Hunan	18	33.71	1.36	994	1146	356
Guangdong	19	8.90	1.17	2347	2319	885
Guangxi	20	9.80	0.52	848	922	273
Hainan	21	0.01	0.00	2347	1433	595
Sichuan	22	67.85	4.95	1153	1061	339
Guizhou	23	36.95	0.47	1014	779	224
Yunnan	24	22.27	0.80	1239	1061	262
Xizang	25	0.01	0.00	2621	1101	593
Shaanxi	26	33.26	0.49	1858	1130	382
Gansu	27	15.64	0.67	1933	1039	521
Qinghai	28	3.20	0.32	4616	1480	605
Ningxia	29	14.43	0.03	2754	1300	528
Xinjiang	30	21.00	0.37	3201	1647	560

Appendix 7-1 Basic Socio-Economic Indices of China (continued)

Region	No.	INDASS (y/p)	MINASS (y/p)	RAWMASS (y/p)	STUDENT (p/tp)	SCIENT (p/tp)
Beijing	1	4036	333	807	12.9	49.4
Tianjin	2	3732	1825	484	5.8	30.7
Hebei	3	1119	313	186	1.2	7.6
Shanxi	4	1860	704	248	1.8	11.2
Inner Mongolia	5	1364	266	262	1.5	11.2
Liaoning	6	3103	517	894	3.1	18.1
Jilin	7	1889	257	215	2.9	13.9
Heilongjiang	8	2409	800	340	2.3	15.1
Shanghai	9	5890	1	1056	9.1	33.8
Jiangsu	10	1467	81	168	2.2	9.2
Zhejiang	11	1139	21	145	1.4	7.5
Anhui	12	686	111	141	1.1	5.8
Fujian	13	805	27	93	1.8	7.5
Jiangxi	14	703	58	107	1.5	7.3
Shangdong	15	1352	347	198	1.2	7.3
Henan	16	757	209	80	0.9	5.6
Hubei	17	1214	55	268	2.4	10.3
Hunan	18	743	56	118	1.4	7.3
Guangdong	19	1266	34	193	1.5	7.0
Guangxi	20	536	26	80	0.9	6.8
Hainan	21	1266	5	18	1.2	6.8
Sichuan	22	786	105	121	1.3	7.5
Guizhou	23	609	76	82	0.8	6.7
Yunnan	24	706	46	86	1.2	7.3
Xizang	25	300	16	53	0.9	6.4
Shaanxi	26	1062	112	111	2.9	11.4
Gansu	27	1297	212	219	1.5	9.0
Qinghai	28	2084	311	206	1.4	14.2
Ningxia	29	1607	415	143	1.7	12.8
Xinjiang	30	1530	668	204	2.0	15.8

Appendix 7-1 Basic Socio-Economic Indices of China (continued)

Region	No.	HOSPBED (b/tp)	INDEMP (p/tp)	INCOME (y/p)	INDVAL (y/p)	ARRVAL (y/p)	URBANP (%)
Beijing	1	5.5	19.7	3379	6759	646	58.4
Tianjin	2	4.1	22.5	2761	7700	622	54.1
Hebei	3	2.4	8.7	1126	1863	593	13.3
Shanxi	4	3.6	10.8	1090	1911	443	18.6
Inner Mongolia	5	2.8	7.6	1079	1229	743	30.4
Liaoning	6	5.0	16.2	1976	4019	685	41.5
Jilin	7	3.7	11.2	1357	2196	752	37.9
Heilongjiang	8	3.4	12.4	1623	2483	706	41.0
Shanghai	9	5.2	29.9	4616	12087	505	64.5
Jiangsu	10	2.4	14.3	1846	4055	852	19.6
Zhejiang	11	2.3	14.7	1743	3508	825	15.1
Anhui	12	1.9	5.9	915	1191	659	13.4
Fujian	13	2.2	6.8	1280	1736	747	17.0
Jiangxi	14	2.4	7.1	929	1112	667	17.9
Shangdong	15	2.1	8.3	1347	2639	776	12.8
Henan	16	2.1	5.7	872	1204	583	12.6
Hubei	17	3.0	7.7	1205	1841	734	19.6
Hunan	18	2.4	5.8	965	1176	656	13.7
Guangdong	19	2.0	9.3	1784	3009	950	21.7
Guangxi	20	1.8	3.6	789	831	593	13.5
Hainan	21	3.3	3.1	1161	690	618	17.1
Sichuan	22	2.3	5.7	892	1150	599	13.9
Guizhou	23	1.8	4.1	642	666	445	12.7
Yunnan	24	2.3	3.7	943	939	576	12.0
Xizang	25	2.3	1.1	845	138	774	18.0
Shaanxi	26	2.6	7.0	914	1363	524	17.1
Gansu	27	2.2	5.7	919	1211	450	15.7
Qinghai	28	3.6	6.3	1102	1247	553	28.0
Ningxia	29	2.3	6.6	1007	1389	530	26.6
Xinjiang	30	4.4	5.4	1340	1431	941	29.0

