INTEGRATING THE INDUSTRIAL COMPLEX INTO THE PORT:
Chinese Developments With Respect To The Metallurgical Sector

BY

XIAOJIN LIU

A Thesis Submitted to the Faculty of Graduate Studies in Partial Fulfillment of the Requirement for the Degree of Master of Arts.

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A Thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

MASTER OF ARTS

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ABSTRACT

The technical progress embodied in the ironmaking and steelmaking process, ultimately having locational implications, has undergone a complicated course in recent decades. The open-hearth, basic-oxygen and electric-arc furnaces, each having associated strengths and weaknesses from the technical and economic viewpoint, co-exist in the contemporary steelworks depending on local circumstances. A similar combination of locations occurs. Various types of locations, coal-field orientation, ore-range orientation and market orientation, have arisen in response to technical circumstances prevailing in a particular country. Without doubt, however, all of them share the movement in steelworks' locations from inland to coastal sites.

The coastal location is owing to changes in a series of locational factors. For example, ore sources are discovered here and exhausted there; frequently in places easily accessible from the sea. This last fact is crucial, since water-borne transport offers the most viable option for moving such materials. Yet, the most important contribution to the coastal tendency of the industry stems from the technical innovation in transport. In modern times, large vessels have realized economies of scale in long-distance ocean transportation. For this purpose, deep-water ports are indispensable. Thus, port-industrial complexes embraced by the concept of the maritime industrial development areas (MIDAs) have come to the forefront because not only can they accommodate large

ships, but they also can achieve cost saving in assembling raw materials and delivering products. While MIDAs originated in the advanced countries, they have their advocates in less-developed countries. Diversified port-industrial zones can be observed in a variety of contexts, permitting the identification of three distinct types. Cases from France, Japan, South Africa and Venezuela are discussed in the light of this typology.

China enters the MIDA picture by virtue of the Baoshan port-iron and steel complex, a classic instance of the coastal orientation of the iron and steel industry. Blessed by the availability of suitable ports but hindered by the poor grade of domestic ore reserves, China has turned its attention more and more to the coastal steel complexes with increasing reliance on imported ore. This strategy has been made abundantly clear not just by the extant port-industrial precedent of Baoshan, but also by incipient MIDAs at Beilun, Rizhao (Shijiusuo) and Zhanjiang, not to say the putative instance of Wangtan. It is demonstrated that, although China inherits its MIDA concept from antecedents in Western countries, it has gone on to evolve them in a fashion peculiarly its own. Indeed, it is shown that China offers an interesting variation on the pattern of contemporary MIDAs, a variation which some developing countries may do well to emulate.

CHAPTER ONE. SETTING THE SCENE

As the thesis title indicates, this work has as its centre-piece two sectors which are important to national economies. Metallurgical industries play an extremely significant role in economic development; and ports, as key elements of infrastructure, can promote international trade and speed up industrial progress. Applying a conceptual framework to this pair is forthcoming with locational analysis: to be specific, it harps on the location theory of metallurgical industries and their predilection to seek coastal sites, the advantages of MIDAs (Maritime Industrial Development Areas) and industrial ports, and the merits of integrating metallurgical complexes with purpose-built port facilities. While considering these issues in general, the particular purpose of the thesis is to show how these issues bear on China. Since the iron and steel industry is held up as the epitome of the group comprising metallurgical industries, it receives most attention in what follows. The immediate object, that which preoccupies this chapter, is to demonstrate the critical importance of iron and steel in economic development; to review the principal locational factors impinging on it, and, finally, to stress that its successful fostering requires attention to the ports sector. To begin with, iron and steel's pivotal importance is underscored.

1.1 The important role of iron and steel industry in economic development

Steel is almost indispensable to the development of modern agriculture and industry. The level of development of any economy is positively reflected in the consumption of steel, albeit in a complex fashion. A study made for the Economic Commission for Europe indicates that in the early stages of a country's economic development large increases in the per capita steel consumption correspond to very small changes in gross national product (GNP). Furthermore, the general pattern of steel utilization is such that during the early stages of development almost 90 per cent of steel consumption takes place in what might roughly be described as the investment sector: construction, production equipment and transportation. Later in the developmental process, as absolute steel consumption increases, the share of steel used in investment declines and that used in consumption increases (Greene, 1967). For the first stage of development, the steel industry promotes the national economic development and the process of industrialization; it is a vital cog in building an industrial economy in the first place. It is this facilitating role during the early phase that is keenly appreciated by developing countries. Subsequently, its role is less critical, having spawned a host of supplementary activities. Nevertheless, it remains a cornerstone of national well-being. In the early 1980s, the significance of steel to Japan was still assessed as being crucial, since every step taken by the steel industry in its progress has a corollary in the progress of the Japanese economy itself (Hogan, 1983).

The importance of steel in the national economy can be directly gauged from the relationship between steel activity and the national economy. What the relationship concerns is the two effects, known as "bottleneck" and "leverage" effects, which steel activity imposes upon cyclical movements in key macro-economic variables. The "bottleneck" effect claims that steel products are indispensable within the modern advanced economy, especially over the short run but also, more generally, over the longer term. In such circumstances, the under-provision of steelmaking capacity would quite conceivably seriously impede the overall growth of the macro-economy. The leverage effect, for its part, centres attention upon the ability of steel producers to raise the trend rate of growth of key macro-economic variables (e.g., gross domestic or gross national product) and to dampen or even to eliminate cyclical fluctuations within the national economy (Rowley, 1971).

If the period from the end of the World War II until the mid-1980s is examined, it can be seen that steel consumption grew faster than GNP until the middle of the 1960s. This was followed by a period of about ten years during which the growth in steel consumption was rather less than the growth in GNP. The third and final phase was characterized by the negative growth in steel consumption while GNP continued to rise. The third phase, therefore, differs fundamentally from the two preceding phases in that the two indicators are now developing in opposite directions

(Kutcher, 1987). An econometric analysis was undertaken to deal with the relation between GNP and the steel industry for the first two phases. The contribution of steel industry to growth of GNP is very positive once GNP is established as the dependent variable and steel output as the independent variable. In the UK instance, regression of GNP on steel output for the years was forthcoming with a regression coefficient of 0.9796, a standard error of 0.1091 and a R^2 of 0.8432 (Rowley, 1971); convincing evidence indeed of steel's role in regulating overall economic well-being. After Broude (1963) examined the United States' case, it was concluded that an exponential trend proved to be the desirable fit for the relationship between steel production and GNP rather than a linear fit. In terms of trend relatives, a high correlation coefficient occurred when steel output for the time series 1919-50 was related to GNP trend relatives. Fig.1.1 shows the configuration of the trend lines. The steel industry also plays an active role in specific indicators of national welfare, as the regression results in Table 1.1 show.

Table 1.1 Regressions of macro-economic variable on key US steel Variables 1950-66

Dependent variable	Independent Variable	Regression coefficient	Standard error	R^2
1 Wholesale price index	Steel price index	0.3357	0.0426	0.8052
2 Wholesale price index	Steel price index$_{-1}$	0.2638	0.0409	0.7486
3 Average hourly earnings	Steel hourly earnings	0.6003	0.2138	0.9813
4 Average hourly earnings	Steel hourly earnings$_{-1}$	0.5741	0.0227	0.9786

Source: Rowley, 1971, p185.

The forward and backward linkages of the iron and steel industry endorse its central role in the industrial structure and

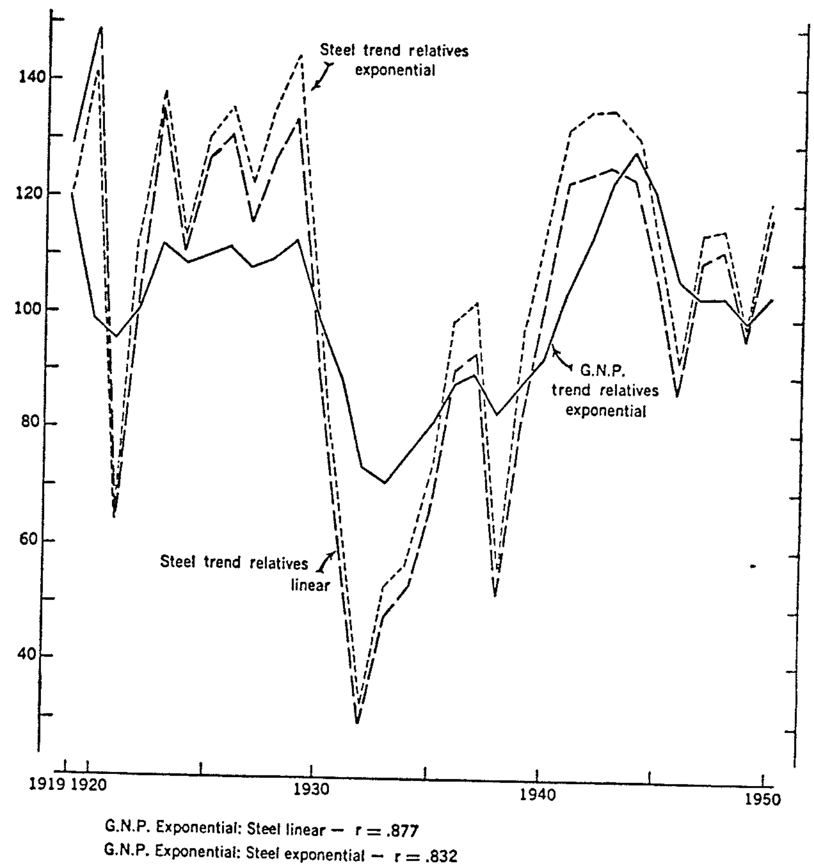

Fig.1.1, Trend relative, 1919-50
Source: Broude, 1963, p35.

national economy[1]. The steel-making process requires many raw materials and fuels including iron ore, coke, scrap iron and steel, limestone, ferrous-alloys, petroleum and natural gas. The establishment of an iron and steel industry should provide incentives for the establishment of domestic industries to supply steel's basic inputs, thereby promoting the development of raw materials' industries. From the vantage point of forward linkages, steel as an intermediate product is consumed in nearly all economic sectors. The iron and steel industry can provide its products to its industrial clients and, in turn, push forward the development of these clients. This is to say that the iron and steel industry can exert huge multiplier-effects on its forward-linked and backward-linked industries (Cole, 1967). Experimental and practical calculations of backward and forward linkage multipliers are shown in the Appendix A based on the input-output tables of the USA and Canada. On examining 1970 input-output coefficients for the USA, it is apparent that primary iron and steel manufacturing has the strongest backward linkage with the iron and ferro-alloy mining industry (the value of "a" was put at 0.061073). Overall, the backward linkage multiplier of primary iron and steel manufacturing

[1] Materials' linkages include the forward and backward linkages. A forward linkage captures that portion of a certain industry's output purchased by other industries. For the i industry, the strength of the forward linkage can be measured by the sum of direct and indirect requirements from all industrial sectors needed to deliver one additional units of output of the i to final demand. A backward linkage implies the input of all industrial sectors demanded by the subject industry's output. For the i industry, the power of backward linkage can be calculated by the sum of all industrial sectors' input needed in order to achieve one unit of output of i industry.

equalled 0.656234. Of the 82 industrial sectors in the table, there are 16 sectors whose multiplier values are larger than that of primary iron and steel manufacturing industry; but no fewer than 65 sectors whose multiplier values are smaller. All these figures attest to the iron and steel industry holding title to one of the stronger backward linkage multipliers. Inferring from the impact matrix of Canada for 1981, the forward linkage multiplier of iron and steel products, 1.8526, is strong. Of the 92 sectors in the matrix, only 36 have stronger forward linkages than iron and steel products.

The important role which the iron and steel industry has played in national economies can be regarded as something of a constant. Yet the same cannot be said with respect to its locational tendencies. The location of the iron and steel industry has undergone several dramatical changes over the years, concluding with a penchant for coastal locations. Before turning to the significance of coastal location, it is necessary to introduce the location theory attaching to this industry.

1.2 Location theory and the iron and steel industry

Least-cost theory, developed by Alfred Weber, is eminently suitable for comprehending the location of the iron and steel industry. After a series of assumptions, he advanced the law of transportation orientation, the law of labour orientation and the agglomeration factor as the determinants of plant location.

For the iron and steel industry, the influences on location include coal, iron ore, scrap, market, location inertia, labour and economies of scale. Coalfields exerted the dominating influence in locating the early furnaces. However, steady increases in the efficiencies of fuel consumption in iron-ore smelting and steel production undermined this dominant pull in succeeding years. With the declining importance of coal in the production of iron and steel, the relative importance of iron ore increased. When two tonnes of coal are required to produce one tonne of metal and one tonne of slag, the same amount of coal as iron ore has to be transported. As a result the coalfields and iron ore deposits have an equal attraction. For well over a century, the 'pull' of coking coal was quite decisive in location, chiefly because of the great quantity used in producing a tonne of pig-iron. In the mid-eighteenth century some 8 to 10 tonnes of coal were required per tonne of pig iron, but technical advances reduced this requirement to about 4 tonnes by the mid-nineteenth century and to about 3 tonnes by 1900. By 1938 it had been further reduced to about 1.8 tonnes in the UK and about 1.3 tonnes in the USA. Many of the centres of production (the Ruhr and the Pittsburgh-Youngstown area, for example) were developed when the pull of coal was very great. But a relative decline of coal in comparison with the pull of ore became evident with the development, in the late nineteenth and early twentieth centuries, of iron and steel capacity on the ore-fields of Lorraine in France and those of the East Midlands in the UK, although admittedly the ores were of relatively low grade and thus not economically transportable, and coal was not far away (Estall and Buchanan, 1973, pp.180-181). With the development of the open-hearth and electric-arc furnaces, scrap became a major material input in the steelmaking process. Owing to the decline in the consumption of coal and iron ore and the increase in the consumption of scrap, the attraction for the industry of iron ore and fuel sources has greatly diminished. Scrap is most available in the steel market areas. If the iron and steel industry were located in other areas, it would necessitate the transportation of scrap to these centres. Thus, the locational attraction of the market is greatly enhanced. In the USA the availability of large supplies of scrap in the North Atlantic coastal area and in the Chicago area added to the other attractions of these expanding steel-producing centres. On the other hand, persistent shortages of locally-arising scrap contributed to the relative decline in capacity of the Pittsburgh area (Estall and Buchanan, 1973). Since World War II, the market orientation of the iron and steel industry has been greatly strengthened; in part because of the scrap consideration but in part on account of other considerations. In sum, these considerations involve the decline in consumption of coal per tonne of steel produced, changes in the source of iron ore, scrap availability, and the realization of economies of scale. Because of the larger quantities of steel produced, a market orientation is of great importance in reducing transportation cost for the finished products. It should be noted, however, that the rush to market-oriented locations has been tempered by the sheer cost of relocating, or erecting from scratch, major steel works. The huge amount of capital intrinsic to investment in an iron and steel complex has been a major factor urging locational stability in the industry. From the viewpoint of cost-efficiency, the expansion and renewal of old steelmaking facilities is much more economical than construction of new facilities on a greenfield site. Thus, the huge capital investment in an iron and steel plant becomes a principal factor in promoting locational inertia in the industry. Furthermore, capital and operating costs in the iron and steel industry are considerably lower in large plants than in small plants. The largest market for steel is for standardized products, for which there is a steady demand and in which the economies of large-scale production are best realized. Inception of new works of substantial scale is a daunting prospect and one not to be undertaken lightly. Far better, in most instances, is to add to existing facilities, thus emphasizing the locational inertia.

Regarding the micro situation of siting the works, a separate series of factors comes to the fore. The first consideration is the availability of level land; a vital requirement, not only for building but also for the storage of raw materials and the disposal of slag. A modest-sized iron and steel plant will extend 2 km in length and cover at least several square kilometres. It is restrictions on land that cause many old works to move out from the built-up areas of cities. The second factor is the availability of a good supply of water, since large quantities of water are necessary for this industry. In 1968, the total intake of water in the USA by all manufacturing was 15,467 billion gallons, of which 4,071 billion gallons were consumed by blast furnaces and steel mills, the prime user. The Chicago-Gary area, for example, is among the largest users of water per tonne of steel produced; location alongside Lake Michigan makes water supply a cheap and easy matter. By contrast, at Fontana, California, water supply is difficult. Kaiser originally wanted a site on tidewater at Los Angeles, but a government loan was made conditional on a location 80 km inland. The result was that the cost of water was about ten times that at Chicago (Estall and Buchanan, 1973). Because fresh water is becoming a scarce resource, coastal locations for steelworks promise access to the alternative of seawater resources. In addition, the availability of transportation facilities is also of vital account in siting a plant, because of the requirements of bulk cargo handling. Extensive rail links and inland waterways to the sites permit easy assembly of the materials and ready means of delivering the products.

Generally speaking, the role of the site factors in determining the location of works is immutable. However, the factors that have influenced the macro location of the iron and steel industry have changed with time, primarily because of technological advances on the one hand, and changes in raw materials' supply, transportation costs and size of market on the other. Because the iron and steel industry throughout has been a major consumer of bulky, heavy raw materials and a massive consumer of fuel, it always sought the lowest costs' point for the assembly of these materials. For the early iron furnaces, the coalfields exerted the dominating influence in location simply because the amount of coal required to smelt a tonne of ore and process the pig iron greatly exceeded the total weight of the ore plus the finished product. In Britain, the progenitor of the modern industry, the early centres of the industry were found on the coalfields of the Midlands, Yorkshire, Derbyshire and South Wales. As mentioned above, with rising efficiencies in fuel consumption in iron-ore smelting and steel production, coal consumption declined steadily for pig iron and this served to lessen coal's importance in locating the iron and steel industry. Nevertheless, a number of steelmaking centres continue to occupy coalfields to this day. As far as iron ore is concerned, historically, a number of iron and steel centres have been oriented to iron ore deposits. The attraction to ore-fields became evident on the European continent and in Britain about the middle of the nineteenth century. However, in the United States a combination of factors rendered the most suitable location for the industry at a break in transportation or intermediate point. Since iron ore was received from both the Upper Great Lakes and the Lower Great Lakes by lake freighters, but coal came from the interior Appalachian fields, 'compromise' industrial centres developed in Cleveland, Buffalo and Detroit. With the development of the open-hearth and electrical furnaces, scrap became a major material input in the steelmaking process. The western Pennsylvania-eastern Ohio iron and steel region occupied a central position between New York and Chicago and was thus able to access scrap from these markets as well as supplying them with new steel. The shift of iron and steel industrial location from raw materials orientation to market orientation, and in particular to coastal sites, gained momentum after World War II. This inclination to adopt coastal locations has come about in response to the influences of many factors, most notably changing sources of fuel and raw materials, ocean transportation shipping and the utilization of large vessels, and the emergence of coastal markets and the increasing importance of overseas markets. Significant examples corroborating these influences can be observed in Japan, and what is now the European Union (Miller, 1977, pp.181-184). The next section will give substance to the reality of the coastal location of steelmaking and underscore the reasons accounting for its occurrence.

1.3 Coastal location and its significance for the metallurgical industries

The significance of coastal location for iron and steel industry derives from the increasing reliance on imported raw materials. In 1950, total production in the world was 246 million tonnes of steel, of which 40.5 million, or 16.5 per cent, were shipped in international trade. In 1974, a year of record steel production up to that time, 883.0 million tonnes of ore were mined, of which 402 million tonnes, or over 45 per cent, were shipped in international trade (Hogan, 1983). The vast increase in this trade is immediately apparent, rising about 29 per cent over the period (Table 1.2 and

Table 1.3). This increasing reliance on traded ore results from the exhaustion of home ores and the discovery of richer or larger sources overseas. However, its incidence only became feasible with the emergence of economies of scale in shipping. Only large vessels are able to carry such materials economically. It was suggested in 1962 that the comparative rates for moving ore in the alternative transport modes were approximately $0.1 per tonne-mile for ocean vessels, $0.4 per tonne-mile for coastal vessels and $1.1 per tonne-mile for rail transport. The highly competitive nature of ocean transport stems fundamentally from its low capital costs per tonne-mile of carrying capacity. Taking the economic advantages of ocean carriers and their low tonne-mile costs, the average trip length for procuring iron ore for most iron and steel producers in the world has increased dramatically. This tendency has been furthered by the appearance of new iron and steel producers, many of which are totally reliant on imported ore (Manners, 1967).

The most obvious example of heavy import dependence is Japan. In 1968, imported iron amounted to 84.7% of all ore used by the industry. The equivalent proportion for coal was 71.9%. In 1980, Japan imported 133.7 million tonnes of ore, which was over 99 per cent of its requirements. In the same year, 58.3 million tonnes of coking coal, or 90 per cent of its requirements, were imported (Hogan, 1983). This trend is also discernible in Europe, the United States and China (Table 1.3). Emblematic of Japan's reliance on

Table 1.2, The Export of Ore from Selected Countries (x ,000 tonnes)

	1951	1961	1971	1981	1991
Algeria	275	2780	2015	0	0
Australia	0	4	53628	71202	107665
Brazil	1320	6281	31020	85798	113301
Canada	2021	15106	34164	41452	29651
Chile	0	6197	9908	4121	6306
France	10599	25854	18454	16574	0
India	20	3362	19320	25210	32493
Liberia	0	2962	21235	20694	13666
Norway	445	49	2903	3667	0
Peru	0	2072	2178	2874	0
South Africa	0	4	5545	10308	6840
Sweden	1587	20434	26549	18014	0
Venezuela	0	14564	19162	12422	15251
TOTAL	16267	94014	246078	312336	325173

Data sources: United Nations, 1951, 1961, 1971, 1981, and 1991 International Trade Statistics Yearbook, New York.

Table 1.3, The Import of Ore into Selected Countries (x, 000 tonnes)

	1951	1961	1971	1981	1991
Belgium	48	20652	28284	21244	19489
Germany	7701	35108	41506	44829	43440
Italy	402	3306	11159	15211	17854
Netherlands	1014	2255	5991	0	0
UK	3741	15215	17755	14848	0
Spain	227	214	3248	4698	0
Japan	3089	21239	114951	123362	127186
Republic of Korea				420	10688
China					18549
USA				28798	
TOTAL	16222	97987	222894	238199	237206

Data sources: same as Table 1.2.

overseas materials is the large number of integrated mills built since World War II. Almost without exception these occupy land reclaimed from the sea; land that is literally fronting onto the water. Nowhere is this more evident than in the Pacific Belt Region. The record of coastal location in the British region of South Wales is even more long-standing. For example, Dowlais Works, Cardiff, was established on the basis of imported ore in 1891. After World War II, Italy and the Netherlands were quick to re-establish their steelmaking capabilities on the basis of coastal works. During the 1960s both countries benefited from duty-free importation of American coal; a benefit denied other European countries which, in endeavouring to protect domestic coal mining, restricted(or prohibited, as in Britain) coal imports. The change was even more pronounced in ore supply. ECSC (European Coal and Steel Community) mines produced 67.5 per cent of the ore needs of its member states in 1955, 41.5 per cent in 1965 and only 35 per cent in 1970. European firms have reacted positively to these changing circumstances. Only about 4 per cent of ECSC pig iron production came from tidewater furnaces at integrated works in 1952 but the proportion rose to 15 per cent in 1965 and had reached 24.8 per cent in 1972. Coastal integrated works made 5.0 per cent of ECSC steel in 1955, 13.9 per cent in 1965 and 20.5 per cent in 1972 (Warren, 1975, pp.154-163). It is obvious that the iron and steel industry in Europe was largely rebuilt after the War with coastal locations in mind and this tendency was strengthened with increasing reliance on imported materials during and after the 1960s. Unlike its counterparts in Japan and Europe, the iron and steel industry in the United States managed to absorb increasing amounts of imported ore without experiencing major industrial dislocation. The major exception to this inertia was Bethlehem's integrated mill at Sparrows Point, Maryland. To be sure, smaller mills have been much more inclined to disperse away from the old industrial heartland. Florida and the Carolinas have received some of these minimills[2], and the managers in charge of site selection have been mindful of access to imported materials. Inland works, persisting in their eccentric location despite declining supplies of local materials, have been compelled to incur the extra expense of obtaining imported ores. The exception, Bethlehem's works, can be traced back to the end of the nineteenth century. By taking advantage of shipping to the tidewater terminals, Bethlehem used foreign ore and, although the tariff on imported ore had to paid, there was a remission on the material that was worked up into

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[2] Any significant increase in steel production in the United States will be made by the minimill segment of the industry. In 1992, it produced 34 million tonnes, or 37 per cent, of a total U.S. steel output of 93 million tonnes, while the integrated segment produced 58 million tonnes, or 63 per cent of the total. The percentage of minimill production will most probably be between 42 and 45 per cent by the year 2000. By the mid-1980s, as minimills moved toward domination in most long-product markets, they had proliferated around the world and had undergone dramatic increases in the size and complexity of their operations.

However, given the extent to which their technology has so far evolved, minimills can supply only a limited range of sheet products, higher quality sheets are beyond their current capacity. In the future, minimills will achieve steel-quality and surface improvements. But, it is unlikely that they will develop the inclination or the funding capacity to install downstream processing facilities as diverse and sophisticated as those presently operated by the integrated mills.

Because China suffers from shortages of high-quality and speciality products, its future rests in the integrated sector. Consequently, I shall not return to the minimill sector in this thesis.

export articles. For the first half of this century, Sparrows Point was unchallenged as the only major eastern tidewater plant. Within Bethlehem's domination of the regional markets it gradually increased its pre-eminence. When the existence of high-grade iron ore in eastern Venezuela had been proved, new liberal shipping policies improved tidewater prospects still more. The approaches through Chesapeake Bay to Sparrows Point were deepened to allow access to carriers increasing in size from 52,000 to 160,000 tonnes and the capacity of the plant was more than 8 million tonnes by 1969. Some big works in the South-east, initiated to tap domestic ore of the lower grade, elected to abandon the Red Mountain sources of supply and are wholly dependent on imported ore (Warren, 1975). For example, as late as 1957, the Woodward Iron Company made its foundry iron almost wholly from Alabama red or brown ores; by 1967 it operated only two Alabama mines and was also using ore from Venezuela and even India. US Steel supplied its southern works from seven active Red Mountain mines with an annual ore-producing capacity of 5.6 million tonnes in the mid-fifties. By 1964, it decided to abandon these mines and become wholly dependent on imported ore. The shift of iron and steel location from inland to the coast is a world-wide phenomenon. To be exact, most of the new integrated iron and steel works and their associated complexes[3] of interlinked activities are located adjacent to deep-water ports.

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[3] A complex is a set of activities at a special location which are linked by certain technical and production interrelations; these interrelations may result in a spatial juxtaposition of the activities.

Table 1.4 lists some of the more prominent examples. The incentives for integrating industrial complexes into ports derive from the advantages accruing to industrial ports themselves, together with the merits that stem from integrating metallurgical activities into bundles of collocated units. The remainder of this thesis dwells on these considerations and, in the next section, their salient aspects are introduced.

1.4 Advantages of industrial ports and the merits of integrating metallurgical complexes with purpose-built port facilities.

The industrial port, or, more properly, the maritime industrial development area (MIDA), owes its rationale to a few fundamental

Table 1.4, The World's Main Coastal Steelworks

Name	Location	Size	Start of production by integrated system
Nippon Steel-Kimitsu	Chiba	> 6 million	1968
Nippon Kokan -Fukuyama	Hiroshima	>10 million	1966
Sumitoma Metal - Wakayama	Wakayama	> 7 million	1961
Usinor-Dunkirk	Nord	8 million	1962
Italsider-Taranto	Taranto	>4.5 million	1964
British Steel Corporation - Port Talbot	Port Talbot	>6 million	
Bethlehem -Sparrows Point	Sparrows Point	8 million	
Baoshan Company	Shanghai	6 million	1985

Sources: Warren, K., 1970; 1973; and 1975.
Murrata, K., 1980.

economic truths. In the carriage of iron ore and coal, the deep-water port can allow access to bulk carriers of a sufficient size to enable the realization of both economies of ship construction and economies of ship operation. Moreover, the creation of planned complexes should enable port investment to be kept at an economic level, with the cost of the infrastructure reduced in national terms. By the latter is meant the concentration of such developments in a limited number of centres will reduce the overall investment necessary to furnish a given amount of capacity. These notions were wrapped up in the MIDA concept of the 1960s. At that time, the British Government and its now defunct NPC (National Ports Council) initiated studies to identify potential sites for MIDAs and set up the following standards for eligibility: (1) the site must be close to deep water; (2) it must have available at least 20 km^2 of level land near the deep water; and (3) it must enjoy a favourable broad economic geographical location[4]. MIDAs were espoused quite widely during the 1960s and the 1970s. As a consequence of projects undertaken then, it is now possible to distinguish three types of MIDAs. The first type revolves around heavy industries, is chiefly found in developed countries, and the port serves as a conduit for importing raw materials; the second consists of diversified industries in the port-industrial areas and this type is scattered about the world; the third type is rooted in

[4] It should itself be, or be close to, a population and industrial centre, with advanced inland communications to markets and good links to other overseas ports.

manufacturing industries that are geared to processing raw materials for export and is favoured in the main by developing countries. Rotterdam in the Netherlands, Dunkirk and Fos in France, to say nothing of a legion of "Kombinats" in Japan spring to mind as practical expressions of MIDAs. They are complemented, however, by a host of Type Two or Type Three MIDAs that are less well-known. The familiar Type One is the subject of detailed attention in Chapter 3. For the purpose of this chapter, the basic advantages attaching to MIDAs are emphasized.

According to the advocates of MIDAs, the area assigned to industries is much smaller than what would be required to accommodate the same amount of industrial activity located in several separate sites. At the same time, smaller-scale industries can share the agglomeration, grasping the external economies that are invested in MIDAs. What is more, concentration of industrial activities eases the task of supervising pollution control. However, an even more convincing argument for MIDAs arises in the fact that integrating the iron and steel complexes into the ports opens the door to the prospect of substantial economies of cargo handling of imported raw materials. These economies can be achieved because the industrial location is close to or actually adjoins the point of transhipment (Takel, 1974). Because the MIDAs rejoice in high market potential, their function as international transhipment points can effect transport-cost savings both by conveying the manufactured products to overseas markets and in facilitating the import of material inputs. The imported raw materials have to be unloaded and stockpiled behind the quays. Erecting the furnaces directly behind stockyards will save at least one step in the handling of the ore and other raw materials. These advantages have universal relevance, but the purpose of this thesis is to demonstrate their particular applicability to China. The following section introduces the China case, underlining its appropriateness as a case study.

1.5 Integrating the metallurgical complexes with port facilities, the important issues in China.

The iron and steel industry is one of the key industries in China. In fact, China has reached the fourth position in the world in terms of steel output. Therefore, all issues having a bearing on steelmaking are very important. From 1970 to 1987, the output value of the iron and steel industry amounted to 6.15% of the total industrial output in China, a figure which compares favourably with the 4.68 per cent in the USA in 1977, the 8.01 per cent in Japan in 1978 and the 6.70 per cent figure for 1979 in West Germany.

The iron and steel industry contributes greatly to national economic development in China. Since China copied the model of the former Soviet Union to calculate its national statistical account, it is necessary to be cognizant of the fact that social production value[5] substitutes for GNP. Figure 1.2 captures the consistency in

[5] The social production value consists of the value of agricultural, industrial, commercial, building and construction production, and the value of transportation service production.

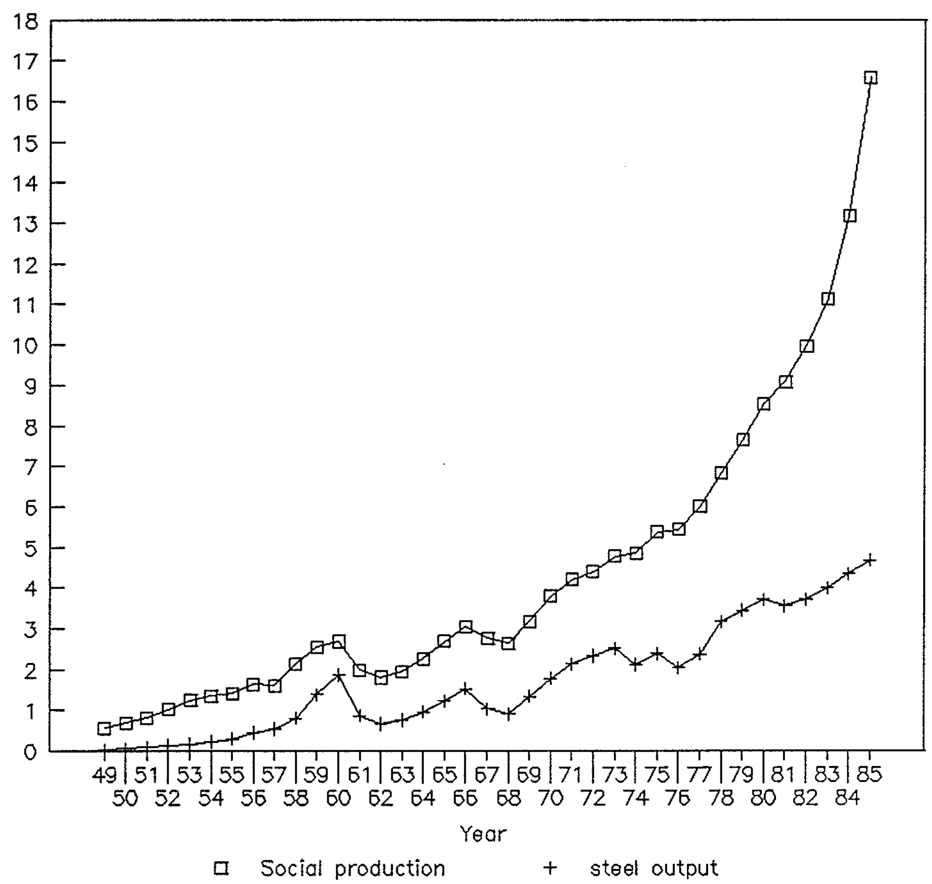

Fig.1.2, The output of steel product and value of social production, 1949-1985.
Social production value, in ten billion yuan.
Output of steel product, in ten million tonnes.
Source: same as the regression equation.

the time series applying to the aggregate indicator of output and the specific case of steel production. A precise gauge of that relationship can be attained by a regression analysis which assigns national output to the dependent position (Y) while allocating steel to the regulating (X) role. A very strong relationship ensues, as is made evident in the footnote[6].

Mindful of the important role that the iron and steel industry plays in the national economic development, China's Government has bestowed special- if inconsistent- attention on it. During the late 1950s and the early 1960s, iron and steel production was treated as a national priority and championed by the political leadership. All economic and manpower resources were hastily mustered in order to force the development of the iron and steel industry. Multitudes of backyard furnaces[7] were set up. As a result, the economic

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[6] $Ys = -150.3 + 2.6305\ X_{st}$

Y_s: variable, the output value of social production.

X_{st}: independent variable, the output of iron products, volume.

R^2, 0.9043; F, 330.81 and DW, 0.4573. 37 observations from 1949 to 1985.

Data source: Bureau of State Statistics, 1990, Collective data of statistics from 1949-1989, Press of Chinese Statistics, Beijing, in Chinese.

[7] Backyard-furnace refers to native and indigenous methods in iron and steel smelting; including ore mined by primitive native methods. The workers used hammers, chisels and hand drills to dig exposed ore on the surface. Hand methods were also employed to load and transport the ore. The furnaces were modest in size. Some backyard furnaces were even smaller than 1 m^3. The average capacity of backyard furnaces was 1,200 tonnes of pig iron, 1,000 tonnes of ingot steel, 900 tonnes of rolled steel, 180 tonnes of refractory bricks and 2,000 tonnes of coke annually.

efficiency of the industry was extremely low and lots of resources were squandered.

Throughout the 1960s, a significant amount of steel output (20-25 per cent) came from the many so-called backyard furnaces. By the end of the 1970s, however, China had set a new course, striving for improvement in steelmaking equipment and emphasizing economies of scale in operations. The Baoshan Iron and Steel Complex was built with modern equipment. Heavy-duty equipment installed in this plant included 450 m^2 sintering machines, 4063 m^3 blast furnaces, 300-tonne LD converters, large slab casters, and a 1370 mm blooming and slabbing mill; not to mention appropriate finishing mills such as a 2050 mm hot-strip mill, cold tandem mill, and a 140mm diameter continuous seamless tube mill. At the extant Wuhan Iron and Steel Company, changes were made in order to utilize fully the already built 1700 mm hot-strip mill and cold tandem mill so as to produce more wide strip and silicon steel sheets. However, owing to the preponderance of old equipment, there remains a severe shortage of high-grade steels in China. Table 1.5 presents figures on the production and import of steel since 1950. Most of the imported steel consists of high-grade product which China cannot make itself. However, the coastal areas suffer most for the want of steel products. The development of the iron and steel industry in south coastal China is not consistent with that region's economic development. In 1990, steel production in the Guangdong, Fujian, Guangxi and Hainan provinces was only 2.21 million tonnes, equivalent to only 3.3 per cent of China's total steel output in

Table 1.5, Chinese steel production and import

	1950 -1957	1958 -1965	1966 -1975	1976 -1980	1981 -1985	1987
Product (1,000 tonnes)	15410	59880	124320	105200	157080	43860
Import	5610	5260	26300	32300	49980	11740
self-supply (%) ratio	74.6	95.1	84.7	77.4	76.8	79.3

Source: Yearbook of iron and steel statistics 1988, Ministry of Metallurgical Industry, Beijing, in Chinese.

comparison with its GDP share of 13.7% of the Chinese total. The ramifications of this alarming mismatch are explored in Chapter 4.

Ironically, in the face of rising absolute output and the national desire to be as self-sufficient in steelmaking as possible, the reliance on imported iron ore continues its inexorable climb. This is owing more to shortages in high-grade ore than to an overall shortage of ore in China, but cause notwithstanding, the outcome is increasing pressure to build new steelmaking capacity along the coast, enhancing accessibility to imported materials. This pressure is especially telling in respect of high-grade steel production. Except for the renovating of existing plants and expanding their scale, the only way to meet the demand for this steel will be through the construction of mills centred in industrial ports.

Before the construction of the Baoshan Iron and Steel Complex, which is the model of things to come in Chinese steelmaking, the location of the iron and steel industry in the country fell into four categories. First were the sites near the sources of coking coal, such as Taiyuan Works. Second were sites which combined ore and coking sources, such as Benxi and the Panzihua Iron and Steel Company. The third category embraced steelworks hard by iron ore deposits, such as the Anshan Works. Finally, a category which combines market and iron ore access, such as the Capital Iron and Steel Company outside Beijing, can be identified. However, the construction of Baoshan is totally different from the extant works, since it is not only reliant on imported ore resources and is located at a market centre, but possesses its own berths and has Shanghai port in its neighbourhood. Shanghai port is the first port of China while the city hosts a number of factories which compose a metallurgical complex in its own right. The advantages justifying Baoshan are latent to other parts of coastal China. A significant portion of Chapter 4 is devoted to revealing those advantages, resting as it does on a comparative analysis of transport costs obtaining at inland sites and potential coastal sites. Teasing out the details of such industrial ports must await that chapter; suffice it to say here that considering the domestic ore reserves, the structure of finished steel products and the regional balance of steel demand, there can be no doubt that integrating the iron and steel complexes into ports will most assuredly work to China's advantage.

In China, overall plans both for the provision of ports and the establishment of industrial complexes are still awaiting resolution. China is cautions because of past mistakes. Even Baoshan is not free of errors. Because neither its own berths nor those available in Shanghai port can accept large ore carriers, the imported ore must be transhipped at Beilun port. The ore is offloaded from large carriers at Beilun, is held in storage for three days, and then transferred to Shanghai by smaller vessels, all at a surcharge per tonne of 19.3 Yuan[8]. An obvious solution would be to erect a metallurgical complex directly adjacent to Beilun Port; for at least the transhipment cost would be avoided in that eventuality. While a strong case exists for such a complex, the very existence of Baoshan - planned, it must be conceded, on the understanding that large carriers would be able to berth there - means that the transhipment process cannot be dispensed with. Severe (and unanticipated) dredging costs make the deepening of the Baoshan berths too expensive to contemplate. The large, optimally-sized ore carriers have no option but to resort to Beilun. In point of fact, viewed from the perspective of China as a whole, there are very few sites left where deep water and ample land for industrial development coincide in the vicinity of major population areas; thus the competition for land near deep water and major population areas is intense. Therefore, as in advanced countries, a primary long-term planning effort must be directed to the identification of sites where development of new ports, possible modifications of extant ports and the positioning of associated industrial activity can most advantageously take place. It is the intent of this thesis to offer some guidelines for that task. Before embarking on that venture directly, however, it is necessary to elaborate on the

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[8] The price of imported ore discharged directly at Baoshan without the Beilun offload is estimated as 37.4 yuan at the exchange of US $1 to 5.8 yuan in 1992.

twin concepts of metallurgical complexes and industrial ports. The next chapter deals with the first of these.

Appendix A Measurement of backward and forward linkages of iron and steel industry

Table A.1, Skeletal input-output table

	1	2	.. i	.. n	Final demand	Gross output
1	X_{11}	X_{12}	X_{1i}	X_{1n}	Y_1	X_1
2	X_{21}	X_{22}	X_{2i}	X_{2n}	Y_2	X_2
..	..	..	..		..	..
i	X_{i1}	X_{i2}	X_{ii}	X_{in}	Y_i	X_i
..	..	..	..		..	..
n	X_{n1}	X_{n2}	X_{ni}	X_{nn}	Y_n	X_n
V	V_1	V_2	V_i	V_n	-	V
Gross outlay	X_1	X_2	X_i	X_n	Y	X

In Table A.1, X_i stands for the gross output of the ith industry, x_{ij} is the output of the ith industry used as input in the jth industry and Y_i denotes the output of industry i available for outside consumption or final demand. For instance, row i in the table shows the sales of industry i to all other industries (intermediate demand) and to consumption, private investment, government spending and exports (which are the components of final demand); intermediate demand plus final demand measures total gross output. Conversely, column j shows the purchases of industry j form all other industries (intermediate inputs), from primary inputs (labour, capital etc.) which are value-added entries taking the form of wages, profit, rent, interest and taxes, and from imports.

If we postulate that every commodity is produced by only one given process and denote $X_{ij}=a_{ij} X_j$ $(i,j = 1, 2, \dots n)$ where a_{ij} stands for the amount of the ith good used to produce a unit of jth product, we can rewrite the system of equation above as:

$$X_i=\sum a_{ij}X_j+Y_i \; (i=1,2\dots n)$$

It follows that the basic input relations can be rewritten compactly as AX + Y = X. A is an NxN matrix of direct input coefficients, as below.

$$A = \begin{bmatrix} a_{11} & \dots & a_{1i} & \dots & a_{1n} \\ . & \dots & . & \dots & . \\ a_{i1} & \dots & a_{ii} & \dots & a_{in} \\ . & \dots & . & \dots & . \\ a_{n1} & \dots & a_{ni} & \dots & a_{nn} \end{bmatrix}$$

For the industry i, its backward linkage multiplier can be measured by the sum of row, $a_{1i}+a_{2i}+\dots+a_{ni}$.

By resorting to the identity matrix I, under the condition that (I-A) has an inverse (in practical circumstances this condition will be met if the Y vector contains at least one-zero element), we may use the inverse matrix to express gross output as a function of (exogenous) final demand:

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

where $(I-A)^{-1}$ is the Leontief inverse matrix. Let $B= (I-A)^{-1}$. Then:

$$B = \begin{bmatrix} b_{11} & \cdots & b_{1j} & \cdots & b_{1n} \\ . & \cdots & . & \cdots & . \\ b_{i1} & \cdots & b_{ij} & \cdots & b_{in} \\ . & \cdots & . & \cdots & . \\ b_{ni} & \cdots & b_{nj} & \cdots & b_{nn} \end{bmatrix}$$

Each entry in this inverse matrix is called an interdependency coefficient. The coefficient b_{ij} represents the direct and indirect requirements of sector i per unit of final demand for the output of sector j. The sum of row, $b_{i1}+b_{i2}+...+b_{in}$, can be taken as the forward linkage multiplier of sector i.

According to the 1970 input-output coefficients, direct requirements per dollar of gross output of primary iron and steel manufacturing is shown in Table A.2. Table A.3 shows the multipliers of all Canadian sectors in 1980, including the iron and steel products.