Appendix 7-1 Basic Socio-Economic Indices of China (continued)

Region	No.	ENECOS (tce/p)	WASWA (cm/p)	WASARI (sm/p)	MIORAIL (t/p)	FREIGHT (t/p)	POPUL (mlp)
Beijing	1	2.49	37.4	8287	84.1	31	526
Tianjin	2	2.34	25.9	2760	48.4	22	749
Hebei	3	0.99	16.1	2603	84.6	9	327
Shanxi	4	1.68	20.2	2911	96.1	22	185
Inner Mongoli	5	1.12	12.1	3273	87.7	11	19
Liaoning	6	1.98	41.3	7406	80.3	18	270
Jilin	7	1.42	23.2	2807	73.5	11	131
Heilongjiang	8	1.47	31.7	1428	83.0	11	78
Shanghai	9	2.38	99.6	10022	50.0	21	1759
Jiangsu	10	0.81	34.5	2181	71.5	5	645
Zhejiang	11	0.62	25.7	2476	63.5	8	397
Anhui	12	0.49	17.4	1267	83.1	6	405
Fujian	13	0.48	25.1	1959	63.4	9	248
Jiangxi	14	0.47	20.2	1501	73.1	5	228
Shangdong	15	0.80	10.3	1475	78.4	5	538
Henan	16	0.60	12.1	1229	83.2	4	522
Hubei	17	0.73	29.8	2686	65.9	8	292
Hunan	18	0.62	30.8	1806	73.7	6	289
Guangdong	19	0.64	22.1	2598	58.7	13	357
Guangxi	20	0.31	24.7	1310	65.1	4	180
Hainan	21	0.18	12.1	241	99.1	11	196
Sichuan	22	0.59	18.2	1653	74.4	5	191
Guizhou	23	0.65	10.5	2013	76.2	5	186
Yunnan	24	0.52	11.4	1488	63.4	9	97
Xizang	25	0.00	0.6	90	0.0	3	2
Shaanxi	26	0.68	12.1	1130	80.5	4	161
Gansu	27	0.96	17.0	3379	70.9	6	56
Qinghai	28	1.13	15.3	2969	79.3	6	6
Ningxia	29	1.50	18.3	1979	92.0	8	91
Xinjiang	30	1.35	10.1	1681	80.9	6	9

Appendix 7-1 Basic Socio-Economic Indices of China (continued)

Region	No.	FOREIGN (US$/p)	OILOUT (mlt)	PIGIRON (mlt)
Beijing	1	91	0.00	3.60
Tianjin	2	251	4.70	1.40
Hebei	3	30	5.71	5.21
Shanxi	4	83	0.00	4.55
Inner Mongolia	5	20	0.00	2.81
Liaoning	6	295	13.69	11.46
Jilin	7	114	3.57	0.71
Heilongjiang	8	38	55.62	0.60
Shanghai	9	587	0.00	5.27
Jiangsu	10	49	0.86	1.54
Zhejiang	11	61	0.00	0.60
Anhui	12	12	0.02	2.86
Fujian	13	79	0.00	0.63
Jiangxi	14	21	0.00	0.89
Shangdong	15	44	33.51	2.88
Henan	16	11	8.82	1.71
Hubei	17	22	0.83	5.05
Hunan	18	14	0.00	1.54
Guangdong	19	205	0.47	0.81
Guangxi	20	18	0.12	0.59
Hainan	21	54	0.00	0.02
Sichuan	22	12	0.16	4.54
Guizhou	23	6	0.00	0.63
Yunnan	24	15	0.00	1.20
Xizang	25	0	0.00	0.00
Shaanxi	26	16	0.70	0.36
Gansu	27	8	1.46	0.49
Qinghai	28	6	0.81	0.00
Ningxia	29	17	0.25	0.06
Xinjiang	30	32	6.97	0.41

Note: mlt=million tonnes; t=tonnes; p=person; tp=thousand persons; tce=tonnes of coal equivalent; cm= cubic metre; sm=square meter.