Table A.2 The 1970 input-output coefficients of the US economy

	A	B
1, livestock and livestock products		0.656815
2, Other agricultural products		0.467273
3, Forestry and fishery products		0.747340
4, Agricultural, forestry, and fishery services		0.536547
5, Iron and ferroalloy ores mining	0.061073	0.704177
6, Nonferrous metal ores mining	0.000307	0.621722
7, Coal mining	0.019871	0.422953
8, crude petroleum and natural gas		0.434868
9, Stone and clay mining and quarrying	0.002367	0.433201
10, Chemical and fertilizer mineral mining	0.000330	0.517378
11, New construction		0.663839
12, Maintenance and repair constructions	0.005276	0.374762
13, Ordnance and accessories	0.000006	0.544438
14, Food and kindred products	0.000350	0.724503
15, Tobacco manufactures		0.501640
16, Broad and narrow fabric, yarn and thread mills		0.752891
17, Miscellaneous textile goods and floor coverings	0.000054	0.700526
18, Apparel	0.000692	0.616631
19, Miscellaneous fabricates textile products	0.000108	0.760302
20, Lumber and wood products, except containers	0.001106	0.739501
21, Wooden containers	0.000108	0.641657
22, Household furniture	0.000062	0.581772
23, Other furniture and fixtures	0.000003	0.544376
24, Paper and allied products, except containers	0.002492	0.657714
25, Paperboard containers and boxes	0.000788	0.640794
26, Printing and publishing	0.001474	0.554611
27, Chemical and selected chemical products	0.014215	0.630932
28, Plastics and synthetic materials	0.000329	0.624212
29, Drugs, cleaning, and toilet preparations	0.002203	0.613362
30, Paints and allied products	0.000864	0.652019
31, Petrochemical refining and related industries	0.015262	0.760154
32, Rubber and miscellaneous plastics products	0.004297	0.546886

	A	B
33, Leather tanning and industrial leather products		0.473905
34, Footwear and other leather products	0.000004	0.556470
35, Glass and glass products	0.000060	0.449249
36, Stone and clay products	0.010777	0.538328
37, Primary IRON and STEEL manufacturing	0.240729	0.656234
38, Primary nonferrous metals manufacturing	0.018103	0.678131
39, Metal containers		0.627869
40, Heating, plumbing, and structural metal products	0.002475	0.605559
41, Stamping, screw machine products, and bolts	0.005181	0.583338
42, Other fabricated metal products	0.017306	0.591288
43, Engines and turbines	0.000102	0.582935
44, Farm machinery and equipment	0.001322	0.654773
45, Construction, mining and oil field machinery	0.000748	0.567000
46, Materials handling machinery and equipments	0.000136	0.651910
47, Metalworking machinery and equipments	0.006368	0.501324
48, Special industry machinery and equipments	0.001147	0.606243
49, General industrial machinery and equipments	0.003558	0.571563
50, Machine shop products	0.008334	0.507615
51, Office, computing, and accounting machines	0.000057	0.449513
52, Service industry machines	0.000092	0.660748
53, Electric industrial equipment and apparatus	0.004350	0.515835
54, Household appliances	0.000161	0.645039
55, Electric lighting and wiring equipment	0.000540	0.550483
56, Radio, television, and communication equipment	0.000022	0.601629
57, Electronic components and accessories		0.514459
58, Miscellaneous electrical machinery and equipment	0.000005	0.620293
59, Motor vehicles and equipment	0.002043	0.715690
60, Aircraft and parts	0.000027	0.477964
61, Other transportation equipment	0.000825	0.631874
62, Scientific and controlling instruments	0.000329	0.560877
63, Optical, ophthalmic, and photographic equipment	0.000078	0.527351
64, Miscellaneous manufacturing	0.000604	0.639606
65, Transportation and warehousing	0.052641	0.413445
66, Communications, except broadcasting	0.004039	0.160841
67, Radio and television broadcasting		0.444182
68, Electric, gas, water, and sanitary service	0.043964	0.510489
69, Wholesale and retail trade	0.033445	0.289927
70, Finance and insurance	0.007541	0.450422
71, Real estate and rental	0.003858	0.254456
72, Hotels, personal and repair service, except auto	0.001057	0.408657
73, Business services	0.010456	0.510484
74, Research and development	0.000965	0.252347
75, Automobile repair and service	0.000431	0.547583
76, Amusements	0.000023	0.451584
77, Medical, educational, and nonprofit organizations	0.001025	0.337661
78, Federal Government enterprises	0.000675	0.395683
79, State and local government enterprises	0.000700	0.423516
80, Gross imports of goods and services	0.031449	
81, Business travel, entertainment, and gifts	0.004377	0.995837
82, Office supplies	0.000468	0.956705

Source: US Department of Labor, 1970 Input-Output Coefficients.

A, input-output coefficient of Primary Iron and Steel manufacturing to all other sectors, same as a_{i37}. B, the sum of a_{ij}, is the backward linkage multiplier of primary iron and steel manufacturing.

Table A.3, Impact (Inverse) Matrix (Aggregation-M) 1981 (total)

1, Grains	1.9897	43, Printing & publishing	1.8089
2, Live animals	1.9797	44, Advertising, print media	1.8046
3, Other agricultural products	1.9808	45, IRON AND STEEL PRODUCTS	1.8526
4, Forestry products	1.9251	46, aluminum products	1.8589
5, Fish landing	1.5340	47, Copper & copper alloy products	1.8553
6, Hunting &trapping products	1.5323	48, Nickel products	1.8578
7, Iron ores &concentrates	1.6380	49, Other non-ferrous metal products	1.8443
8, other metal ores		50, Boilers, tanks & plates	1.8213
& concentrates	1.6737	51, Fabricated structural metal products	1.8332
9, Coal	1.6374	52, Other metal fabricated products	1.8194
10, Crude mineral oils	1.6301	53, Agricultural machinery	1.6219
11, Natural gas	1.6302	54, Other industrial machinery	1.6774
12, Non-metallic minerals	1.6564	55, Motor vehicles	1.5836
13, Services incidental		56, Motor vehicle parts	1.5987
to mining	1.7729	57, Other transport equipment	1.6023
14, Meat products	2.3315	58, Appliance & receivers, household	1.6943
15, Dairy products	2.3872	59, Other electrical products	1.6709
16, Fish products	2.3844	60, Cement & concrete products	1.8831

17, Fruits & vegetables preparations	2.3772	61, Other non-metallic mineral products	1.8771
18, Feeds	2.3671	62, Gasoline & fuel oil	1.8735
19, Flour, wheat, meal & other cereals	2.3877	63, Other petroleum & coal products	1.8401
20, breakfast cereal & bakery products	2.3314	64, Industrial chemicals	2.0622
21, Sugar	2.3877	65, Fertilizers	1.8150
22, Misc. food products	2.3631	66, Pharmaceutical	2.0817
23, Soft drinks	1.9577	67, Other manufactured products	2.0737
24, Alcoholic beverages	1.9570	68, Scientific equipment	1.7427
25, Tobacco processed unmanufactured	2.2312	69, Other manufactured products	1.7820
26, Cigarettes & tobacco Mfd.	2.2312	70, Residential construction	1.7976
27, Tires & tubes	1.8314	71, Non-residential construction	1.7976
28, Other Rubber products	1.8446	72, Repair construction	1.7976
29, Plastic Fabricated products	1.9473	73, Pipeline transportation	1.4099
30, Leather & leather products	1.8382	74, Transportation & storage	1.7894
31, Yarns & man-made fibres	1.8452	75, Radio & television broadcasting	1.3483
32, Fabrics	1.8426	76, Telephone & telegraph	1.3483
33, Other textile products	1.8404	77, Postal services	1.3483
34, Hosiery & knitted wear	1.7118	78, Electric power	1.2713
35, clothing & accessories	1.7146	79, Other utilities	1.2708
36, Lumber & timber	2.1231	80, Wholesale margins	1.5613
37, Veneer & plywood	2.1260	81, Retail margins	1.4715
38, Other wood fabricated materials	2.1037	82, Imputed rent owner-occupied dwellings	1.1261
39, Furniture & fixtures	1.8441	83, Other finance, ins, real estate	1.4510
40, Pulp	2.0564	84, Business services	1.3907
41, Newsprint and other paper stock	2.0550	85, Education Services	1.4284
42, Paper products	2.0173	86, Health service	1.3632
		87, Amusement & recreation services	1.6753
		88, Accommodation & food services	1.7196
		89, Other personal & misc. services	1.4578
		90, Transportation margins	2.7337
		91, Supplies for office, lab and cafeteria	2.2378
		92, Travel, advertising and promotion	2.4718

Source: Statistics Canada, 1987, The input-output structure of the Canadian economy, 1961-1981.

CHAPTER TWO. COLLOCATION OF METALLURGICAL INDUSTRIES

2.1 Introduction

As asserted in Chapter 1, in theory, the iron and steel industry has strong and far-reaching technical links. A product of these technical links, the iron and steel industrial complex, conceptually, is easily identifiable. Figure 2.1 indicates the successive stages of manufactures from the ore and fuel to the finished rolled iron and steel (Daugherty, et al, 1937). Each of these stages or sequences requires an industrial operation in its own right; together they constitute the industrial complex associated with iron and steel. The object of this chapter is to review technical progress in the iron and steel industry for the first part, and then to illustrate the iron and steel complexes around the world by categorizing their location.

2.2 The ideal steel-based industrial complex

Steelworks vary widely in scale, operating conditions and technology, but are nevertheless capable of being classified into three types: integrated iron and steel works which produce pig iron and steel products from iron ores in an integrated manner; electric furnace steelmaking plants which do not have ironmaking facilities but perform electric heating; and steelmaking facilities that perform rolling only. Integrated iron and steel works are the

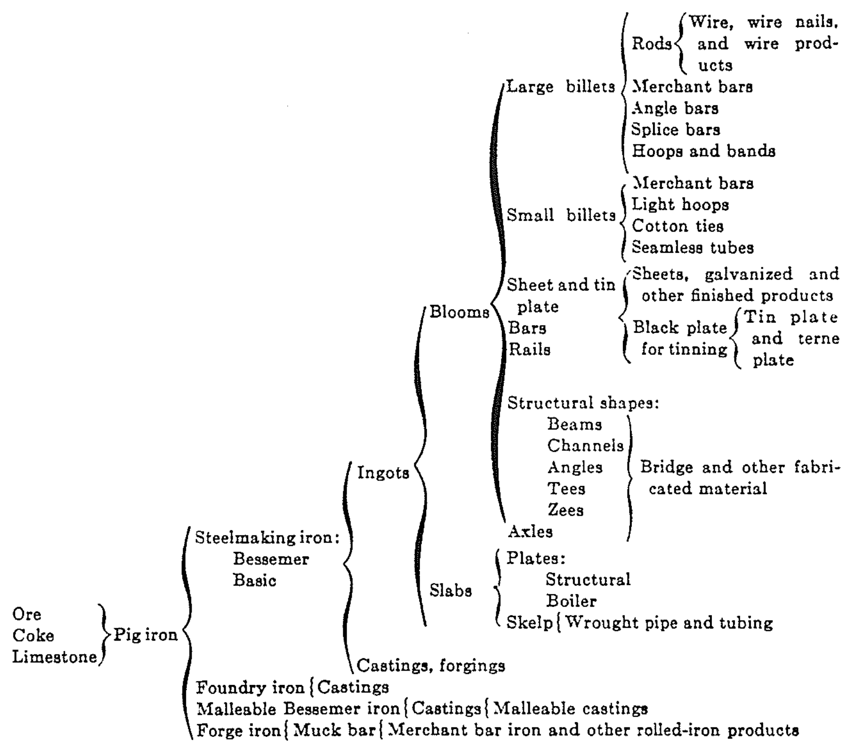

Fig.2.1, Sequences of production of iron and steel products. Source: Daugherty, etc., 1937, p12.

largest in scale (Kawaguchi and Sugiyama, 1989). The process underpinning this typology deserves elaboration.

(1) Production equipment. Integrated iron and steelmaking is a continuous flow of processes from steel manufacture to rolling, so equipment must be provided for all the steps in the chain. The heart of the manufacturing process is the blast furnace. Raw materials must, however, be pre-treated before the furnace can be charged, which requires suitable equipment. Iron ore is often used in the form of pulverized ore heated (sintered) with limestone, so sintering equipment is of prime importance. Coal, too, is not fed into the blast furnace as it is, but is first converted to coke. A large-scale coke oven must therefore be provided.

In steelmaking a wide variety of processing equipment is necessary: for example, the oxygen converter (basic oxygen furnace), continuous caster and the ingot-making plant. Rolling equipment includes primary mills (blooming, slabbing and billet mills), plate mill, hot strip mill, cold strip mill and mills for making sections, wire rod and steel pipe. Besides this core plant there are secondary processing facilities such as the continuous annealing plants, and tin plate or zinc plate manufacturing facilities for tinning or galvanizing the steel. In addition, many works have facilities for giving the galvanized sheet a coating of coloured paint or vinyl chloride.

(2) Auxiliary equipment. Apart from equipment directly required for product manufacture, a steelworks also has many kinds of supporting equipment or infrastructure. This set includes wharves

and unloading machines for receiving materials and shipping products, and transportation facilities for moving raw materials and semi-finished products inside the works. These transportation facilities alone take up an immense area.

In steelworks, vast quantities of water are required for cooling the blast furnace and for the hot-strip mill. Extensive facilities are therefore necessary to ensure that machines are kept supplied with the required amounts. For greater efficiency, used water is recovered and recycled, so large storage reservoirs and purification plants must be provided.

A wide range of other facilities is also required. These facilities embrace electric power plants, oxygen generation plants, gas supply facilities, side-product manufacturing plants and research and development (R&D) facilities. Each of these can assume the proportions of a large factory. It can be said, therefore, that a steelworks is not only a place where steel is manufactured, but it is, at the same time, a large transport undertaking, warehousing business, water, gas and electricity operation, chemical factory and cement works (in respect of sintering). In recent years, a tendency has occurred at many steelworks for power generation and side-product manufacturing facilities to be managed by other firms.

(3) Operation flow. As mentioned above, a steelworks comprises many kinds of facilities and factories. All of these are organized in such a way as to eliminate unnecessary operation in the transportation of raw materials, and achieve as high a level of efficiency as possible.

Looking at the sequence of steps as a whole, the transformation of iron ore to finished steel products is a very complex operation. It may, however, be broadly divided into three stages; namely, ironmaking, steelmaking and rolling.

Iron ore is converted to sintered ore by heating it with limestone in a sinter furnace to make lumps, and is sometimes processed into spherical pellets. Coal is converted to coke in a coke oven, and is transported to the blast furnace to be used in ironmaking. The molten pig iron which leaves the blast furnace is transported to the steel-manufacturing plant in a ladle-shaped hot metal car or torpedo car, and is then supplied to the oxygen converter to be refined into steel. After the steelmaking process, molten steel removed from the furnace by a ladle is transformed by a continuous caster into semi-finished products suitable for rolling blooms (for large-size bar steel), billets (for small-size bar steel), and slabs (for plate or sheet). These are turned into finished products such as plate, sections, wire rod and steel pipe by heating and rolling in a rolling mill.

(4) Rational organization. The raw materials for making steel products circulate within the steelworks as they are transformed by each process.

The equipment and plants in the steelworks are thus organized so that the whole process goes smoothly, and so that material is not transported needlessly. Steelworks of recent construction have developed the "flow line" principle to a higher degree than their forerunners. The fact that they do not occupy so much space in proportion to their capacity provides a good indication of the extent to which transportation inside the works has been rationalized. Fig. 2.2 shows the arrangement of equipment and layout of a typical steelworks. However, when long-established works in Europe were expanded, implementation of the continuous-flow principle occasioned major difficulties. A works of one million tonnes' capacity has the internal problem of handling between six and twelve million tonnes of materials in and out of the works and between departments. The main difficulties which arise are usually attributable either to geographical restrictions outside and around the works or to lack of space between existing pieces of equipment within the works. Such restrictions very often give rise to inefficient flows of materials and impose limits on the size to which the works can be expanded.

Integrated iron and steel works have the following advantages: (1) the heat can be utilized efficiently and economically as the molten pig iron from the blast furnace is directly charged into the BOF (blast oxygen furnace); (2) the gases produced in the blast furnace, BOF and coke ovens can be used as fuels and various by-products can be obtained from coke oven gas and other effluent; and (3) the slag formed in the blast furnace and BOF which contains impurities can be effectively utilized for the production of cement, aggregates, etc. (Kawaguchi and Ueyama, 1989). As a matter of course, the ideal iron and steel industrial complex is equipped with modern steelmaking technology. However, the evolution of

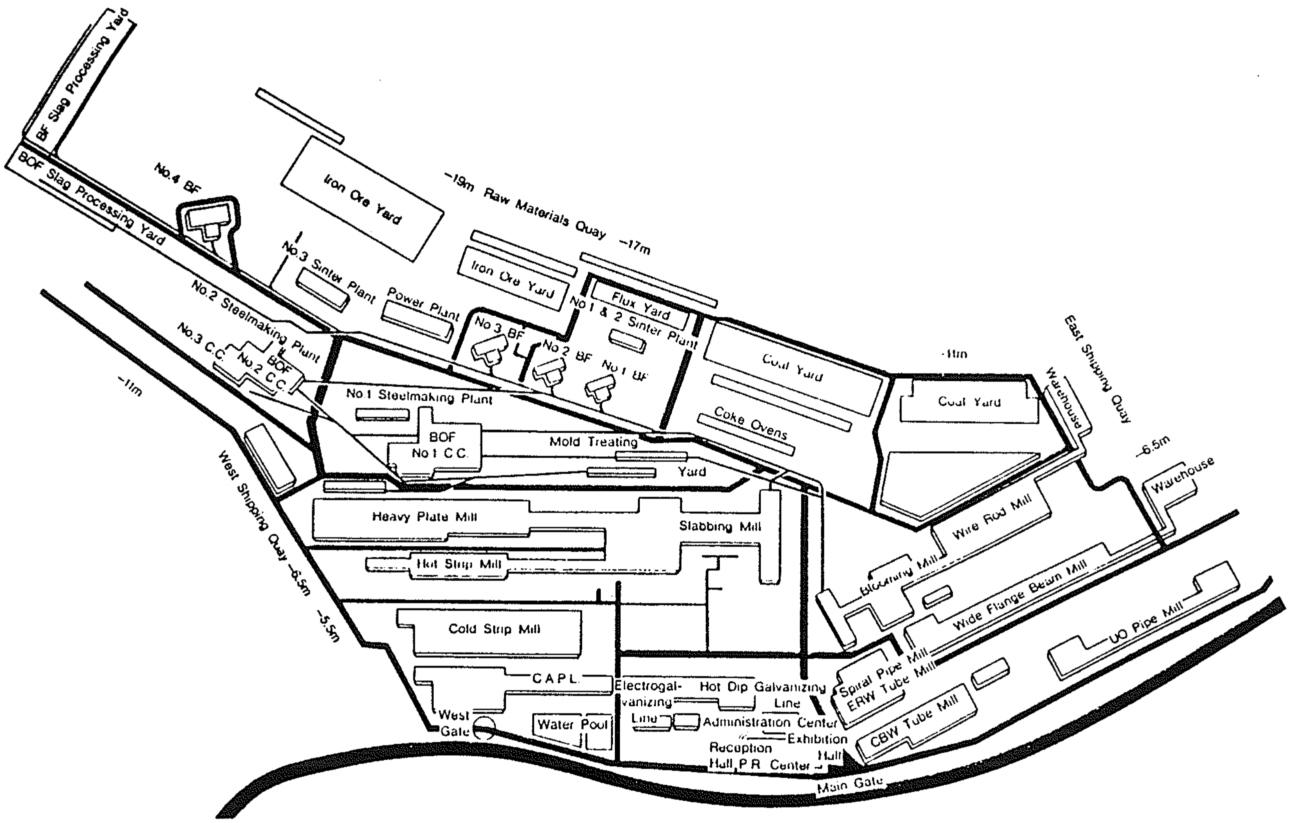

Fig.2.2, Layout of steelworks with an annual crude steel production of 10 million tonnes.
Source: Kawaguchi and Sugiyama, 1989, p9.

steelmaking technical renovation was a complicated process, which will be elaborated in the next section, and contemporary mills - and their equipment - are a compendium of this evolving technology.

2.3 Production, technical process and cost-efficiency analysis

2.3.1 The technology inherent in production

1, Overview

A simple, schematic view of the production sequence entailed in the highly complex business of iron and steelmaking is provided in Fig.2.3. There are five major groups of activities discernible from this: (1) coking, (2) sintering, (3) iron-making, (4) steelmaking, and (5) final rolling and finishing (Russell and Vaughan, 1976). I shall describe each of these in turn.

Coking: coking involves heating coal in the absence of air, and results in the separation of some portion of the non-carbon constituents of the coal (volatile matter, water, and sulphur, which are carried off in a gas stream) from the product--coke--which is principally carbon (about 90 per cent), the remainder being ash and sulphur. Coke is used as a fuel and source of carbon monoxide in the iron-making compartment (blast furnace), while the off gas from the coal is processed to remove salvageable by-products (light oil, sulphur, tar, phenol, ammonia).

Sintering: sintering is the process that agglomerates fine ore

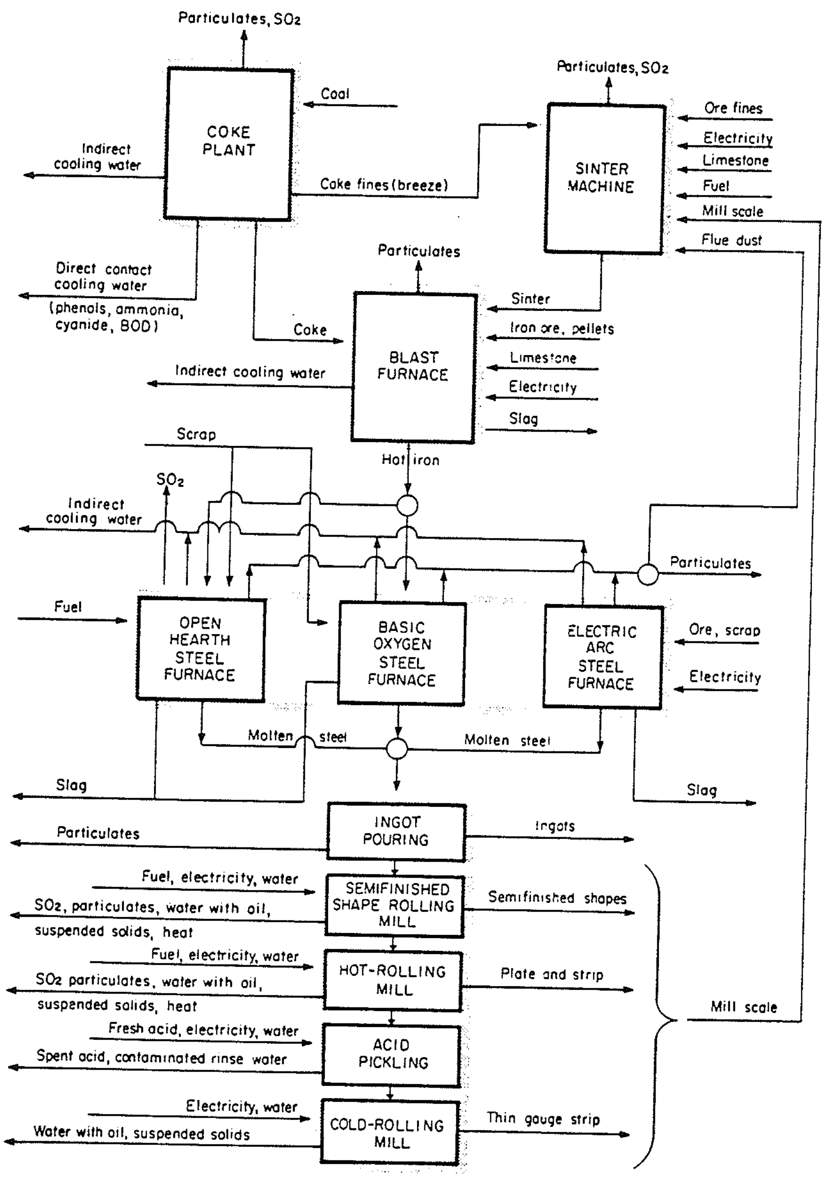

Fig.2.3, A simplified schematic view of iron and steel production.
Source: Russell and Vaughan, 1976, p22.

particles into a porous mass for charging into the blast furnace. This is accomplished by the application of heat from the combustion of coke mixed with an ore and flux (limestone) charge. Sintering was developed in order to make use of iron ore fines and recovered blast furnace flue dust, and its effect is to increase blast furnace efficiency by decreasing the weight of the blast furnace charge required to produce a tonne of iron, principally through decreasing the dust loss, the coke requirement at the furnace and the weight of flux required.