Appendix 7-2 Factor Output Data Set

Region	No.	Factor 1
I (4)		(x > 1.0)
Shanghai	1	3.50480
Beijing	2	2.48326
Tianjin	3	1.69454
Liaoning	4	1.43869
II (4)		(0 < x < 1.0)
Heilongjiang	5	0.24920
Shanxi	6	0.111684
Jilini	7	0.11011
Jiangsu	8	0.00344
III (11)		(-0.5 < x < 0)
Guangdong	9	-0.01537
Hubei	10	-0.10967
Xinjiang	11	-0.11180
Qinghai	12	-0.13541
Zhejiang	13	-0.14417
Inner Mongolia	14	-0.19385
Hebei	15	-0.26969
Ningxia	16	-0.28303
Shangdong	17	-0.32675
Fujian	18	-0.42007
Gansu	19	-0.44881
IV (11)		(X < -0.5)
Shaanxi	20	-0.52677
Sichuan	21	-0.52416
Hunan	22	-0.53536
Jiangxi	23	-0.55540
Anhui	24	-0.60561
Hainan	25	-0.61058
Henan	26	-0.64808
Yunnan	27	-0.68832
Guangxi	28	-0.78369
Guizhou	29	-0.80146
Xizang	30	-0.86283

Region	No.	Factor 2
I (4)		(x > 1.0)
Liaoning	1	2.37565
Shanghai	2	1.66787
Hubei	3	1.27403
Sichuan	4	1.14635
II (15)		(0 < x < 1.0)
Hebei	5	0.91765
Anhui	6	0.73089
Jiangsu	7	0.47978
Hunan	8	0.45228
Henan	9	0.44357
Shandong	10	0.33657
Shanxi	11	0.32289
Guangxi	12	0.21959
Zhejiang	13	0.14953
Guangdong	14	0.13969
Jiangxi	15	0.12852
Guizhou	16	0.08042
Fujian	17	0.06997
Inner Mongolia	18	0.02921
Yunan	19	0.01522
III (3)		(-0.5 < x < 0)
Gansu	20	-0.24721
Shaanxi	21	-0.36059
Hainan	22	-0.36399
IV (8)		(X < -0.5)
Jilin	23	-0.64501
Ningxia	24	-0.91885
Qinghai	25	-1.06906
Heilongjiang	26	-1.29314
Xinjiang	27	-1.37819
Beijing	28	-1.59002
Tianjin	29	-2.45650
Xizang	30	-2.65714

Appendix 7-2 Factor Output Data Set (continued)

Region	No.	Factor 3
I (3)		(x > 1.0)
Shanxi	1	2.83971
Liaoning	2	1.89525
Heilongjiang	3	1.71954
II (10)		(0 < x < 1.0)
Hebei	4	0.76159
Inner Mongolia	5	0.71911
Shandong	6	0.60582
Xinjiang	7	0.59395
Henan	8	0.35789
Sichuan	9	0.35673
Beijing	10	0.27675
Ningxia	11	0.26577
Jilin	12	0.10388
Qinghai	13	0.01018
III (10)		(-0.5 < x < 0)
Tianjin	14	-0.04042
Anhui	15	-0.06331
Hubei	16	-0.07114
Shaanxi	17	-0.15892
Guizhou	18	-0.16678
Gansu	19	-0.20581
Hainan	20	-0.20967
Hunan	21	-0.32208
Yunnan	22	-0.37355
Jiangxi	23	-0.48417
IV (7)		(X < -0.5)
Guangxi	24	-0.75241
Jiangsu	25	-0.83051
Fujian	26	-0.85471
Zhejiang	27	-1.09888
Guangdong	28	-1.10484
Xizang	29	-1.80724
Shanghai	30	-1.96172

Region	No.	Factor 4
I (3)		(x > 1.0)
Heilongjiang	1	3.03267
Shandong	2	2.13478
Tianjin	3	1.36651
II (6)		(0 < x < 1.0)
Jiangsu	4	0.65126
Henan	5	0.64917
Zhejiang	6	0.40025
Liaoning	7	0.34643
Guangdong	8	0.35446
Xinjiang	9	0.27038
Hebei	10	0.00985
III (13)		(-0.5 < x < 0)
Guangxi	11	-0.01132
Fujian	12	-0.02604
Anhui	13	-0.11957
Hunan	14	-0.14172
Jiangxi	15	-0.14919
Jilin	16	-0.22870
Sichuang	17	-0.35434
Gansu	18	-0.37988
Shanxi	19	-0.40170
Shaanxi	20	-0.41808
Yunnan	21	-0.41825
Qinghai	22	-0.47148
Guizhou	23	-0.49629
IV (7)		(X < -0.5)
Beijing	24	-0.73580
Inner mongolia	25	-0.90243
Hubei	26	-0.54322
Hainan	27	-0.75988
Ningxia	28	-0.82943
Shanghai	29	-0.96140
Xizang	30	-1.26331