Ironmaking: in the blast furnace, molten iron is produced by the reduction of iron ore. The ores and processed iron-bearing materials, such as sintered ore and sintered flue dust, are charged into the top of the furnace in combination with predetermined amounts of limestone and coke. At the bottom of the furnace, preheated air is blown into the charge to burn the coke in the descending mass. The gas from the burning of the coke (principally carbon monoxide) is responsible for most of the reduction as the stock of materials descends counter-currently to the flow of gases. The fusion of the acid part of the ores with the lime in the limestone and the other bases in the charge creates a slag which floats on the molten iron and is drawn periodically from the furnace. In this way, the iron in molten form is separated from the nonmetallic part of the ore and from impurities such as sulphur and manganese.

Steelmaking: while the blast furnace is designed to reduce iron oxides and to separate the resulting iron from the large quantity of impurities in the ore, the making of steel from molten iron or scrap, or both, primarily involves removal of relatively small amounts of certain impurities from the metallic charge through oxidation. In particular, molten iron is saturated with carbon and contains undesirable amounts of silicon, manganese, phosphorus and sulphur; these impurities are, with the exception of sulphur, oxidized, and the oxides are removed by solution in the furnace slag.

Rolling and Finishing: in order to convert molten steel into a semifinished product, it must be solidified into a shape suitable for further processing. The traditional method has been to pour the metal into ingot moulds, allowing the steel to cool and solidify. The ingots are subsequently removed from the mould, reheated, and rolled into semifinished shapes which are, in turn, converted into finished products by further hot and cold rolling, acid pickling (for surface cleaning), and galvanizing. All this involves considerable energy expenditure both in the reheating and the rolling activities. Now that the salient feature of the production process have been described, it is necessary to comment on the technology embodied in the process.

2 Technical progress in steelmaking

What is of particular interest, because it ultimately has locational implications, is the technical progress embodied in the steelmaking process. There are various production means for steelmaking, each having associated strengths and weaknesses from the technical and economic viewpoints. My purpose is to draw out these merits and failings in the discussion that follows.

The Open Hearth Furnace: in the open hearth (OH) furnace a long, shallow charge bath of iron-bearing materials is heated by radiation from a flame. The fuel may be natural gas, coke oven gas, fuel oil, coal tar, or a combination of these.

The OH is the most flexible of the steel furnaces in its ability to handle different proportions of scrap and hot iron. OH furnaces are housed in large steel buildings, generally over 100 metres long, designed and arranged to facilitate the charging of the furnaces, the making of the heats[1], and handling of the finished molten steel. The furnaces are arranged lengthwise approximately between the columns and along the centreline of the building, with the same distance between the ends of adjacent furnaces. Space may be left at either end of the line of furnaces for storage or other purposes (United States Steel, 1964).

The consensus in favour of the basic OH process for the production of steel for ingots has been grounded in the ability of this process to remove phosphorous and some sulphur, as well as carbon, silicon and manganese. The acid OH process, however, is limited to removal of carbon, silicon and manganese and must use carefully selected raw materials that contain less than specified amounts of phosphorus and sulphur.

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[1] In a typical heat, the fuel furnishes about four million British thermal units (a large Calorie is equivalent to 3.9683 Btu) per tonnes of steel produced.

Basic OH furnaces for the most part were built on existing ironmaking sites and, in consequence, efforts were soon made to charge the iron in its molten state. At the time in question, the late nineteenth century, the quantity of scrap available was small in relation to present-day availability, so a series of duplex processes was invented to allow the use of 100 per cent molten iron when needed. The first phase was to remove most of the silicon and part of the phosphorous from the iron, and then treat the refined metal by the normal finishing process. The average size of a modern, large basic OH furnace is 200-225 tonnes of capacity. The rise of the basic OH technology in world output, technical efficiency,and productivity can be considered from two perspectives: (a) the changing role of the shop-floor worker (the melter), the melting-shop manager, and their relations with research; and (b) technical innovations and developments in the furnace and process.

In earlier times, steelmaking was an art almost entirely in the hands of the senior melter (1st hand) on each furnace, and it was entirely his responsibility to work each charge and ready it for tapping. The sample examined to decide whether the furnace was ready for tapping was the responsibility of the samplepasser, a worker invested with vast experience. However, some changes soon came, with the examination of samples being conducted in the laboratory. The research section in the steelmaking company replaced the samplepasser. By this time, the era of steelmaking as an art was dead.

The principal areas of technical development which contributed to the rise of OH-based steelmaking are fivefold. In the first place, the introduction of cold, high calorific fuels in the OH was a major development. It increased capacity life, and weekly and yearly production; it reduced refractory consumption and enabled the operator to reach the higher, metal-bath temperatures frequently required to meet certain needs. Secondly, gas production became a department of the melting shop and in modernized plants was giving good quality gas, as determined by analysis, at constant pressure to the steel furnace. This was an important step in improving the efficiency of furnace operation. It saved fuel and manpower, and increased steel production. Thirdly, in the earlier furnaces, the regenerator filling was firebrick; later the upper layers were changed to silica, and finally to high-quality aluminous firebrick. In modern furnaces efforts were made to control automatically the temperature of the upper layers by reversing the furnace. Fourthly, enhanced water or gaseous flow patterns increased production and reduced the fuel usages. Finally, increasing furnace size was the major factor in increasing productivity and efficiency prior to the introduction of the tonnage oxygen[2].

However, in later years it became apparent that certain factors

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[2] The introduction of tonnage oxygen is associated with the direct steelmaking in the OH furnace. In the OH furnace, gaseous oxygen can be introduced through the fuel burner when firing from either end of the furnace to intensify combustion and increase heat input to the furnace during the period when scrap and other solid ram materials are being charged and melted.

which tended to decrease furnace productivity gradually became increasingly significant. The factors at issue were (1) making steels low in impurities; (2) making steel hotter for degassing processes and continuous casting; (3) making steel hotter so that it could be held in the ladle before starting pouring to allow the flotation of impurities or be teemed (brought to fruition) more slowly to improve ingot quality. To all intents and purposes, OH steelmaking had been perfected by the 1890s (Jackson, 1976, pp.1-9).

The Acid Hearth is a variation on the OH theme. The hearth of an acid OH furnace is similar in contour to that of its basic counterpart, the difference in construction being that acid brick instead of basic brick is used in the hearth structure and only acid material is used above the hearth brickwork. The average capacity of acid furnaces in the United States is approximately 60 tonnes, and the largest acid furnaces are of 125 tonnes' capacity. A modern acid OH furnace would have the same steel bottom pans as used in the latest designs for basic furnaces.

The OH furnace is both reverberatory and regenerative. It is reverberatory in that the charge is melted on a refractory hearth, which is shallow in relationship to the length of the hearth, by a flame passing over the charge so that both the charge and the relatively low (above the hearth) roof, built of refractory brick, are heated by the flame, with a part of the heating effect on the charge accomplished by radiation from the heated roof. Radiation from the flame is an effect, the intensity of which varies with the kind of fuel used and the method by which it is burned. OH furnaces are regenerative in that the hot gases (from the combustion of fuel) pass out of the reverberatory furnace chamber through passages into fire brick (US Steel, 1964).

The Basic Oxygen Furnace: in the basic oxygen process, nearly pure oxygen is introduced from above the surface of a bath of molten iron contained in a basic-lined cylindrical furnace. The basic oxygen process is characterized by: (1) use of gaseous oxygen as the sole refining agent, thereby assuring that the refining reactions generate the maximum possible amount of heat; (2) a metallic charge composed largely of blast-furnace iron in a molten condition, thus greatly reducing the thermal requirements of the process; and (3) chemical reactions that proceed quite rapidly in a bath of comparatively low surface-to-volume ratio, thus minimizing external heat losses. This combination results in an extremely versatile autogenous process that requires no external fuel yet provides a capability for melting an appreciable quantity of scrap. The use of pure oxygen for refining, however, in no way alters the fundamental chemical reactions and equilibria involved in steelmaking. The reactions of greatest importance are those pertaining to the elements carbon, silicon, manganese, phosphorus, sulphur, nitrogen, and oxygen (Russell and Vaughan, 1976, pp.21-33).

The process is less flexible than the OH in its ability to use cold iron and scrap steel in the charge on account of the nature of its heat balance.

In this process, oxygen of high purity is blown at high velocity onto the surface of the bath in a basic-lined vessel by a vertical pipe or lane inserted through the mouth of the vessel. Plants utilizing top blowing with oxygen have been in operation since 1952-53 at Linz and Donawitz in Austria. These operations, sometimes referred to as the Linz-Donawitz or L-D process, were designed to employ pig iron produced from local ores that are high in manganese and low in phosphorus; such iron is not suitable for either the acid or basic bottom-blown pneumatic processes. The basic oxygen process, however, is readily adapted to the processing of blast-furnace metal of medium- and high-phosphorus contents and is particularly attractive where it is desirable to employ a steelmaking process requiring large percentages of hot metal as the principal source of metallic input.

By the mid-1960s, there were 35 basic oxygen steelmaking plants in operation throughout the world; six of them in the United States and two in Canada. In total, 17 furnaces were installed in the six plants in the United States with an estimated ability to produce 7,500,000 tonnes of steel annually. The five furnaces in the two Canadian plants were capable of producing 1,600,000 tonnes annually. The output per furnace per heat ranged from 60 to 200 tonnes.

A major advantage of the basic oxygen process is its flexibility in handling raw materials of many types and compositions. The scrap used can be either heavy or light, and the oxide charge, if used, may be dry ore, sinter, pellets, or mill scale. The process can be used in the basic open-hearth furnace.

For blast furnace operations, a great number of developments such as burden preparation via agglomeration of ores and bedding of fines, higher blast temperatures, increased top pressures and oil injection, have led to a decrease in coke consumption per tonne of pig iron from a figure of about 900kg just after 1945 to about 425 kg in the mid-1970s (Fig.2.4); at the same time this has resulted in a corresponding increase in productivity from 0.5t/m^3 to over 2.0t/m^3. At the same time, furnace sizes have grown from about 800m^3 to 5000m^3. A further major development was in the life cycle of a furnace lining, both in years and in tonnes produced, owing to much better refractors, better cooling methods and better process control (Fig.2.5). On scientific grounds it is clear that fundamental technical limits have been reached now for coke consumption and productivity per cubic metre; the total energy consumption has come very close to the theoretical value for reduction of ores in a counterflow process and further coke savings can only be realized by replacing it by fuels which are less abundant than coal. Productivity in t/m^3 is controlled by the flow pattern in the furnace, which sets a limit in order to avoid channelling of gases and flooding of the slag. As far as size is concerned, bigger furnaces still could be made but the gains in production costs become marginal and can be offset easily by losses caused through breakdowns of components and other interruptions and through production losses caused by the high tonnage production level not matching the intake into the steelworks. So an end to a

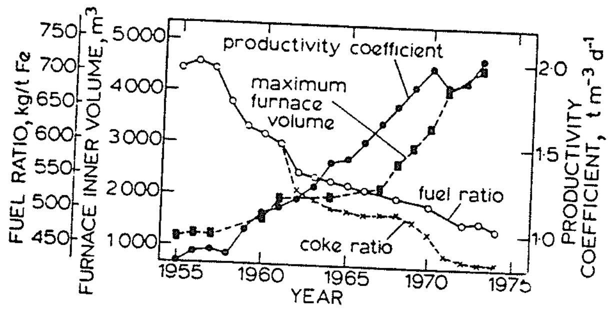

Fig.2.4, Blast furnace operation results in Japan.
Note: productivity coefficient refers to the output amount of pig iron per one m³ of furnace volume in a day.
Source: Callenfels, 1979, p145.

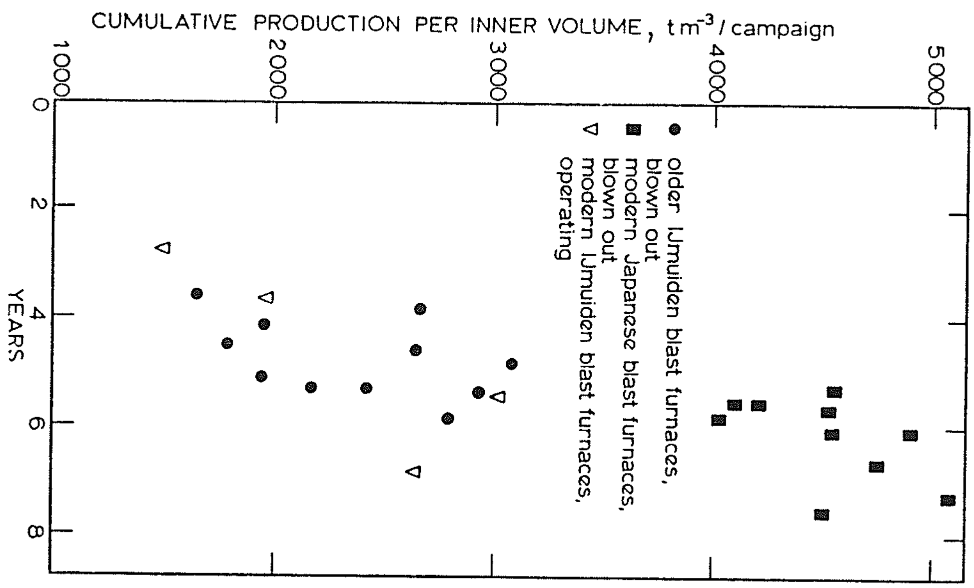

Fig.2.5, Cumulative blast furnace production per inner volume.
Source: same as Fig.2.4.

period of major developments in process technology is clearly in sight (Callenfels, 1979).

<u>The Electric Arc Furnace</u>: in the electric arc furnace (EA), electric power is the source of heat, with graphite electrodes positioned above the cold charge to produce an arc which melts the scrap. Refining is carried out by a combination of the heat radiated from the arc and either oxygen injection or an ore charge may be used as the principal source of refining oxygen.

Numerous types of furnaces utilizing electric current as the source of heat have been developed by a large number of innovators, but relatively few types have survived as practical tools for steelmaking.

Methods of Electric Heating-- electric current can be used for heating in only two ways: first, by utilizing the heat generated in electrical conductors by their inherent resistance to the flow of current; and secondly, by utilizing the heat radiated by the electric arc.

Two general methods of heating by resistance are possible; namely, the indirect method in which the charge is heated by radiation and conduction from separate resistors through which the current is passed, and the direct method in which the current is passed into the metal charge of the bath itself. The indirect method of resistance heating for steelmaking operations is not practicable for many reasons. The direct method in which high-voltage, low-amperage current is transformed to low-voltage, high-amperage current, is employed instead. The bath in this latter method acts as the secondary circuit for the current which is generated from a primary circuit by induction; the method is known, therefore, as induction heating.

Likewise, arc heating may be applied in two general ways. In the first the arc may be made between electrodes supported above the metal in the furnace, which thus is heated solely by radiation from the arc. This method is known as indirect-arc heating. In the second case, the arcs may be made between the electrodes and the metal. In this second method, known as direct-arc heating, the current must flow through the bath, so that the heat developed by the electrical resistance of the metal, though relatively small in amount, is added to that radiated from the arcs. This choice makes it theoretically possible to use two types of furnaces; that is to say, those with a non-conducting bottom and those with a conducting bottom. In reality, though, the latter type has not been successful for practical steelmaking use (Russell and Vaughan, 1976, pp21-33).

In reviewing the postwar period, it is evident that many technology developments have been made. Some of these can be considered fundamental breakthroughs in the steelmaking process. Foremost among them are: (1) the oxygen converter, which has revolutionized the steelmaking process; (2) continuous casting, which has eliminated four steps from the conventional steelmaking process and has conserved substantial quantities of energy; and (3) direction reduction of iron ore outside the blast furnace, which makes it possible to produce iron without coke made from metallurgical coal[3]. Adoption of the basic-oxygen process in Europe and Japan has been impressive, although its acceptance has been slower in the United States. Table 2.1 shows the relative importance of the steelmaking processes adopted in the United States and Japan during the 1960s, a crucial decade in the dissemination of technology. In the United States, from 1961 to 1968, the shipment of products made by the oxygen process increased 30 per cent, and in Japan from 1961 to 1971, the figure rose by 75 per cent. These trends have been consolidated since. Of the 127.8 million tonnes of steel produced in the EEC in 1980, for example, 73 per cent derived from the basic oxygen process, 23.8 per cent came from electrical furnaces and only 3 per cent originated from OH furnaces. Steel in the world in 1989 was produced principally by the basic oxygen converters, which turned out over 60 per cent of the total; the electric furnaces produced more than 30 per cent and the open hearth less than 10 percent (Hogan, 1991). However, the era of blast furnace construction for the most part has passed in the industrialized countries. There will be very few furnaces constructed in Japan, the United States and Western Europe in the years ahead, but in sharp contrast, much new capacity will emerge in the Third World. It is now appropriate to turn from technology and enquire into the cost-efficiencies that arise from its

[3] Owing to the desire to employ lower-grade ores and available fuels, a direction reduction process was developed, which would at least partially supplant the blast furnace as a source of iron ore for steelmaking. Its purposes are: (1) to produce steel directly from iron ore; or (2) to make a product from blast furnace pig iron for use in the steelmaking process; or (3) to produce low-carbon iron as a melting stock for making steel by existing processes.

application.

Table 2.1, US and Japanese steel production by process (million tonnes)

	1961		1968		1971	
USA						
Open hearth	76.9	88.0%	59.8	50.1%	32.3	
Electric	7.9	8.9%	15.2	12.9%	NA	
Oxygen	3.6	3.1%	44.3	37.0%	58.1	
Total	88.4	100.0%	119.3	100.0%		
Japan						
Open hearth	16.9	60.0%	5.4	8.1%	2.09	2.2%
Electric	5.9	20.9%	12.2	18.2%	15.63	17.8%
Oxygen	5.4	19.1%	49.3	73.7%	70.84	80.0%
Total	28.2	100.0%	66.9	100.0%	88.56	100.0%

Sources: AISI and Japan Iron and Steel Federation

2.3.2 Cost-efficiency analysis

The elements which determine the cost in ironmaking and steelmaking are very complicated. The two largest controllable cost elements in steelmaking are those of labour and energy, being 25% and 18% respectively during the middle 1970s. Obviously, a prime purpose of adopting technical innovation is to realize cost savings. Table 2.2 shows the cost variation arising from the two principal technologies: the electric arc furnace and the basic oxygen furnace. The total steel cost per unit (tonne of steel) associated with the electric arc furnace is $176.99 whereas $199.87 is the equivalent cost for the basic oxygen furnace. The difference largely arose from the expense of raw materials. The coke cost per unit associated with the blast furnaces was about $50 against no coke cost in the electric arc furnace. The sponge iron fee incurred by the electric arc furnace amounts to $72 while no cost is incurred in the basic oxygen furnace.

The global trend to larger size steelworks is very obvious. In the middle years of the nineteenth century the average British blast furnace made 25 tonnes of iron a day; by 1969 the average was over 800 tonnes. World records were already many times higher still. At Fukuyama, Nippon Kokan's output was as much as 6,000 tonnes a day in the late 1960s. By the spring of 1970 Yawata Steel operated sixteen blast furnaces in five works. Only four of these were rated at less than 1,000 tonnes daily, five were in the 1,000-2,000 tonne range, four ranged from 2,600-3,600 tonnes, one was of 5,225 tonnes, another of 6,000 tonnes, and one of 6,600 tonnes. On its drawing board were units of 9,500 tonnes. At that time the largest furnaces in western Europe were in the 2,500-3,500 tonne class, though the British Steel Corporation was about to construct a 5,000-tonne facility at Port Talbot, and by 1973 Thyssen had a 10,000-tonne a day furnace at Duisburg. In 1974 a 13,000-tonne per day furnace was commissioned at Krivoy Rog in the then Soviet Union. With a rapidly increasing output the number of blast furnaces in the six countries at that time constituting the EEC fell from 402 to 286 between 1958 and 1972.

There have been similar trends in steelmaking. The average heat size of the oxygen converters installed throughout the world in 1964 was 90 tonnes, but increased to 130 tonnes by 1969. By 1972 three 330-350-tonne converters were being installed at Novokuznetsk Works, with a total annual capacity of about 8 million tonnes. Ahdanov Works was earmarked for equipping with three 400-tonne

Table 2.2, Integrated steel mill estimated cost comparison

	Unit Price, $	Direct reduction electric arc furnace Units	Direct reduction electric arc furnace cost,$	Blast furnace basic oxygen furnace Units	Blast furnace basic oxygen furnace Cost, $
Ironmaking					
Raw materials					
iron oxide pellets, t	34.78	1.49	51.82	1.45	50.43
coke, t	90.00			0.55	49.50
natural gas Nm^3	0.07	368.0	25.76		
limestone, t	7.50			0.14	1.05
Extra items					
labour, man-hours	7.50	0.4	3.00	0.26	2.00
power,kwh	0.02	135.0	2.70	1.00	2.00
repair materials			2.50		3.25
utilities			0.50		0.50
Misc. supplies			1.85		0.70
royalty			1.00		
total iron cost			89.12		109.43
Steelmaking					
raw materials					
Sponge iron t,	89.13	0.81	72.20		
hot metal, t,	109.43			0.86	94.11
plant scrap, t,	45.00	0.13	5.85	0.13	5.85
purchased scrap, t	75.00	0.18	13.50	0.18	13.50
finishing additive			1.94		2.22
Extra items					
labour, man-hours	7.50	0.55	4.13	0.5	3.75
oxygen Nm^3	0.03			51.2	1.54
Power, kwh	0.02	570.0	11.40	30.0	0.60
electrodes,kg	1.58	6.5	10.32		
refractors				3.7	0.97
Fluxes, kg	0.03	30.0	1.05	75.0	2.63
repair and maintenance			2.40		2.40
Misc. supplies and service			2.00		2.00
General overheads			1.00		1.00
Fixed costs			47.00		68.80
total steel cost			176.99		199.87

source: Brown and Reddy, 1979, p29.

converters (Warren, 1975, p67).

The upward trend in plant and equipment size is matched by that in whole works. The average crude steel output of the same 22 plants or complexes of plant in the steel industry of England and Wales went up from 374,000 tonnes in 1945 to 649,000 tonnes in 1955, and 806,000 tonnes in 1967. Even so, by 1973 Britain had only seven plants of annual capacity greater than 1.5 million tonnes of steel as compared with 37 in the USA. In 1972 Fukuyama Works made 10.4 million tonnes of steel and Magnitogorsk 13.5 million. On the whole, however, of output emanating from all works, there was a steady increase in the proportion from larger plants during the 1960s (Table 2.3).

The larger size of plant and equipment can result in substantial economies of scale. The concept of economies of scale involves decreases in unit costs as size increases. Both capital and running costs are involved, and savings may be broadly divided into technical and organisational. The sizes on which it all depends will be measured by a variety of indices.

Table 2.3, Growing plant sizes for ironmaking and steelmaking

	1965	1969
Blast furnaces		
Daily cap each (tonnes)	4,600	6,300
Oxygen steel plant		
Annual cap (million tonnes)	3.0	4.8
Slabbing mill		
Annual cap (million tonnes)	3.0	3.0
Continuous Casting plant		
Annual cap (million tonnes)	--	2.0

source: Warren, 1975, p73.

It is well known that the large size of the average American steel firm contributes in a greater variety of ways to higher productivity than was generally the case in Britain, but it is extremely difficult to be precise about the elements of the situation[4]. In 1965, 302,000 men worked in the British industry and its output was 27 million tonnes of crude steel; but 458,000 men in the US industry turned out 119 million tonnes in the same year - an impressive difference in annual output per man of 89.4 tonnes to 259.8 tonnes.

The higher the capacity of a unit, the lower are the capital charges because capacity tends to be a cubic function of linear dimensions whereas cost tends to be a quadratic function. Increasing the capacity of a unit by a given percentage seldom increases the manning in proportion. Process efficiency is affected to a lesser extent by size, though savings will accrue in heat consumption as a result of smaller radiant heat losses; in maintenance owing to a lower area of surface exposed to wear in blast furnaces or steel plants for any given output and; generally speaking, an improvement in yield on account of the smaller number of units, enabling a closer degree of management control to be exercised (Warren, 1975). Table 2.4 indicates the economies of scale prevailing across a number of criteria.

Capital costs per tonne of installed capacity decrease as the

---

[4] Though, note, British Steel (the firm) became one of the most "productive/efficient" of the world's steel-makers during the 1980s.

Table 2.4, Scale versus technology and labour and capital savings in new plants (90% operating rate)

Scale (million tons)	1960s Technology Capital Costs ($/t)	Labour Use (MHPT)	C/L ($/MH)	1980s Technology Capital Costs ($/t)	Labour Use (MHPT)	C/L ($/MH)
Integrated (CRS)[b]						
2.00	1715	8.90	193	1475	6.00	246
3.00	1541	7.35	210	1276	4.85	263
3.30	1522	6.95	219	1250	4.63	270
4.00	1472	6.50	226	1205	4.30	280
5.00	1386	6.10	227	1147	4.05	283
Mini-mill (WR)[c]						
0.25	890	10.45	85	450	3.50	129
0.40	711	8.35	85	372	2.81	132
0.50	651	7.40	88	327	2.40	136
0.75	582	6.15	95	300	2.00	150
1.00	545	5.70	96	286	1.90	151
Integrated (WR) A. [c]						
0.50	1549	12.90	120	1030	6.40	161
0.75	1321	10.30	128	880	5.15	171
1.00	1201	9.00	133	800	4.50	178
B. [d]						
2.00	1015	8.35	122	675	3.95	171
3.00	965	7.80	124	640	3.70	173
4.00	945	7.45	127	625	3.55	176

a. Technology includes operating practices.
b. Plant size, all hot- or cold-rolled sheet.
c. Plant size, all wire rod.
d. Plant size, mix of rod, bar and light structural, 0.75 million short tons wire rod.
Source: Barnett and Schorsch, 1983, p194.

size of the production unit increases and as techniques for speeding up throughput are adopted; the proportionate cost of tracks, utilities, maintenance shops and other auxiliaries goes down, and "off site" facilities such as townships, marshalling yards and mines are better utilised. At the same time, operating costs favour a large plant. Costs of centralised maintenance and utility systems are lowered, transportation is more effectively used and there is a significant improvement in labour productivity. Also, overheads and fixed charges are significantly reduced (Warren, 1975). These advantages are strikingly illustrated in the anticipated cost savings from the extension of the three major new integrated works of Hindustan Steel (Table 2.5) on the one hand and detailed British calculations (Table 2.6) on the other.

Table 2.5, Capacity and estimated capital costs per tonne at the Durgapur, Rourkela and Bhilai steel plants

	1962		1966	
	capacity (million tons)	investment per annual ton (Rs)	capacity (million ton)	investment per annual ton (RS)
Durgapur	1	1,728	1.62	1,436
Rourkela	1	2,349	1.8	1,834
Bhilai	1	1,734	2.5	1,229

Note: (a) 18Rs= 1 pound (1970); (b) investment includes townships and mines.
Source: Warren, 1975, p74.

Table 2.6, Comparison of equipment, inputs and capital cost per tonne of finished product in five existing and two future British strip mills

	Five existing works		Two planned works	
	Plant	Input (m tons)	Plant	Inputs (m tons)
Coke making				
Number of ovens	945	--	520	--
Coking coal	--	0.96	--	0.71
Ironmaking				
Blast furnace	15 (19.5 to 31ft diameter)	--	6 (32ft diameter)	--
Iron ore	--	1.62	--	1.69
Injected oil	--	--	--	0.17
Steelmaking				
Furnaces and converters	46 (OH, LD&VLN)		6 (LD)	--
Scrap	--	0.58	--	0.43
Fuel oil	--	0.20	--	--
Hot mills	5	--	2	--
Cold mills	11	--	6	--
Electricity (per tonne)	--	47.0k Wh	--	37.0 k Wh
Man hours (per tonne)	--	24.2	--	7.6
Capital (pound per tonne)	--	77.0 pound	--	70.0

Source: Warren, 1975, p80.

In fact, cost saving is connected with multiple causes. For example, in Japan, although expensive, new plants have been installed at lower costs than in the West. This is partly a function of lower capital cost, in part another reflection of Japan's prevailing lower wage levels, but there are other factors too. Shortage of land has resulted in building either on reclaimed land or on sites small by Western standards. High standards of efficiency have been attained in compact works' layouts, which reduce the need for movement facilities and the internal transfer costs, both directly and through reduced heat loss. Negotiations for supplies of iron ore were carried on in the early and mid-1950s throughout East and South-east Asia. Agreements were made with various mining concerns in the Philippines, Johore (Malaysia), Goa, Orissa (India) and Hong Kong. However, delivery costs were high. By 1962 ore of 62 per cent iron content costing $11.50 per gross tonne in dock in India was charged $5.0 freight to Hirohata. Already attention was shifting to new, more distant, but richer deposits. Peru, Chile and Brazil supplied only 5.9 per cent of Japanese imported ore in 1957 but 23.8 per cent by 1961. The average distance of ore carriage went up steadily from 4,660 km in 1955 to 6,400 in 1960, 8,800 in 1965 and 9,650 by 1968-9. In spite of this, the average cost of foreign ore landed in Japan fell --from $14.23 a tonne in 1960 to $12.66 a tonne by 1967. Cost reduction was achieved by a variety of means. An early development involved increasing control over the shipping. Only 8 per cent of the tonnage of imported ore was carried in Japanese bottoms in 1956 but as early as 1960 this had been raised to 50 per cent. Increase in vessel size was more decisive, and for this the provision of deep-water terminals was a prerequisite. Initially Japan was ill equipped to provide these facilities. In rectifying that situation, plant location underwent a thorough review. The result was the emergence of industrial complexes. These, and other examples of complexes, comprise the subject of the next section.

2.4 Industrial complexes in practice

Regardless of their size and composition, industrial complexes have spread all over the world, from the developed countries to the developing countries, from the countries with rich reserves of ore and coal to the countries which rely completely on imported ore and coal. Industrial complexes can be grouped geographically according to their evolution and their orientation. Four types are discernible.

(1) The coastal type, located for the convenience of imported ore and coal materials as well as for accessibility to major manufacturing centres. The obvious examples are the iron and steel industrial complexes positioned around Tokyo Bay.

(2) The relict type, originally depending upon domestic iron-ore and coal reserves, but latterly switching to the use of imported iron-ore materials. The industrial complexes of the Pittsburgh-Youngstown and Chicago areas in the United States and South Wales in the UK conform to this group.

(3) The ore-based type, relying on local ore and imported coal, Lorraine is the seminal example.

(4) The coal-field type, dependent on a combination of local coal and imported iron ore. Germany's Ruhr is the principal example.

These sorts of industrial complexes play a very important role in world iron and steel production. They will be elaborated upon in the following pages.

2.4.1 Industrial complexes in Tokyo Bay

1, Introduction

Japanese steel production volume occupies third position in the world, following the former Soviet Union and the USA. The growth of Japanese steelmaking has occurred in response to the rapidly expanding needs of a national economy, especially one geared to such industries as shipbuilding, construction, mechanical engineering led by automobiles, and electrical machinery.

Technical progress greatly assisted Japan in reducing its steelmaking costs. In 1963, oxygen converter production costs in Japan were 6-10 per cent lower, and by 1968 as much as 30 per cent lower, than OH practice. Blast-furnace technology in particular has reached very high standards. The coke rate fell from 900kg per tonne in 1950 to only 499 kg/tonne in 1968, by which time it was 100-200kg below Western European and US levels. By 1969-70 eight of the world's 10 biggest blast furnaces were Japanese; in mid-1970s Japan had 22 blast furnaces with a volume greater than 2,000m^3; the USSR had 17, the USA possessed one, and the United Kingdom none (Warren, 1975).

The most efficient organisation for assembling raw materials is a key factor accounting for Japanese success. Home mineral production has been quite unable to meet spiralling demand. The pattern of iron ore and coking coal imports has changed greatly since 1941, as Tables 2.7 and 2.8 make clear. In terms of iron ore supply, Japan switched the suppliers, from Malaya and China in the 1930s to India and Australia in the 1970s. For the coking coal, the amount from China dropped dramatically, from 78.8 per cent in the 1930s to nothing in 1972.

As remarked earlier, the average distance of ore carriage went up steadily, from 4,660 km in 1955 to 6,400 km in 1960, 8,800 km in 1965 and 9,650 km by 1968-9. However, the average cost of foreign ore landed in Japan was falling --from $14.23 a tonne in 1960 to $12.66 a tonne by 1967. A 1946 Allied survey showed that only three out of 61 Japanese docks used for all purposes had a draught of 9m or more. Before 1959 most ore ports had 10 m draught restrictions

Table 2.7, Pattern of imported iron ore supply to Japan

	1936	1952	1959	1964	1968	1972
Malaya(%)	42.0	17.2	36.1	21.2	7.5	0.3
China	31.1	2.7	1.1	0.5	--	--
Philippines	14.2	24.8	12.4	4.8	--	--
India and Goa	0.6	14.1	31.5	21.5	18.7	16.0
USA	0.1	29.9	5.1	6.4	5.2	0.6
Canada	0.4	10.4	6.5	5.6	2.9	1.8
Peru			0.9	11.2	10.8	6.2
Chile			0.6	17.4	12.7	6.0
Brazil			1.5	1.4	3.2	8.4
South Africa			1.4	3.2	4.2	2.1
Australia				0.2	20.2	43.5
Others			0.2	2.6	14.6	15.3

Source: Warren, 1975.

Table 2.8, Pattern of supply of coking coal to Japan

	1936	1952	1959	1964	1968	1972
USA (%)	--	77.4	79.6	47.4	47.4	35
USSR	0.1	1.7	7.5	8.1	8.1	5
China	78.8	0.3	--	1.3	1.0	NA
Canada	21.0	20.5	1.9	6.8	3.3	16
Australia	*	*	9.7	35.9	37.7	41

Note: * included in the Canada total.
Source: Warren, 1975.

and so were limited to 18,000 dwt vessels. Already, however, in a few cases expensive reclamation to prepare sites for new steelworks had made it possible to provide deep-water channels to ore-receiving facilities-- as at the Chiba Works where a site of 360 hectares was reclaimed from Tokyo Bay in the early and mid-1950s. In 1959 the Ministry of Transport began a two-year programme to provide 14 ports with draughts of 11.9m in order to render them suitable for vessels of 40,000-44,000 dwt. By mid-1966 nine of the 15 major iron ore ports could take 70,000 dwt vessels and one was suitable for 100,000 dwt ships. At this time only two of 21 ECSC (European Coal and Steel Community) ore terminals could handle 70,000 dwt carriers; in the world's other ore-importing countries not one port of this class existed (Warren, 1975, p.114). Table 2.9 shows both the increase in the Japanese bulk fleet and the average capacity of vessels used for importing iron ore. In 1965, the ratio of Japan's imported ore to total ore consumption was 88 per cent and the traffic volume reached 35.5 million tonnes. In 1968, 56.6 million tonnes of ore were imported, with the import ratio rising to 95 per cent (Kawahito, 1972). In 1980, the country imported 133.7 million tonnes of ore, which was over 99 per cent of its requirement. In the same year, 58.3 million tons of coking coal, or 90 per cent of the industry's requirement, were imported (Hogan, 1983).

Table 2.9, Japanese ore and bulk carriers (average capacity in thousand tonnes dwt)

	1966		1969		1972	
	No	Average	No	Average	No	Average
Ore and pellet carriers	59	34	78	41	78	59
Coal Carriers	9	33	26	39	28	51
Ore-coal carriers	--	--	3	47	20	78
Ore-oil carriers	--	--	16	83	31	90

Source: The Japan Iron and Steel Federation. The Steel Industry of Japan 1966/1969 and 1972

2, Industrial complexes on Tokyo Bay and in the Osaka District

When the location of metallurgical development switched from the raw-material-oriented plants of the early phase to the coastal-market-oriented plants characterized by adjacency to deep-water, a flat site, ample process water and limestone flux, the most desirable locations became those as near as possible to the big markets of the industrial heartland. In Japanese terms that corresponded with the eastern seaboard area from Tokyo through to Northern Kyushu. Within it are some core areas, notably that of Kanto, centred on Tokyo Bay, and Kinki, with Osaka-Kobe as the industrial core.

On Tokyo Bay, Nippon Kokan operated the two neighbouring works of Kawasaki and Tsurumi and in 1956 started construction of a third just to the north at Mizue. Growth in the manufacturing economy is most rapid there. Both land and labour are scare and costly, but competition in the steel business is keen, and the area has a strong attraction for expansion-minded management. As a result, although Nippon Kokan turned to the Inland Sea after building Mizue, in the mid-1970s it gave serious attention to a relatively low-cost way of increasing its Tokyo Bay capacity. It has a major raw material terminal, storage depot, and preparation and forwarding operation on the artificial Oogishima Island, offshore from its three mainland steelworks (Warren, 1975,pp.125-127). Fig.2.6 shows the location of industry in these two areas.

Since the growth in the manufacturing economy was most rapid there and the advantages of deep-water port facilities could be taken into account, firms in other districts have found development in the Tokyo area so desirable that they have been prepared to overcome the difficulties of relocation. Kawasaki Steel of Kobe was the first, when in 1951 it began to build the Chiba Works on reclaimed land at the north-eastern end of Tokyo Bay. By 1968 Chiba already had a capacity of 6 million tonnes. In the 1960s Yawata, originally located in southwest coastal Japan, made a major entry into the area by building the Kimitsu Works. Sumitomo's nearest integrated works is 400km away from Tokyo, near Osaka, and although 85 per cent of the output from Wakayama leaves by water, it too recognized the desirability of a plant much nearer the prime industrial area. Beginning with pipe mills and a hot strip mill supplied from other works, it now has a fully integrated plant at Kashima, on the spit enclosing the Kita Ura lagoon on the Pacific Coast, less than 90 km north-east of the centre of Tokyo, a works eventually to boast 15 million tonnes of steel capacity in 1970.

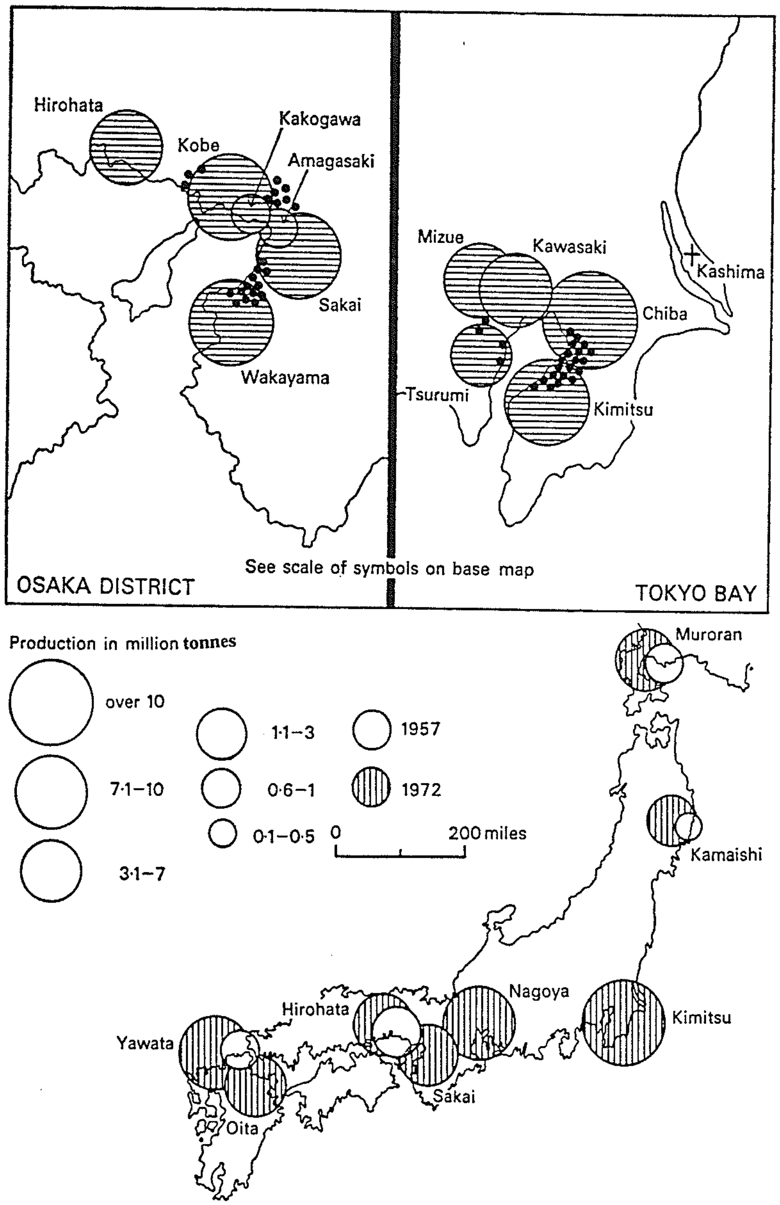

Fig.2.6, The steel industry of Osaka District and Tokyo Bay, 1968.
Source: Warren, 1975, p121.

In Osaka District, the small Kobe steelworks grew as an integrated operation from a capacity of 0.3 million tonnes to 3.3 million tonnes between the mid-1950s and 1969. In 1965 it linked with the integrated Amagasaki works and in the late 1960s built a new integrated works at Kakogawa 96km west of Kobe. Kawasaki Steel, with an important, though unintegrated, works at Kobe, brought into operation a new, fully-integrated plant at Mizushima, between Fukuyama and Hirohata, in 1967. By 1968 the new works was capable of 2 million tonnes, and in 1973 reached a 9-million tonnes capacity. The first pig iron plant controlled by Sumitomo Metal Industries of Osaka was acquired in 1953 through the purchase of the small integrated works at Kokura in northern Kyushu, whose ingot capacity it increased from 0.14 million tonnes in 1954 to 1.0 million tonnes by 1968. Meanwhile at Wakayama, about 112km south-west of Osaka, capacity went up over the same period from 0.26 million tonnes to 6.5 million tonnes and in 1969, as a result of extensions to ironmaking, capacity was increased to 8.5-million tonnes of steel (Warren, 1975, p.125).

The last expansion programme, inaugurated in 1973 and 1974, was based on the conviction that world demand would remain strong and thus would require Japanese exports. The construction of a substantial amount of capacity between the late 1960s and the early 1970s, in fact, proved to be far in excess of demand in consequence of the worldwide steel depression that began in 1975. However, schemes for continual improvement of the Japanese steel industry have been implemented since 1980. These centre on ongoing investment in steel plant and equipment directed at minimizing costs, developing new products with a higher value-added and diversifying business operations into engineering and chemicals (Hogan, 1983). These schemes do not aim, however, to change the locational pattern of Japanese steel industry formed during the 1960s and 1970s.

Japanese construction of big capacity plants at deep-water sites accessible to world minerals and markets has provided a model for steelmakers in other countries. However, countries of the Third World lack the concentrated demand to justify such an intense pattern of development. Western economies which do have the necessary consumption levels unfortunately also have a huge commitment to plant built in times when location choices were very different. Even so, Japanese experience serves as a useful test case for the steelmakers in other countries.

2.4.2 The relict type: industrial complexes in both Pittsburgh-Youngstown and South Wales

The industrial complexes in these two regions originally depended upon domestic iron-ore and coking coal, but were compelled to turn to the imported ore when local stocks were exhausted. They are considered in detail.

1, The Pittsburgh-Youngstown District

The Pittsburgh district is close to both the market of the north-eastern United States and its resources of coking coal in the Appalachian. For over a century Lake Superior ore has been carried by rail from the Lake Erie ports to this industrial area, and coke and, later, coking coal have been distributed from the Connellsville area. As long as high-grade ore could be brought from the Upper Great Lakes to the Lake Erie ports and overland by rail, Pittsburgh and its surrounding valleys had a price advantage over other regions. The Youngstown area, not accessible by barge from Connellsville, has been at a disadvantage, while this has been reflected in the need to concentrate there on the production of more specialized and higher-priced steel goods that are in less direct competition with Pittsburgh itself (Pounds, 1968).

Although Lake Superior district ores were not much favourably situated with respect to plants in the Pittsburgh-Youngstown area, these plants obtained their iron from inadequate or not too satisfactory local sources or from more distance sources, either the Lake Superior district or foreign mines (Fig.2.7). The use of specially-designed, very large ocean-going vessels and complementary deep-draught ports and efficient ore-handling facilities have greatly reduced ocean-freight costs. Thus, it may cost no more to transport ore 3,200 km by sea under favourable conditions than transport it 160 km by domestic rail lines. Hence, imported ores can in many cases be delivered to seaboard plants at

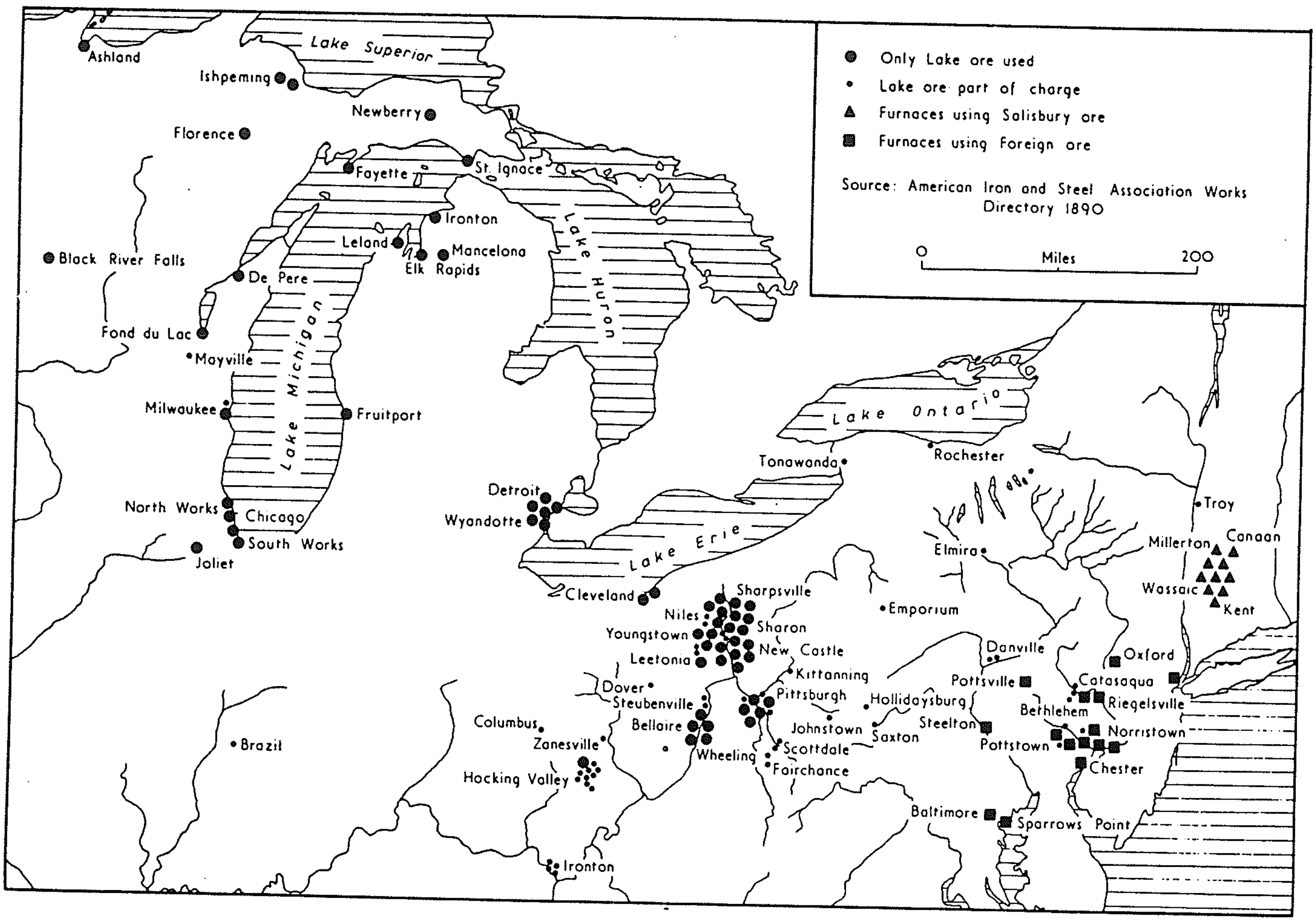

Fig.2.7, Blast furnaces using Lake Superior and foreign ore, 1890.
Source: Warren, 1973, p118.

costs comparable to or lower than the cost of local ores and considerably lower than the cost of Lake Superior ores at the plants in question. The second reason for the increasing use of foreign ores is that it has been found generally to be more economical to increase production from existing furnaces by using higher-quality raw materials, even at higher prices, than to construct new blast furnaces. Many foreign ores in their natural state are of better quality than domestic ores, and accordingly, are preferred by furnace operators. As a consequence, foreign ores have to some extent replaced Lake Superior ores in Pittsburgh (USS, 1964, p177).