CHAPTER VIII

SUMMARY AND IMPLICATION

The aim of this study is to explore the contemporary role of mineral industry in regional development based on China's record of industrialization during the past forty years. For the purpose of evaluation, a target system is set up at the beginning of the study which undertakes to explore this issue in the light of insights offered by the material intensive-use theories, the export-based theory and the Centre-Periphery Hypothesis, together with a series of methods, including input-output, regression, factor and cluster analyses. Each of these theories and methods addresses a specific hypothesis following the order of the flow diagram in Chapter I, and it can be summarized in the manner of Figure 8-1.

Inquiring into China's experiences, there is much evidence to support this general hypothesis that mineral industry can act as a powerful instrument in furthering national, and ultimately, regional development. From this evidence, it can be confirmed that the development of mineral industry can act as a catalyst in effecting the structural transformation of a country or a region from an agrarian economy (dominated by the production of primary goods) to an industrial economy (led by the production of manufacturing goods) with a much higher rate of economic growth in comparison with what went before. Furthermore, the evidence supports the view that expansion of mineral activities is instrumental in reinforcing the existing centre-periphery pattern in Chinese regional growth ; a pattern which presides over the

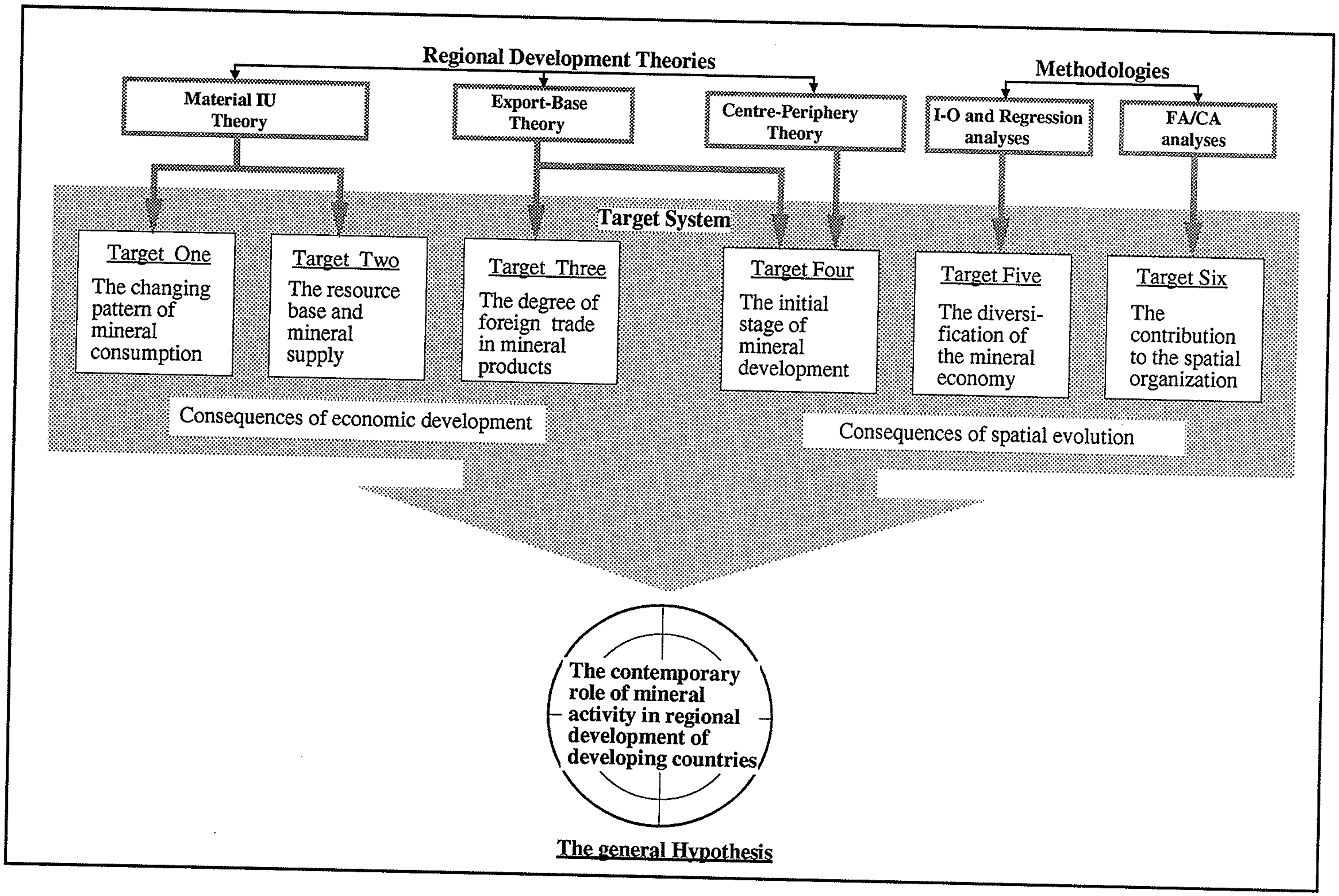


Figure 8-1 A Summary of Applied Development Theories and Related Methodologies

concentration of economic activity, particularly manufacturing industries, through the expansion of mineral-export activity. All the results coalesce to provide pointers as to the role of mineral activities in fostering regional development. These can be listed in summary form.

A. In the early stage of structural transformation, a rapid development of industrial production, particularly heavy industry, stimulates great increases in the domestic mineral consumption. Along with such a change, therefore, a stable mineral supply of key resources, particularly those well suited for the domestic market such as iron and steel, building materials, coal and oil, becomes a major factor of production to assure economic growth. Moreover, the more developed the economy of a country or a region becomes, the greater are the domestic demands. This is witnessed by the energy shortage which occurred in China just a few years after its economy began booming in consequence of the "Open Door" policy.