The Pittsburgh-Youngstown district had achieved a dominant position by the second half of the nineteenth century. But its standing subsequently declined. For example, this area made 30.4 million tonnes of steel in 1947, some 39.5 per cent of the US total, and 32.8 million tonnes in 1968, only 27.5 per cent of national output. Obviously, the Pittsburgh and Youngstown areas were the products of an age when proximity to coal was a pre-eminent advantage in iron and steel manufacturing (Warren, 1975).

In spite of the relative decline in the Pittsburgh district since the Second World War, Pittsburgh remained one of the world's eight biggest steel-producing districts before 1980[5] (Fig.2.8).

[5] By 1990, most works in this area were closed, which almost eliminated this producing centre as a significant player. The plants abandoned include the Homestead and Duquesne Works in Pittsburgh and the nearby Youngstown plants. The Wheeling-Pittsburgh Steel Corporation and the plants in Steubenville, as well as Monessen, declared bankruptcy (Fig.2.8).

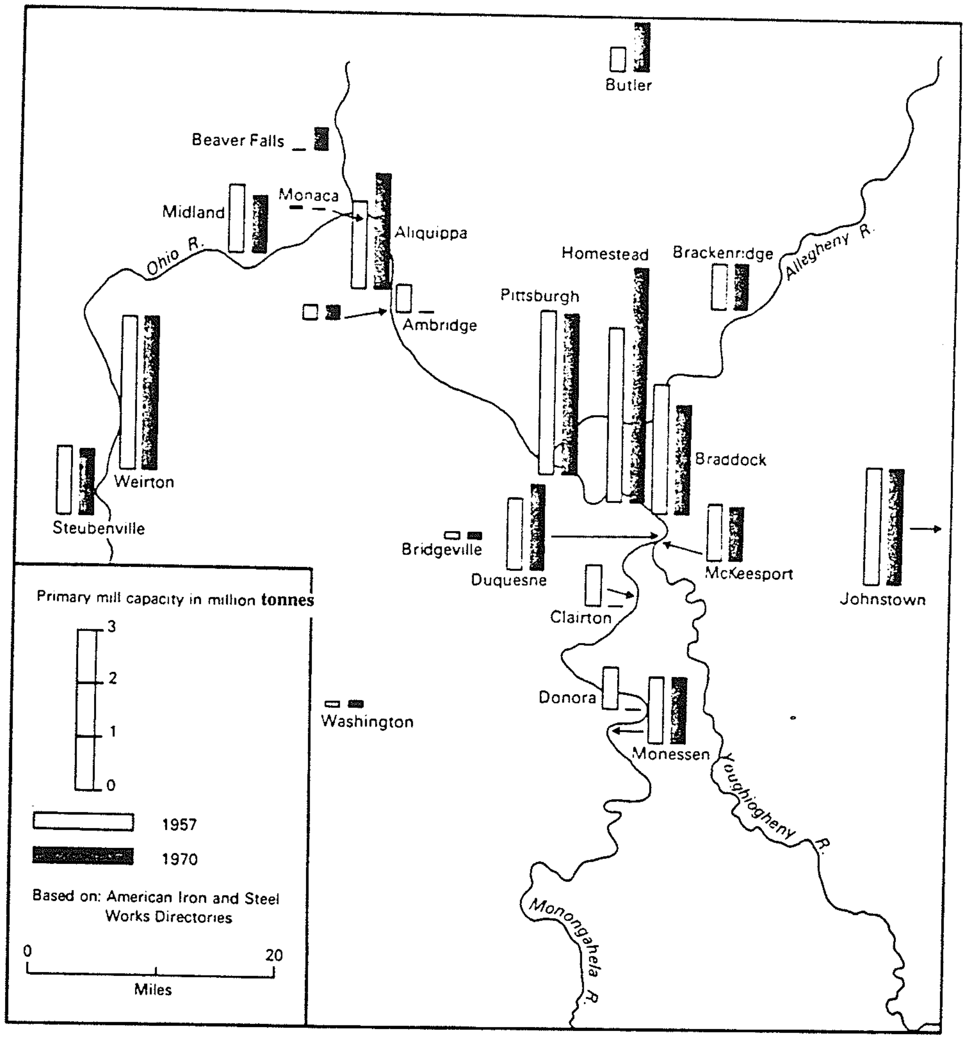

Fig.2.8, The Pittsburgh district 1957-70.
Source: Warren, 1973, p286.

Progressive fuel economy, growth of distant markets, and generally increasing difficulty in competing in these markets have been the chief factors in its worsening situation. Cheapness of expanding existing plants and the localization of labour skills were undoubtedly important in bolstering its enduring importance. Extension of truck shipments of light flat-rolled steels, and water shipments, notably of tubular products, checked the worsening situation in distribution. Other Pittsburgh district plants have been saved by means of new interlinkages. Duquesne, threatened with closure after the War, has since been thoroughly modernized to become one of the US Steel Corporation's most successful operations, and supplied most of the steel for McKeesport tube mills. Melting shop extensions at Duquesne, Edgar Thomson, and Homestead in the 1950s were designed to support an extension of plate, structural, and forging output at Homestead (Warren, 1973). The inadequacy of demand remains the most severe problem facing Pittsburgh steel-makers, for in times of recession they cannot retain distant customers located nearer to competing mills.

For US Steel Corporation, in 1981, there were twelve operable blast furnaces in the Pittsburgh district. These were located in groups of four at three steelmaking plants; namely, Homestead, Edgar Thomson, and National-Duquesne Works. At Homestead, in addition to four blast furnaces, there was an open-hearth shop, built during World War II, with eleven furnaces each capable of 320 tonnes per heat. There were also blooming and slabbing mills as well as two plate and two structural mills. In addition, Homestead had a special division for making forging with steel obtained from the electric furnaces at National-Duquesne Works. Since 1981, the four blast furnaces and the open-hearth shop, with over 3.0 million tonnes of capacity, have been closed down so that the plant is now a finishing mill, rolling steel (obtained from Edgar Thomson) into plates and structural products. In 1981, the Edgar Thomson plant listed four operable blast furnaces, a basic-oxygen steelmaking shop installed in 1972, and a slabbing mill. The National-Duquesne Works listed four blast furnace in 1980; one, Number 6, was the largest in the Pittsburgh district. The plants in the Pittsburgh area were put under one management in 1982. The annual report for that year states:

"In the Pittsburgh area, a new Mon Valley Works was created, consisting of four plant units: a unified Edgar Thomson-Duquesne plant with blast furnaces, basic oxygen and electric furnaces for iron and steel production, plus a bar mill and an iron foundry; the Homestead plant with plate and structural rolling facilities and related operations; the National plant with tubular operations, and the Claiton plant with coke and chemical operations" (Hogan, 1984, p22).

As economic conditions in the American steel industry worsened in 1977, a number of companies made plans to reduce capacity by closing obsolete facilities. In the later 1970s, the industry had a capability of producing approximately 145 million tonnes of raw steel, and that figure fell to less than 136 million tonnes in 1981. The only expansion since the early 1980s in steel-industry capacity has been in the minimill sector. Despite the fact that the integrated producers are not adding new steelmaking facilities, they are intent on adding continuous-casting equipment. Indeed, since 1980, many steelmaking facilities in the integrated works have been either mothballed indefinitely or closed altogether (Hogan, 1983). In 1983, USS (United States Steel) announced that it would thoroughly restructure its steel facilities. The Pittsburgh area was materially affected. The blast furnaces and steelmaking equipment at National-Duquesne Works were abandoned with the blooming mill and Number 1 seamless pipeline plant, which resulted in a loss of 2.7 million tonnes of steelmaking capacity. However, the restructuring process in the USA has not altered the fundamental pattern of the industry's location.

2, South Wales

Because of its widely scattered coal- and ore-fields and its long and varied history of metalmaking, Britain in modern times has had an unusually wide distribution of steelmaking throughout the national territory. In 1969, South Wales, the leading British steel district, made only 22.1 per cent of the national output. South Wales production is less than one-quarter that of the Ruhr but the area involved is 64 km^2, comparing with 57 km^2 from Duisburg to Dortmund, and production there is divided between a number of works, including four integrated ones. The South Wales industry is an interesting amalgam of the old and the new. The attraction of the region lay originally in the ironstone that could be obtained from the northern margin of the South Wales coal-field. With diminishing iron ore reserves, one by one the works in this area closed. But South Wales had an abundance of good coking coal as well as a local market in the tinplate industry. Imported ore gradually replaced local ore, and a location near the coast, especially where, as in western Glamorgan, the coal-field reaches the sea, offered cost advantages over positions far inland. Smelting has thus come to be concentrated in works located on the tideway at Cardiff, Port Talbot and Briton Ferry. In 1936, a large integrated works was established inland at Ebbw Vale, an area where the smelting and steel industry had been declining for a century. Since the war, an even larger plant has been built as a part of the Steel Development Plan at Margam on the Glamorgan coast. It is a large, integrated works, producing steel sheet for electrolytic tinning, by means of a continuous strip-mill. It uses South Wales coal and imported ore, which it receives through its own docks. These two developments have restored the South Wales region to the position of primacy which it lost with the rise of the Teesmouth industry. A new plant, built at Llanwern outside Newport, added yet more to the capacity of South Wales (Pounds, 1968).

By the early 1970s three major foci for the growth of British steelmaking were emerging, and these were confirmed by the industry's development strategy (Fig.2.9). One is the divided focus of Port Talbot- Llanwern, of which only the former has a deep-water harbour but both have major and expanding installations for oxygen

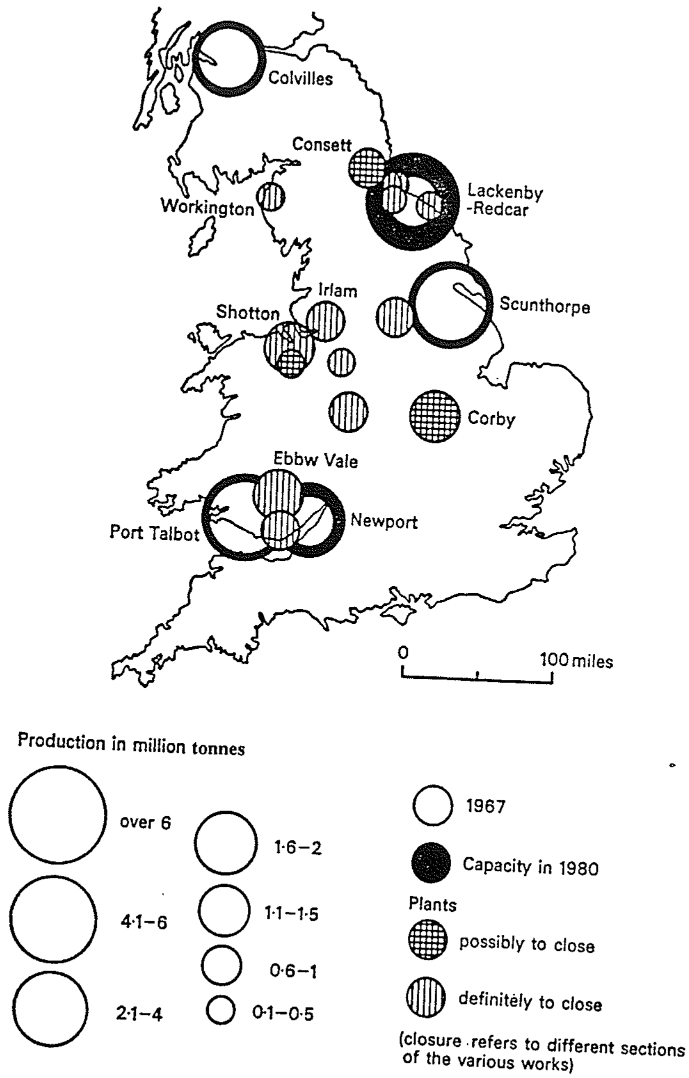

Fig.2.9, The British integrated steelworks.
Source: Warren, 1975, p195.

steel and hot strip mills. Port Talbot was extended to 6 million tonnes and Llanwern to 4 million tonnes during these years (Warren, 1975, p195).

One must stress that the modernisation of the sheet-steel industry remained inextricably bound up with, and usually dominated by, the reorganization of tinplate production. Given the locational concentrations of activity in quality sheet and the structure of the main existing firms, this ensured that new developments were almost inevitably a South Wales matter (Fig.2.10).

However, with the coming of the 1980s, the collapse of the steel boom and the subsequent prolonged depression which took place, production and sales of the British Steel Corporation (BSC)[6] dropped sharply and losses mounted. As a consequence, plans for expansion were abandoned. The most outstanding project was the construction at Teesside of a 10,000-tonne-a-day blast furnace, complete with coke ovens, as well as sinter and pellet plants. Among the reorganizations of the 1980s, the elimination of obsolete capacity and the modernization of existing facilities were accorded great importance. For BSC, this brought the closures at Bilston, Corby, Shotton, Shelton and Consett. As in the 1960s reorganizations were inevitably a South Wales matter, and the region was not spared in the capacity reduction.

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[6] BSC combined all UK steelmaking firms of any size when the industry was nationalized in the 1970s. The company was privatized in the 1980s.

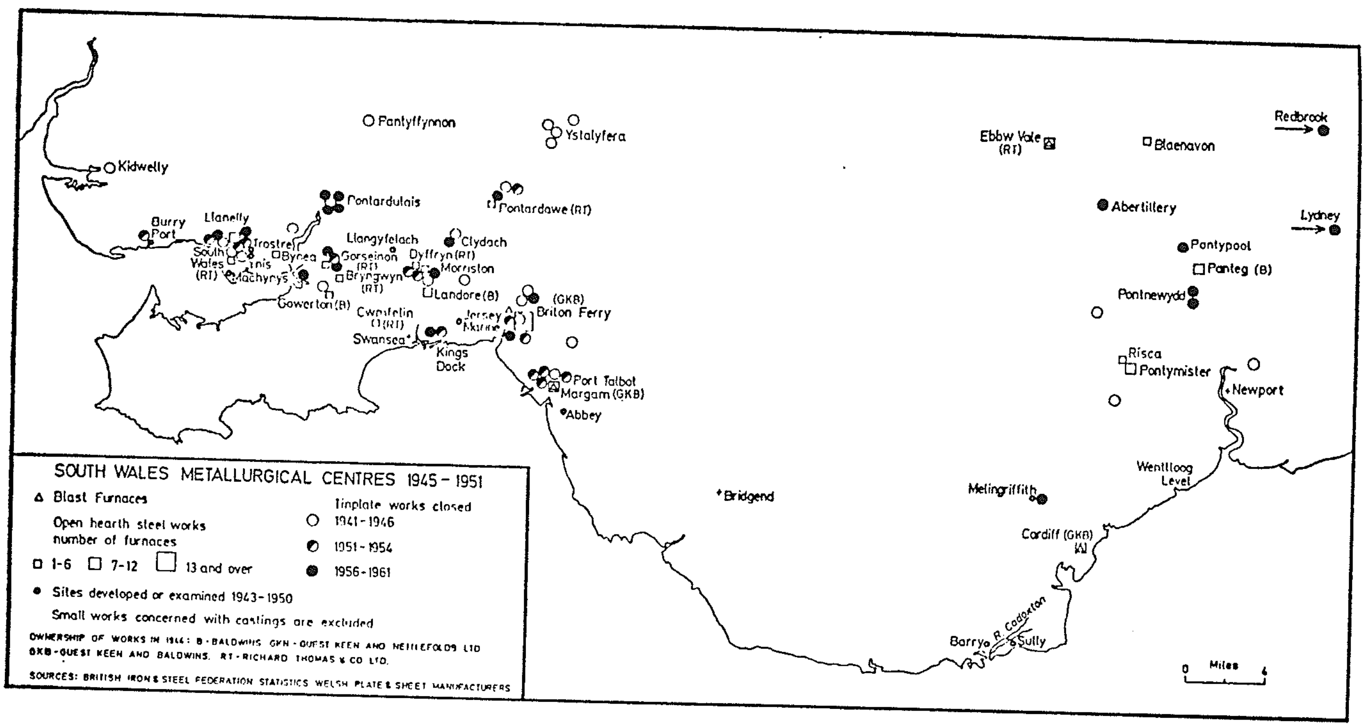

Fig.2.10, Plant was heavily concentrated in Wales.
Source: Warren, 1975, p207.

2.4.3 The ore-based type: Industrial complexes in Lorraine

France has very large reserves of low-grade, phosphoric ore but very little ore of higher quality. Her coal resources, located mainly in the north and in Lorraine, are not in general suited to the making of metallurgical coke, and France has had to rely heavily on imported fuel, chiefly from Germany. Works on the ore-field of Lorraine produced about 78 per cent of France's pig iron and about 66 per cent of its steel in the 1960s (Pounds, 1968). The most extensive coal resources in France are also in Lorraine, where they form an extension of the Saar coal-field. The coal has, however, never been considered of good coking quality, but recent experiments in blending the Lorraine coal with fuel from other sources have met with a large measure of success.

Through to the 1960s the largest absolute capacity increases made in France were in Lorraine (Table 2.10 and Table 2.11).

Table 2.10, France crude steel production (Million tonnes)

	1938	1960	1970	1974
East France (Lorraine)	4.2	11.3	14.0	16.8
North France (Nord)	1.1	4.0	7.1	12.5
Other districts	0.9	2.0	2.6	5.5
total	6.2	17.3	23.7	34.8

Source: Warren, 1975, P183.

Table 2.11, France output of pig iron, crude steel, electrical steel and rolled steel by district, 1970 (%)

	pig iron	crude steel	electrical steel	rolled steel
East France (Lorraine)	66.7	59.1	26.9	62.2
North France (Nord)	29.3	29.9	15.3	26.2
Other districts	4.1	10.9	57.6	11.4

Source: Warren, 1975, p.183

The steelworks of Lorraine are found in three sub-regions. The most important concentration is in the Moselle Valley from north of Metz to Thionville and in the Orne and Fentsch valleys, which drain into the Moselle from the ore district of the Briey plateau to the west (Fig.2.11). The second group lies to the north-west from Ottange to Chiers, centred on the ore of the Longwy Basin. From Pont a Mousson on the Moselle midway between Metz and Nancy is a smaller, more widely scattered group, stretching through Pompey and Nancy to Neuves-Maisons on the Moselle Est canal. The works of the Thionville-Fentsch-Orne area early benefited from self-fluxing ore. Since the mid-1960s the works in the Moselle Valley itself have been the only ones in the region to gain direct benefit from the canalization of the Moselle (Warren, 1975, p184).

In 1968 De Wendel merged with Sidelor and the Societe Mosellane. By 1971 Wendel-Sidelor produced 8.1 million tonnes of steel, making it second in the ECSC only to Thyssen. By the end of 1971, with the extension of the Gandrange plants from 1.2 to 4 million tonnes, almost half of its capacity was concentrated there. This was one factor requiring the closure of other plants. Another was a 1971 Belgian offensive in steel sales which led to reduced prices and narrowed profit margins. From the creation of Wendel-Sidelor in 1968 to mid-1971 it closed 16 blast furnaces out of 49, two Thomas[7] shops out of eight, two OH works out of five and 21 rolling mills out of 64, all without reducing output. In 1971 alone

[7] Thomas process is also called the basic Bessemer process, a kind of bottom-blown basic pneumatic process.

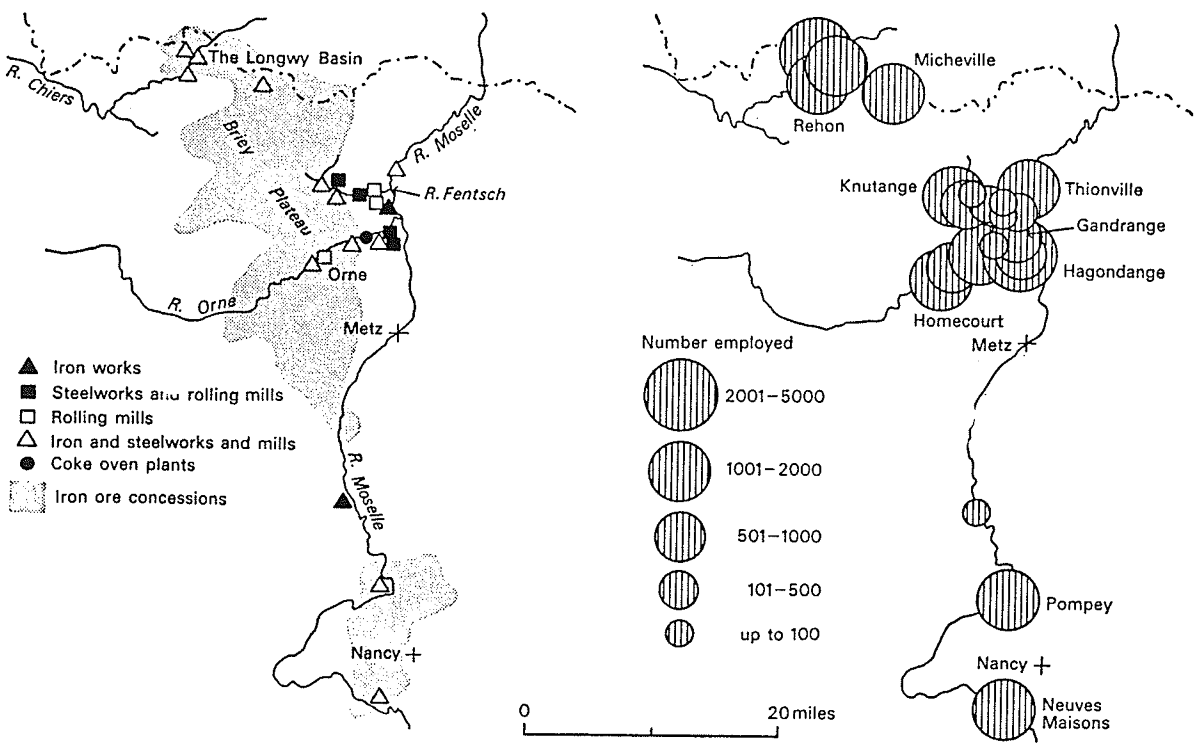

Fig.2.11, The steel industry of Lorraine, 1972.
Source: Warren, 1975, p185.

it closed the Micheville coke plant and melting shop, the OH plants at Homecourt and Hagondange, two mills at Rombas and at Knutange, two blast furnaces, a Thomas plant and a blooming mill and four finishing mills.