B. Under the pressure of an increasing demand, the most important object of economic growth for a developing economy is to build up a reliable mineral supply system based on domestic resources if possible. This saves foreign exchange on the one hand, while ensuring that scare investment is not diverted to paying for more imports on the other. It can be said that mineral production is a reflection of the way in which industry, government power and society as a whole is organized, and it is a reflection of the way in which the mineral industry is perceived as the leading sector in the early stage of economic growth.

C. The development of mineral production not only serves to meet the needs of the domestic market but also forms the material basis for expanding foreign trade, so that the nation's ability in both the import substitution of manufacturing goods and the mineral production itself can be improved.

D. At the beginning of mineral production, mining activity has always a strong spread-effect on regional development through creating new jobs, attracting capital investment from both domestic and foreign sources, and improving local infrastructure. What is more, it embeds outward orientational services in the resource frontiers. All of these changes can be regarded as conspiring to provide a precondition for further development.

E. As a consequence of developing the forward and backward linkages of mining activity, the more diversified mineral economy can provide a great opportunity for deepening structural transformation in the host region. There is a pitfall, however, for spoliation of regional environment has become increasingly significant as an accompaniment of the location of mineral-based manufacturing activities, particularly in large urban areas.

F. Last, but not least, developmentally-dominant effects emerging from the growth of the minerals economy can really shift the nature of regional growth patterns in developing areas mainly through the development of the forward linkages of mineral activities creating growth poles able to foster diversified development. Unfortunately, these effects are not of sufficient magnitude to alter the entrenched centre-periphery structure which characterizes the country. On the contrary, that structure tends to be reinforced by virtue of the provision of an integrated transport infrastructural system which grants a leading role to core regions in the development of mineral input-output relationships existing between them and their peripheral suppliers.

As was said at the outset of this thesis, industrialization in developing countries is part of the global Industrial Revolution that began in Europe well over two centuries ago. It conforms to many of the same premises, exhibits many of the same traits, faces many of the same problems, and in most respects is defined in much the same way. As such, industrialization in China has essentially meant increasing exploitation of natural resources and energy harnessed to more technology. It has meant, besides, a drive both to exert more extensive control over nature and to apply intensive uses of such mineral materials to raise GDP.

Historical evidence does suggest that the role of a nation's mineral-resource base in fostering economic growth is very great during the early stages of the process. More to the point, mineral activity can provide the start of regional growth for many production sequences and prepares a region for achievement of the "take off' point. Considering regions as a group, mineral activity lends its influence to the development of a 'centre-periphery" structure for the nation as a whole. Using historical analogies it can be argued that the importance of the mineral endowment to China's developing economies is at the point where the wealth engendered by it can definitely lubricate the growth path. With this in mind, mineral wealth has been eagerly sought throughout the country since the 1950s. Resource shortage, particularly where it comes to bear on energy resources, has a considerable growth-restricting effect, while resource abundance is growth facilitating. The advantage of a productive mineral-resource base lies in its ability to permit the region which contains it not only to stimulate new techniques and to attract capital from both domestic and foreign sources but also to provide opportunities to create new patterns of regional development. To be sure, at the national level, the development of the mineral industry does not change the original pattern of the centre-periphery structure, rather it tends to reinforce the dominant position assumed by the central areas mainly through improving the prospects of raw-material manufacturing carried out there. However, such a development does reshape the development patterns among the developing areas, elevating the well-being of those able to barter their mineral wealth.

Yet, as the structural transformation runs its course in like fashion to what has occurred in the advanced-industrial countries, economic structure will be transformed from a "products" economy to a "processing and service" economy. In China, for instance, the tertiary industry rose in importance in GDP by 7.5 per cent between 1981 and 1992 while the secondary industry registered a rise of only 1.0 per cent and the primary industry actually recorded a decline, diminishing by 8.5 per cent. Also, mineral activity tends to become less important in creating new jobs in direct proportion to its increasing inclination to absorb more capital and technology. According to Chang Wei-min (1993), in 1993, at least 140,000 coal workers had been laid-off from the state-run coal enterprises and transferred to other industries, many of them service businesses, because of a great effort to upgrade the technology and equipment of the coal industry. But these transitions in both economic structure and factor input do not mean that mineral resources have become less vital; rather, it suggests that mineral activity will remain important for regional development in the later stage not only because of its uneven spatial distribution, but also on account of the steadily increasing demand for minerals, both in quantity and kinds. It follows, then, that development of mineral industry will still disproportionately benefit some localities, while ignoring others, and continue to impact on the development of the "centre-periphery" structure.

In 1990, the total population of China reached 1.14 billion, an overwhelming number. This large base constitutes a 'huge denominator' in the equation of material intensive use. Over the past forty years, consumption of major basic materials such as pig iron, cement, coal and crude oil increased 25 to 90 times, while the population approximately doubled. If the growth rate of China's population could be maintained at the present level (1.3 per cent annual increase, the lowest since 1984), the consumption of mineral products would increase 1.5 times for energy and nearly double for steel products, for example, for the next decade even though there will have been no change in mineral consumption per capita.

In fact, all the signs suggests that there will be considerable increases in minerals and energy consumption per capita in China owing to the changeable consumption patterns displayed by China's households. In 1990, more than 54 per cent of the typical household's expenditure was on food (China's Statistics Bureau, 1991), a finding in keeping with low-income countries in terms of Engel's Law. It is very natural to expect that, as income continues to growth, the tendency of household expenditure will increasingly turn to better living conditions such as larger living space, to say nothing of more durable goods and social services. Between 1985 and 1990, China's overall household expenditure increased nearly 0.8 times or at an annual growth rate of 12.1 per cent. In the meantime, year-end possession of major durable goods such as bicycles, refrigerators, washing machines and televisions (unit: set) for the average hundred persons increased from 21.1, 0.4, 2.9 and 6.6 to 34.2, 2.6, 8.4 and 16.2 respectively, while per capita living space for the average urban resident was enlarged by 1.2

metres (China's Statistics Bureau, 1991). It is certain that such a changing pattern of household expenditure will have a great influence on mineral and energy consumption. Both population growth and rising living standards are sure to stimulate sharp rises in mineral and energy-resource consumption, and the mineral industry cannot fail to expand in consequence.

In the newly-ended Eighth National People's Congress (NPC), the Chinese government announced that the planned annual growth rate of GNP for the 1990s in the Seventh NPC was changed from 6 per cent to 8 or 9 per cent (Beijing Review, 1993). This means that the new development plan will trigger a fresh impetus to exploit all kinds of mineral and energy supplies, and the existing tight relationship between demand and supply of minerals and energy resources will be exacerbated even further if the government fails to push ahead with the development of the mineral industry.

To pursue the goal of becoming a modern industrialized state, China should reconstitute its new development strategy. Under the new strategy, regional development in most parts of the hinterland, those regions constituting the middle and western zones, should continue to rely on programmes grounded either in the 'mineral-led growth' or 'mineral export' thinking that are mainly focused on the ever-growing domestic market. Under the new strategy, regional development of the coastal areas should centre on the 'export-led growth' programmes which cater to the expansion of both domestic and world markets.

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