Lorraine has always been a basic industrial area, steel and coal employment accounting for 50 per cent of the industrial work-force in 1962 in the Department of Moselle. As opposed to the Nord or to the Ruhr, its industrial economy lacks a major metal-fabricating sector. In 1962 Lorraine had 11 per cent of its workers in primary activities, 52 per cent in secondary and 37 per cent in tertiary lines. This high degree of dependence on minerals and steel implies not only that there is much less market attraction to compensate for other disadvantages in steelmaking but also that decline in steel employment will be much more important for the regional economy than in the Ruhr. However, by the early 1970s it was clear that the rationalization tendency could not be contained (Warren, 1975, p.187).

The France steel industry used to be centred round two large integrated companies, Usinor and Sacilor. In 1979, because of financial difficulties and huge losses, both Usinor and Sacilor were nationalized as the government converted its debt holdings in these companies to equity. Usinor-Sacilor was formed in 1988 by a merger between Usinor and Sacilor. The Usinor-Sacilor composition has five basic divisions. Sollac, whose principal plants are Dunkirk, Fos and Lorraine; Unimetal, also largely located in Lorraine; Ugine; a metallurgical division; a transformation division and an other activities division. From the late 1980s, Usinor-Sacilor acquired a large number of companies. It also entered into a number of joint ventures in several countries (Hogan, 1991).

Because of the world-wide recession in steelmaking, a number of expansion plans that had been envisaged during the prosperous days of the 1972-74 boom were either scrapped or postponed. Among the more material of them were: (1) the proposal by Usinor to increase the size of the Dunkirk plants in northern France from 8.0 million tonnes to 12.0 million tonnes; and (2) the plan to double the size of Solmer's plant at Fos in southern France from 3.5 million tonnes to 7.0 million tonnes. Notwithstanding these interruptions, the French steel industry's centre of gravity shifted away from Lorraine as the 1970s progressed. Indeed, by the end of that decade the other producing districts were accounting for more steel than the traditional Lorraine heartland. Much of the credit for this shift can be laid at the feet of the two port-steel industrial complexes in Fos and Dunkirk.

2.4.4 The coal-field type: Ruhr industrial complexes

The Ruhr coal-field is not only the richest in Europe in terms of total resources, but also enjoys the highest proportion of coal of coking quality. The ore used by its steelmakers comes mainly from northern Sweden by sea and is transhipped to barge at Rotterdam or Emden. The Ruhr industrial area is well placed for the reception of its raw materials and the distribution of its products. Apart from a well-developed railway net the Ruhr area has at its western end the navigable Rhine. Stretching from west to east through the region are the Herne and Lippe canals. At the eastern end these merge with the Dortmund-Ems Canal which provides for water-borne transport to the North Sea port of Emden.

The smelting and steelmaking works are clustered at the eastern and western ends of the Ruhr area. Most are near the Rhine port of Duisburg-Ruhrort, but three of the largest lie near Dortmund. Except in the latter vicinity, they are placed close to either river or canal, so that ore is unloaded directly from barge to stockpile (Pounds, 1968).

In spite of the spectacular growth of new steel districts, the Ruhr still contains the heaviest concentration of steel capacity in the world. For over half a century this district has epitomised the giant, fully-integrated, rationalised steelmaking and steel-fabricating complex.

Already before 1900 Ruhr production was being concentrated either to sites fronting the Rhine, with its deep-water access to imported ore and to south German and foreign markets, or to sites in the east, where the new Dortmund-Ems Canal gave an alternative route for ore imported through the north German ports. Construction then of Krupp's Rheinhausen works and the choice of Huckingen for major development by the tube firm of Mannesmann were major steps confirming the Rhine orientation. Expansion of the Hoesch and Dortmund Horde works in Dortmund was a reflection of the second trend. Since World War 2, polarisation of the industry has proceeded much further. The war-ruined Krupp works at Essen was not rebuilt, reconstruction and expansion being concentrated at Rheinhausen. After rebuilding and extension at a lower unit cost than in contemporary British developments, the August Thyssen operations in the Duisburg area emerged as a major growth point. In the mid- and late-1950s Dortmund Horde was for a time the biggest producer in Germany (See Fig. 2.12).

In the early 1960s, as competition became keener, it was realised that German steel firms were becoming too small. Subsequently, several distinct steps to rationalisation of Ruhr steelmaking have been taken. First, a number of co-operative agreements were made to reduce the ill effects of overcapacity and economise in capital outlay, such as an agreement in 1962 between Thyssen, Mannesmann and Huttenwerke Oberhausen leading to savings on strip-mill investment. In 1966 the German steel industry formed four Walzstahlkontore or rolled-steel offices, to coordinate sales and ensure the greatest efficiency in rolling-mill programmes. Thyssen and Mannesmann three years' later made a co-operative agreement, the upshot being that the Thyssen tube business was made over to Mannesmann and much of Mannesmann's other finishing plant transferred to Thyssen. The latter company reckoned that this saved capital investment of DM 300 million and reduced annual costs by DM 100 million.

Long before this, rationalisation was under way through merger and closure of old or badly-located plants. In 1966 Hoesch and

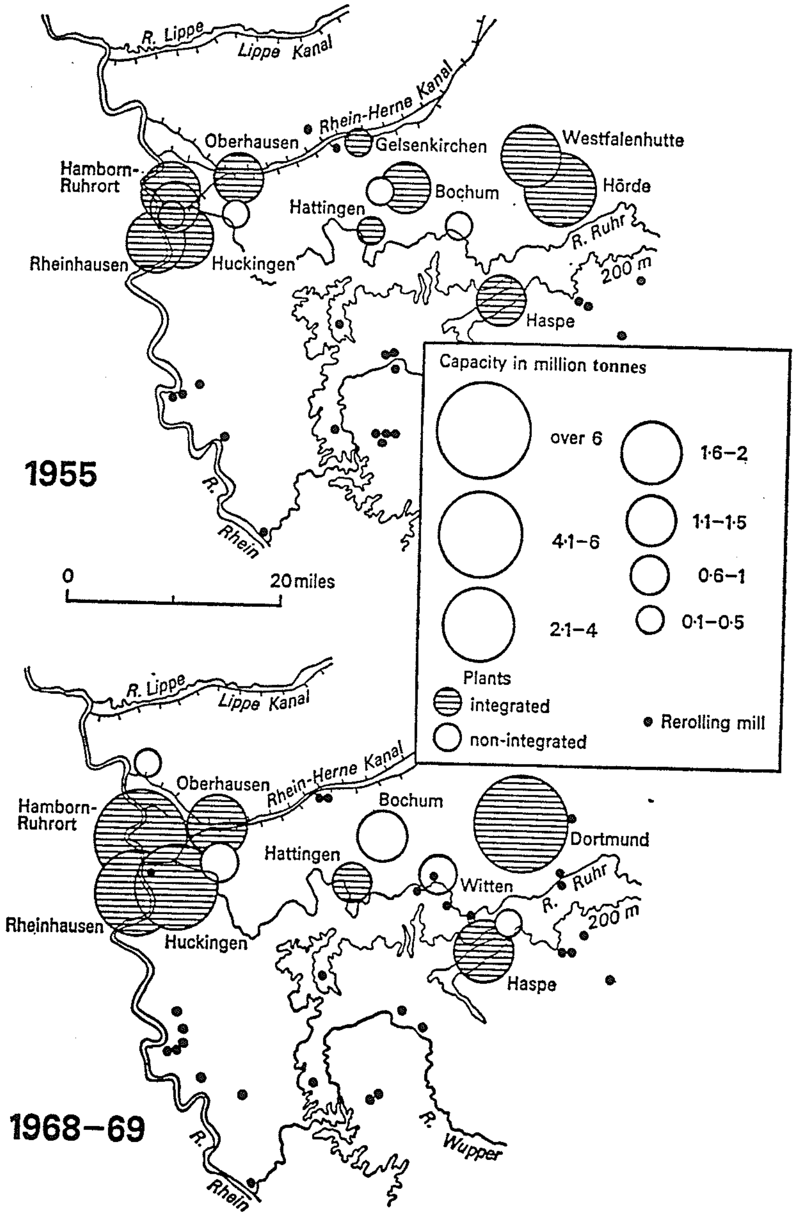

Fig.2.12, The steel industry of the Ruhr, 1955 and 1968.
Source: Warren, 1973, p175.

Dortmund Horde joined together, a logical merger considering Hoesch's emphasis on light sections and sheet and Dortmund Horde's on plates and heavy sections. In 1965 Krupp acquired Bochumer Verein, which had made 3.9 million tonnes of steel in 1964. Already Thyssen was becoming the nucleus of even bigger groupings, acquiring in turn Niedderheini-schehutte of Duisberg, Deutsche Edelstahlwerke of Krefeld and the Handelsunion of Dusseldorf. In 1964 the absorption of Phoenix Rhenirohr made it a 7.5 million-tonne concern, and in 1968 it took in Huttenwerke Oberhasuen. Merger was followed by rationalisation of plant and the achievement of large capital economies and process-cost economies. After the Hoesch-Dortmund Horde link the group shut down a Bessemer steelworks and six rolling mills. By 1967 Thyssen had closed the Niedderheische ironworks and steel plant, and the absorption of Oberhausen prevented duplication of a new special-steel works, so saving $37.5 million. In 1973 Thyssen took over Rheinstahl. This process of merger and rationalisation has been applied throughout Germany, with important developments in the Saar and Saxony as well as the Ruhr. The country increased its crude steel output about 30 per cent but cut its work-force nearly 20 per cent. Even so, German steel was hit severely by successive revaluations of the Deutschmark after 1969, by wages, which went up 40 per cent in 3 years, and by increases in coal costs - while the Federal Government refused to permit large imports of coking coal. By mid-1973 the list price of German coal was more than DM 25 a tonne over the international level.

German steel's reaction to these difficulties has taken various forms. After holding aloof and indeed even being aggressively opposed to them, it has given some recognition to the value of mini-mills, Klochner has become associated with Korf, which operates such plants at Kehl and Hamburg. But mini-mills provide no general answer to the problems afflicting giant integrated concerns. More promising is a further development of steel finishing and using interests. Krupp, long prominent in this field, has strengthened its interests within recent years. Mannesmann has recently acquired a majority holding in the big equipment and engineering combine of Demag and, through its merger with Rheinstal, Thyssen, far and away the biggest producer but dangerously overdependent on steel sales, is moving in the same direction.

Both these lines of development are important, but greater economies will be secured from two methods of adjustment which are much more obviously geographical; that is to say, from further concentration of iron and steel making in bigger units at the most favoured locations within the Ruhr and from new projects outside the region. The first of these strategies is much further advanced than the second. Krupp has closed the Bochum iron-works, supplying molten iron now from its expanding Rheinhausen operations. Later it began to close down steelmaking at Bochum as well, even though finishing operations remain important there. Klockner has closed iron and steel manufacture at the Haspe-hagen works, and now buys billets for that plant's wire-rod mills. Rheinstahl's Hattingen works has been moving over increasingly to special grades of finished steel. By 1971, with two big new stacks building at Duisberg, Thyssen had ceased to make iron at Oberhausen. Hoesch has made major new additions to its Dortmund operations with a new sinter plant, blast furnaces and oxygen steel plant, but it is becoming increasingly obvious that Dortmund is less favoured than the sites along the Rhine frontage. By 1971 Dortmund obtained about 35 per cent of its ore by water and 65 per cent by rail. The rail freight alone on ore from Rotterdam to Dortmund was about DM 6-7 a tonne, comparing unfavourably with a Rotterdam-Duisburg barge rate of DM 2.5 per tonne, and even with rail freight and transhipment to barges a total of no more than DM 5.8 per tonne.

There is scope for further improvement of ore movement on the Rhine, a development particularly important as ocean hauls in bigger vessels reduce the unit cost of ore delivered at the mouth of the Rhine. The ore trains which deliver ore to Hoesch in Dortmund carry about 1,200 tonnes, whereas trains of barges on the Rhine are made up of four units each laden with 2,000-2,500 tonnes of ore, and in spring 1971 experiments were made with barge trains of six units having a combined ore capacity of up to 15,000 tonnes per delivery. With such advantages there seems every prospect of long-term growth in the Duiburg-Hamborn-Rheihausen area. Eventually Thyssen plans to have new furnace plant at Duisburg, giving it a nominal iron capacity of some 15 million tonnes, and, even allowing for one furnace being down for relining, an effective capacity of over 10.5 million. The latter is a tonnage equal to half the pig iron output of North Rhine-Westphalia in 1970. Meanwhile Krupp has announced important, though smaller, extensions at Rheinhausen. Between 1972 and 1974 Krupp set about building a 2.4 million-tonne oxygen steel plant there, later to be extended to 6 million tonnes. Evidently, Dortmund's works have felt the strengthening coastward pull, a pull which has affected all German works severely.

Table 2.12, Ruhr integrated steelworks crude steel capacity or production (million tonnes)

	1954-5 (production)	1971 (capacity)
Rhine frontage		
August Thyssen, Duisburg	1.3	
Huttenwerke Oberhausen	1.5	
Phoenix Rheirohr	2.2	total 12
Niedderheinische Hutte, Duisburg	0.4	
Krupp, Rheinhausen	1.8	4
Mannesmann, Huckingen	1.6	3
Interior works		
Bochum	1.1	1
Klockner, Hasps-hagen	0.5	1
Rheinstahl, Hattingen	0.4	0.75
Eastern Ruhr		
Hoesch, Dortmund	1.5	
Dortmund Hord, Dortmund	2.5	total 5-5.5

Source: Warren, 1975, p176.

In 1938 when the great Salzgitter complex was building to join older works such as Peine, North Germany made only 1.0 million tonnes of steel as opposed to the 15.9 million tonnes accounted for by North Rhine-Westphalia. Salzgitter was rebuilt after wartime destruction and postwar dismantling, and by 1960 North Germany made 4.0 million tonnes of steel in contrast to the Ruhr's 24.7 million.

By 1970 their respective outputs were 7.2 and 30.5 million tonnes and by 1974 capacity reached 11.3 million tonnes and 42.5 million tonnes. In pig iron the North's 1974 capacity had climbed to only just less than one-third that of North Rhine-Westphialia. The increasing locational attraction of North Germany may be traced to the postwar development of the firm of Klockner.

Klockner operated two integrated works in the early 1950s, at Haspe-hagen, south of the Ruhr river, and at Geogsmarienhutte-Osnabruck, near low-grade north German ore deposits. In the mid-1950s Klockner built the major new Bremen integrated works at fairly low capital cost per tonne. Bremen has since become the Klockner growth focus. Georgsmarienhutte has concentrated on special and high-quality steels. Haspe has gradually narrowed its rolling programme to iron rods, and in 1972 closed its iron and steel capacity. By the end of 1970 Bremen Works had been extended to a steel capacity of 1.8 million tonnes.

During the early years of the 1980s, a considerable programme of modernization was undertaken by a number of German companies. Mergers and plant reorganizations have caused some restructuring of the industry. Thyssen reduced its capacity from 19 million tonnes to about 16 million tonnes through the elimination of obsolete OH furnaces. In 1977, Krupp improved its ironmaking capacity substantially by constructing one large 11-metre blast furnace at its Rheinhausen plant to replace three small, relatively less-efficient units. As a whole, the German industry has reduced its steelmaking capacity from the 55-60 million tonnes prevailing at its peak in the mid-1970s to approximately 47 million tonnes in 1990 (Hogan, 1991). Thyssen, cut back from 18-19 million tonnes in the 1970s to 11-12 million tonnes in 1990 by closing a number of its plants so as to bring capacity into more realistic alignment with demand.

The evidence of a strong coastward pull on German steel is incontrovertible. In 1954 the Ruhr made 69.6 per cent of the combined steel output of West Germany and the Netherlands, in 1965 its share was 67.4 per cent and by 1972 its share stood at 59.0 per cent. Yet in every case the possibility of making a major greenfield development was becoming more difficult as costs escalated and as environmental standards become more exacting. The Ruhr would decline in relative significance in German and European steelmaking, and there would be continuing sub-regional change within it, but the prominence which it has built up over more than a century will persist for many years (Warren, 1975, pp.170-182). However, because of Germany's relative advantage in deep-water transportation, the rate of decline in the Ruhr's contribution to Germany's steel output should be slower than that of Lorraine's case in the French industry. Most of its plants, with the exception of Klochner's in Bremen, are inland. Yet, while the Klockner plant has access to the sea, it cannot accommodate ships over 40,000 dwt. Most of the large steel-producing plants are in the Ruhr and are serviced by the Rhine River.

As the cases from Japan, the United States and West Europe testify, the movement of the iron and steel industry to coastal locations is very strong. However, the shift in locations from inland to coastal sites is more pronounced in some countries-such as in Japan and France- than it is in others, such as in the USA and Germany. The better the deep-water port facilities in a country, the more significant is the coastal location for the iron and steel industry. This introduces us to the question of the relationship between the coastal location of the iron and steel industry and the inauguration of ports. The following chapter will elaborate on one of the important functions of ports, that is, to serve as hosts for metallurgical industries.

CHAPTER THREE, PORTS AS HOSTS FOR METALLURGICAL INDUSTRIES

As discussed in the last chapter, it is possible to discern an accelerating shift in iron and steel industrial location across the world from inland to coastal areas, together with an increasing reliance on imported raw materials. In this chapter, attention will be directed to analysis of the cause of this shift. As the principal cause of the relocation, the MIDAs facilitate the gathering of imported materials, offer benefits in the way of industrial processing, and deliver the resultant manufactured products to both the domestic and overseas markets. Embodied in the advantage of MIDAs, the ports primarily promote themselves as hosts of industrial complexes; assuming the mantle of industrial ports. This chapter will embark on the theoretical merits of industrial ports in the first instance before presenting case studies of actual industrial ports.

3.1 The theorical merits of industrial ports

Reverting back to the precepts of classical industrial location theory and, in particular, to the simplying assumptions of Weberian analysis, one can conclude that locations at the raw materials sources or at the market or at any intermediate point are justified so long as equal total transport cost conditions prevail. A port can be conceived as a classic intermediate point after the fashion of Hoover (1948), who envisaged the port fulfilling an industrial function as a complement to its transhipment role as a necessary break-bulk location in multimodal transport systems[1]. In general, the basic relations between procurement, distribution and processing costs, together with the trade-off inherent in raw material and market orientations, conspire to confirm the attractiveness of ports as industrial locations (Robinson, 1981).

For long-distance transportation, the larger the size of ships, the cheaper is transportation cost per unit of cargo. The emergence of larger ships, increasing reliance on imported raw materials and economic centres of gravity moving towards coastal areas, all led to seaports playing a very important role in national economic operations. Among the aforesaid three factors, it was economies of scale in shipping that promoted the others, acting as the necessary technical means to render feasible the others. The size and sophistication of ships progressed by leaps and bounds. As stated: the greater the ship size, the lower the freight cost per tonne. For distances of 8000 km and allowing a port stay of 10 days, the cost per tonne of cargo carried in tankers is $2.92 for vessels of 25,000 dwt, $1.33 for those of 100,000 dwt and $0.86 for ships in

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[1] In Hoover's view, sometimes there is a peculiar conformation of the gradients of procurement and distribution cost that makes the total transfer cost least at some intermediate point, usually where two different modes of transport, e.g., water and rail, meet. Suppose the route between the material source and the transhipment point is a water route, while that from the transhipment point to the market is a rail route. It is clear that by locating the production process at the transhipment point, the total transport costs will be minimized, since neither material nor product will then have to be shifted from ship to car. The material will use water transport only, and the products rail transport only (Hoover, 1948).

the 300,000 dwt class. The large size of vessels enables the import of raw materials at economic rates. In this sense, ports are sources of raw materials for industry. In consequence, the primary-processing industries located in ports are sources for the secondary-processing and other manufacturing industries. In other words, seaport industries are characterized by strong backward and forward linkages (Bird, 1971).

In the past, port industrialization was normally directly dependent upon the port function in the sense that most port-related industries derived their raw materials from goods passing through the port, took advantage of the break-of-bulk point after the fashion of Hoover, and thereby contributed to the provision of employment within the urban area. This element of resource orientation is still a major port-industrial function in both advanced and less-developed countries, as the processing of agricultural raw materials or minerals is frequently concentrated in port locations in producer-exporter countries or in market-imported areas. But the traditionally close dependence of port industries upon the port function in this sense has been considerably modified in recent decades. This has produced an increased emphasis on the creation of planned port-industrial complexes on a large scale, so that the levels of port throughput and patterns of port-industrial activity in designated coastal zones now far transcend those associated with traditional port industries (Hoyle and Pinder, 1981). Planned ports were conceived around port-related activities embracing the following kinds of industries: (1) shipbuilding and other forms of maritime engineering which inevitably require a waterfront location; (2) basic industries which process sea-borne imported raw materials; and (3) industries producing goods mainly for an export market. This surging development of port industries in designated coastal zones is made comprehensible when it is put into the context of MIDAs.

3.1.1 Introduction to MIDAs

Following a visit to Europe in 1966 by officials of the National Ports Council (NPC) of Britain, the Council formally converted to the merits of MIDAs and recommended their implementation in its 1966 Annual Report. A number of salient points were raised in this report, points that constitute the grounds of the discussion that follows.

It must be recognised that to meet the port requirements of import of bulk materials by the development of separate facilities for each user may not, in all cases, be economic. This is particularly the case where the industry is sensitive to the size of the immediately-adjacent market. There are very few areas left in the UK, for example, where deep water and ample land for industrial development coincide in the vicinity of major population areas. This relates, of course, to the import of bulk materials for processing and in this context the NPC considered that 'deep water' must mean not less that 12.2 m of water at LWOST or low water ordinary spring tide (Takel, 1974, pp.12-13).

At the deep-water port and its associated industrial sites, it would be possible to bring large bulk carriers to berths immediately adjacent to the plants that use or produce the cargoes which the vessels would carry. The economy of large vessels compared with smaller ones would result in lower costs of ocean carriage, and the absence of land transport costs for the bulk goods would be an added gain. The combined berths and processing facilities--the essence of MIDAS-- offer considerable advantages for industries, particularly those using materials that can be imported in large bulk carriers but which are demanded by individuals who might not be able to support the cost of independent facilities. The NPC was impressed by several cases in Europe where new ports or port extensions were being designed so that they could permit large vessels to gain access to extensive areas of land available for industrial development. The competitive advantages of industry so sited was thought to be considerable. The ports in question, incidentally, will be the subject of further discussion later in this chapter.

The British Government and the NPC initiated studies to identify potential sites for MIDAs. Three key criteria were stipulated. First, the would-be MIDA must be close to deep water (that is, 15.2m-18.3m. MHWN without excessive dredging). Secondly, it must have available at least 20 km^2 of level land reasonably near to the deep water. This land must be suitable for heavy industrial development with or without reclamation, and it must be supplemented with substantial contiguous backland areas. Thirdly, the location must enjoy a broadly favourable economic geography, including such factors as sizeable population, significant presence of industry and inland communications, not to mention established links to markets and to overseas ports. If these factors are favourable, they will promote the rapid growth of both the port and the port industries. Referring to population, a large labour pool can support the demands of industry and underwrite industrial expansion. Advanced inland communications can speed up the output and input transactions of a port and have positive influences on port throughput and augment its hinterland scale. Existing industries can provide some raw materials and manufactured products for the port industries and form the basis of an integrated complex of forward and backward linkages consistent with agglomeration economies[2]. The advantage of a MIDA close to markets is specially important to those industries which are market-orientated, since proximity to an international port can effect transport-cost savings both by conveying the manufactured products to overseas markets and in facilitating the import of material inputs.

Therefore, a MIDA can be defined as a planned and co-ordinated port containing industrial complexes. It is operated so as to achieve the kinds of economies specified in the next few paragraphs.

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[2] The agglomeration economies derive from a cluster of economic activities at a special location, which are linked by technical and production interrelations or enjoy a spatial juxtaposition to share some infrastructure. By this way substantial economies can be achieved.

1. Economies of Ship Transport Costs for Bulk Raw Materials.-- The sites require sea access for bulk carriers of sufficient depth to enable the optimum ship size to be used, particularly in the trades of crude oil and iron ore.

2. Economies of Cargo Handling Costs for Materials.-- This implies an industrial location close to the point of transhipment. The exact location will depend on such factors as the bulk/value ratio, the effect of reduced bulk processing, and the ease of handling. In the first case, the lower the value in relation to the unit of bulk, the higher would be the effect (in percentage terms) of transport on total cost of raw material delivered. The second and third factors, whilst also linked with the bulk/value consideration, are important as well in deciding locations. Proper economy in dock construction will mean zoning of industries according to the economies of handling their particular cargoes.

Industrial zoning development is one way to obtain the savings in the cost of new port construction, but the zoning development must be based on the properties of commodities. The two factors of economic working distance of mobile appliances and the berth/land ratio will decide the depth of the port zone. The port operational zone should be designed to accommodate warehouses, transit areas, container terminals, bulk and buffer storage, grain milling and some special berths. Since steel and non-ferrous metals and other dry bulk-using industries make demands on conveyors combined with buffer storage, it is suitable to locate these industries in the second zone. Liquid bulk is easily handled, however the pumping cost increases with the distance, so the industries using bulk liquid, such as oil refining, petrochemicals, and chemicals, might be zoned in the third strip. Port service and communications require substantial land, but since they should not interfere with cargo operations, they should be located in the outer side zone away from the port (see Fig.3.1).

3. Economies of Scale.-- The creation of planned complexes should enable port investment to be kept at an economic level with the cost of infrastructure reduced in national terms. The concentration of such developments in a limited number of centres will reduce the overall investment necessary, while, at the same time, realizing economies of scale both in the resultant port works and in their attendant industrial complexes.

4. Control and Amenity. The spoliation of coastlines is a very sensitive issue in any country and is a cause of concern to the environmental movement. By means of MIDAs, the area assigned to industries is much smaller than the same amount of industries located in several discrete sites. By the same token, smaller-scale industries can share the agglomeration and the concentration that ensues eases the task of supervising pollution control (Takel, 1974, pp.15-17).

The emergence of MIDAs was an important feature of the 1960s and 1970s. Various port industrial zones can be observed here and there. As a result of the rapidity of economic change and development on a global basis it is already possible to identify

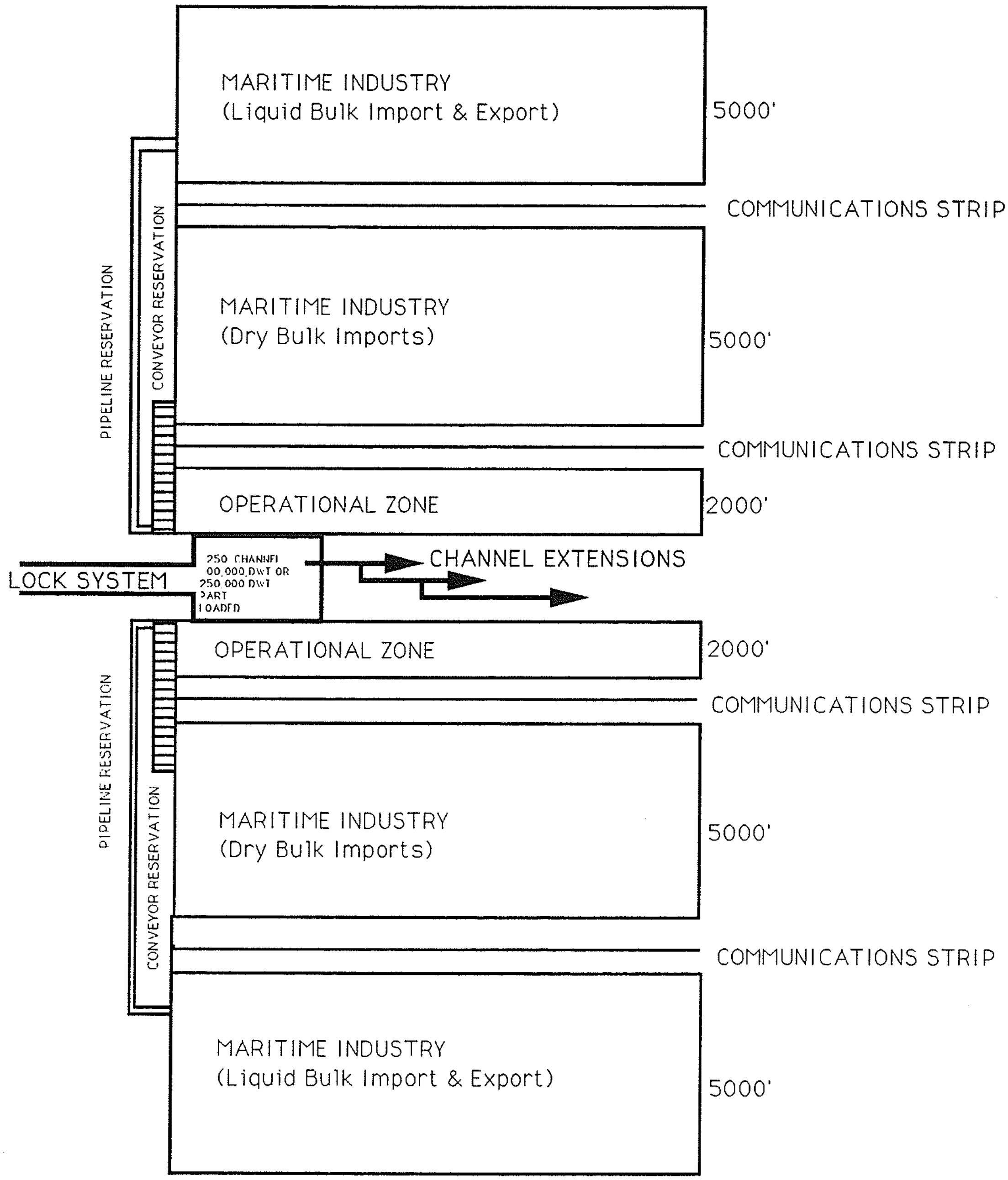

Fig.3.1, The MIDAs' layout in the industrial port.
Source: Takel, 1974, p174.

three distinct types or stages of growth in MIDAs. The first is the Rhine model, characterized by heavy industry; the second is marked by the admixture of varied industries and maritime trade functions; the third is associated with the developing countries. These will be described in turn.

The first generation: the Rhine model

The Rhine Delta played a pioneer role in affirming the MIDA concept. The Botlek Scheme at Rotterdam became operational in 1958 on the basis of a project designed in the immediate post-World War 2 period but subsequently adapted in the context of European co-operation and in response to the increasing size of bulk carriers. The Europort development was planned in the late 1950s, but the realization of the scheme extended over 10 years, followed by the later Maasvlake project. Within the plan area, a total of over 10,000 ha of land is devoted to oil, chemical and shipbuilding industries. During the same period Antwerp launched a 10-year plan (1955-65) for the development of heavy chemical industries on a 3000-ha site on the right bank of the Scheldt. Other developments took place at Amsterdam and at Ijmuiden where the Hoogoven steelworks set a precedent for the introduction of a major iron and steel complex as one of the primary bases of coastal industrialization. During the 1955-70 period the transformation of the Rhine delta provided, essentially, an experimental model which has subsequently been adapted and utilized elsewhere (Vigarie, 1981, p.24).

The Japanese national port development plans for 1965-9 and for 1971-5 outlined two principal methods of expansion: the infilling of coastal indentations, together with the creation of interlinkages with island ports, as in the case of Tokyo, Ise and Osaka-Kobe which established open spaces for industrial and port development in formerly sandy or swampy zones that would otherwise have remained underutilized. An excellent example of the application of the latter method is provided by the new industrial cityport of Kashima, begun in 1969, and developed on the basis of naphtha refining, chemical industries, ironworking and thermal-electricity production (Vigarie, 1981, p.25). The huge factories of Nippon Steel, Nippon Kokan, Kawasaki Steel, and Sumitomo Metal Industries are located here.

Kashima has 2,682 hectares of sandy area of reclaimed land. It was created under the terms of the Act for Promotion of Special Areas for Industrial Consolidation in 1964. The industrial zone has flourished around harbour facilities. Sumitomo Metal Industries moved to Kashima to retain its competitive edge. Reclamation for the Tokyo-Chiba complex and the dredged harbour at Kashima respectively symbolize the first and last stages of development during the period of very fast growth. The land for the port industrial complex of Kashima was established with the dredged spoil (Murata, 1980). The first generation of MIDAs involved in the developed countries was characterized by the heavy industries relying on imported materials. With the ore and oil imported at a rate commensurate to achieve the economies of scale in transport attendant on the use of large vessels, the petrochemical and metallurgical sectors dominated the port industrial area. It is also recognized that environmental pollution, a corollary of rapid growth of heavy industries and their high concentration in the port area, engendered serious public concerns. This led to unfavourable public reaction to the development of MIDAs of this category. In response to this pressure, the MIDAs were compelled to constrain their economic activities and limit pollution. Diversification of economic activities, in consequence, became the catchword of the second generation of MIDAs, which will be described below.

The second generation: industrial diversification and the limitation of pollution.

The MIDA of Hamburg should be outlined to illustrate this type. The expansion of the associated port-industrial region was not begun until 1962 when 10 km^2 were reserved. Land is being released gradually for the new industrial developments and some of the major industries are displayed in Fig.3.2. In terms of turnover, oil refining is Hamburg's largest industry, followed by electrical engineering, chemicals, engineering and shipbuilding (Burtenshaw, 1974). At the end of the 1960s, the port's entire area had reached 125.5 km^2 while the industrial site occupied 46 hectares.

In 1970, a press campaign using the slogan "Hamburg must not become another Ruhr" resulted in the withdrawal of a plan for a

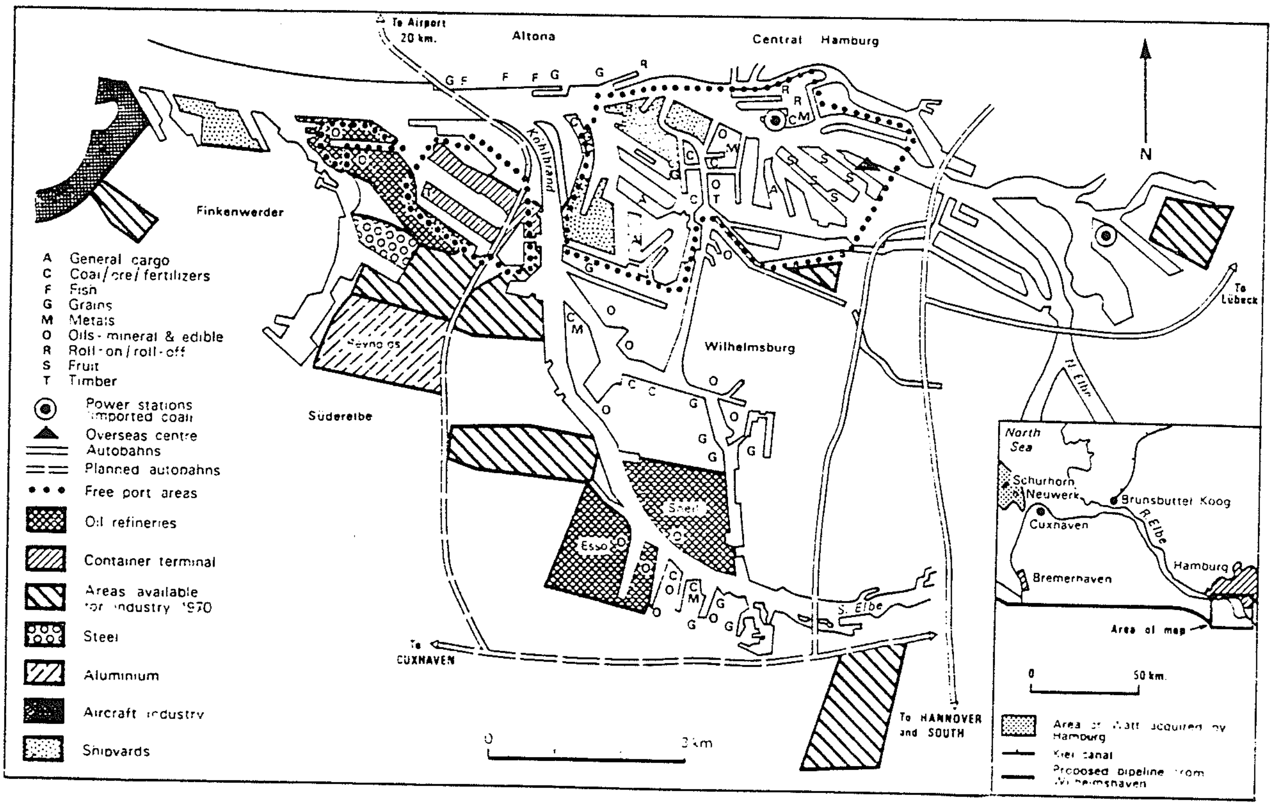

Fig.3.2, Hamburg MIDA 1970.
Source: Burtenshaw, 1974, p59.

large-scale iron and steel complex in the Hamburg MIDA. Similarly, in Rotterdam, a projected iron and steel complex was rejected in 1970 for a variety of reasons: pollution, tensions in the labour market, an excess of heavy industry and the influence of left-wing viewpoints less concerned with the strictly economic factors involved in industrial growth.

It is interesting to note that a climate of opinion increasingly unfavourable towards the concentration of heavy-industry development in Japan emerged at about the same time, particularly in Yokohama from 1966.

Reasons for changing attitudes towards MIDAs are thus quite varied, but the broad agreement between West and East in this context is of considerable significance. From the late 1960s onwards a marked change has occurred in the structure of MIDAs: large areas have been devoted to warehousing, commercial activities have been increasingly introduced, and attempts to develop light industry have become more commonplace. A representative European case is that of Montoir, on the lower Loire, where an industrial zone originally devoted almost exclusively to fertilizer manufacture has been diversified by the introduction of a large methane project and by the development of facilities for handling unitized goods. The evolutionary process has moved still further ahead in Japan where areas within newly-initiated MIDAs are reserved for urban residential areas and community facilities. An instructive comparison may be made at Yokohama between the Negishi MIDA, begun in 1956, and that at Kanazawa where development started in 1968; in the former case 84 per cent of the land area is devoted to industry, whereas in the latter case the figure is only 41 per cent (Vigarie, 1981, pp.25-27).

The third generation: MIDAs in the Third World

The emergence of maritime industrial zones in less-developed countries now in the early stages of industrialization is, of course, only one aspect of a far wider phenomenon; but the technological evolution of MIDAs in LDCs is at least partly dependent upon modern shipping fleets, especially large bulk carriers, and is clearly related to the fact that large quantities of raw materials are normally available for domestic industrialization programmes in addition to the tonnages exported to advanced countries. The considerable industrial possibilities introduced in this context by the era of the giant oil and ore carriers have not escaped the attention of LDC governments. They pose the question: the revolution in bulk maritime transport has created MIDAs in advanced countries; why should a similar effect not be produced in the less-developed world?

The appearance of a new type of coastal industrial zone may, in fact, already be observed here and there; most are very different from those discussed above in that they occur within an initial, elementary phase of industrialization rather than within a framework of advanced technology. In Tunisia, the maritime industrial area at Gabes, based upon the Gafsa phosphate workings, is a useful example. Two chemical companies are involved: the Societe des Industries Maghrebines d'Engrais and the Societe des Engrais Phosphates et Azotes. The production of phosphoric acid totalled 365,000 tonnes in 1978 and was expected to reach 550,000 tonnes in 1981; the Societe Gabes Chimie transport firm was established to provide a fleet of five specialized carriers to convey phosphate exports to the Far East, India and Brazil. The phosphate-exporting ports of Morocco are tending to develop along similar lines, as chemical industries are expanded with a special emphasis on the production of sulphuric acid. Other examples include the integrated development of mineral resources at Ciudad Bolivar (Venezuela) and associated maritime industrial activity at Puerto Ordaz on the lower Orinoco river; the petrochemical industry in Iran, Saudi Arabia and elsewhere on the shores of the Arabian Gulf; and a variety of projects in "new" countries such as Australia which have already achieved a high level of technological development (Vigarie, 1981).

A new, distinctive type of maritime industrial area has thus emerged: frequently unifunctional, and normally characterized by a simplified range of industries in comparison with counterparts in Western Europe or Japan. MIDAs in this newer category are smaller in size, area and throughput, but the factors and processes involved in industrial location and development remain the same: a coastal situation; dependence on low-cost maritime transport by very large bulk carriers; and reliance upon a similar range of basic heavy industry--principally iron and steel, heavy chemical and petrochemical industries, and aluminium production.

Comparing this kind of MIDA with the previous two, the MIDAs in LDCs are often treated as a part of national development strategies aimed either at developing import-substitute, export-orientated manufacturing industries, or raising resource value by the manufacturing of key raw materials at home. The first two kinds of MIDAs, in marked distinction, rely on imported raw materials. However, the difference between the first kind and the second kind of MIDAs lies more in industrial diversity: to be sure, the second generation espouse heavy industries but the enthusiasm for these is much less pronounced than was the case with the first generation.

3.1.2 Ports as hosts of iron and steel industrial complexes

Although there are some differences among these three kinds of MIDAs, the common point which determines the existence of MIDAs, whether they are of the first, second or the third kind, is reliance on the linkage of port and the related industries.

Links between industries and ports may be analyzed in terms of the causal factors involved. The intensity of port-industry links varies considerably both within and between defined categories of economic activities, and also over time. It is important also to take account of technical integration which leads to linkages between industries generated by the port and the derived industries. The spatial association that goes hand in hand with this integration is another variable factor. In the context of general causality, an initial group of industries may be cited that is linked on the one hand with infrastructures and on the other hand with port functions distinct from the carriage of goods by sea. The most obvious group is that concerned with ship construction and repairing. A second major category of industries of predominant importance consists of enterprises directly associated with the transport of goods by sea, together with technologically-dependent industries. The metallurgical industries are key to this group, with iron and steel being the most important undertaking within it (Verlague, 1981, p.71). As Chapter 2 made clear, an intermediate location for the iron and steel industry seems to be the most desirable outcome. The use of water transport for ore is not only the cheapest but also the most flexible mode. A works may have been established on a navigable inland waterway or on the coast usually for the purpose of taking ore from a specific source, but it can easily turn to other sources should that option arise. At the coast, furthermore, the ore has to be unloaded and stockpiled along the quays; erecting the furnace directly behind them will save at least one step in the handling of the ore.

Developed countries exhibit heavy reliance on ore imported from overseas. Ore, crude oil and other raw materials, of course, are bulk cargoes. Because bulk cargoes consist typically of raw materials requiring further processing, and arrive in shipments far too large (up to half a million tonnes at a time) to be transferred directly to land transportation modes, such as freight wagons or trucks, it usually makes sense to terminate their journey in the port area, dumping the vast consignments of oil or minerals into large-capacity storage vessels near the waterfront. The bulk materials can then be retrieved from storage at convenient times in a manageable flow, either to be hauled inland in smaller installments by barge or train, or (increasingly) to be refined or treated by giant processing industries conveniently located on the spot, in the port area. In integrating the industrial complexes into the ports, the advantages accruing to firms and port authorities alike can be taken into account, besides saving on transhipment cost. Therefore, a highly sophisticated kind of MIDA, the port-industrial complex, is formed. In a nutshell, this is why iron and steel complexes, heavily reliant on imported raw materials, are best situated in seaports. I shall illustrate this point with a few actual cases.

3.2 Empirical examples

As pointed out above, MIDAs first evolved in developed countries, but spread fairly rapidly to LDCs. In this dissemination process they assumed new form. By no means are they confined to the iron and steel industry, but their attendant industry can include heavy industries relying on imported oil and raw materials, including the petrochemical industry, to say nothing of related light industries. Nevertheless, the cases emphasized here will be centred on metallurgical complexes by virtue of the focus of the thesis.

3.2.1 Overview

Italy and the Netherlands were the pioneers in establishing iron and steel industrial complexes as adjuncts to the ports. Taranto was from the outset a planned development, linked to a decision by the Italian government in 1959 to set up the fourth national iron and steel complex there. The Consorzio per i'Area di Sciluppo Industriale di Taranto, created in 1960, requested the Tekne company of Milan to draw up a master plan. This led to the creation, on a little less than 1000 ha, of a heavy industry zone including, in addition to the iron and steel plant set upon 608 ha (Italsider, 1961), a cement works on 31 ha, a brick factory (SANAC) and a Shell oil refinery on 196 ha (1967). Interior zones for lighter industries were also planned. Pipelines and jetties were installed within and outside the natural harbour of Mare Grande, and they give access to 300,000-dwt bulk carriers and 230,000 dwt crude-oil tankers. However, during the 1960s, the French iron and steel complexes constructed in Fos and Dunkerque grew to overshadow the Taranto predecessor.

Japan is specially worth examination at the aggregate level. After 1960, seaports were catapulted into prominence by Japanese planners. As a means of spreading "growth impulses" port-centred industrial complexes were designed as "growth-poles" to produce a more "balanced" regional development (Fig.3.3). These

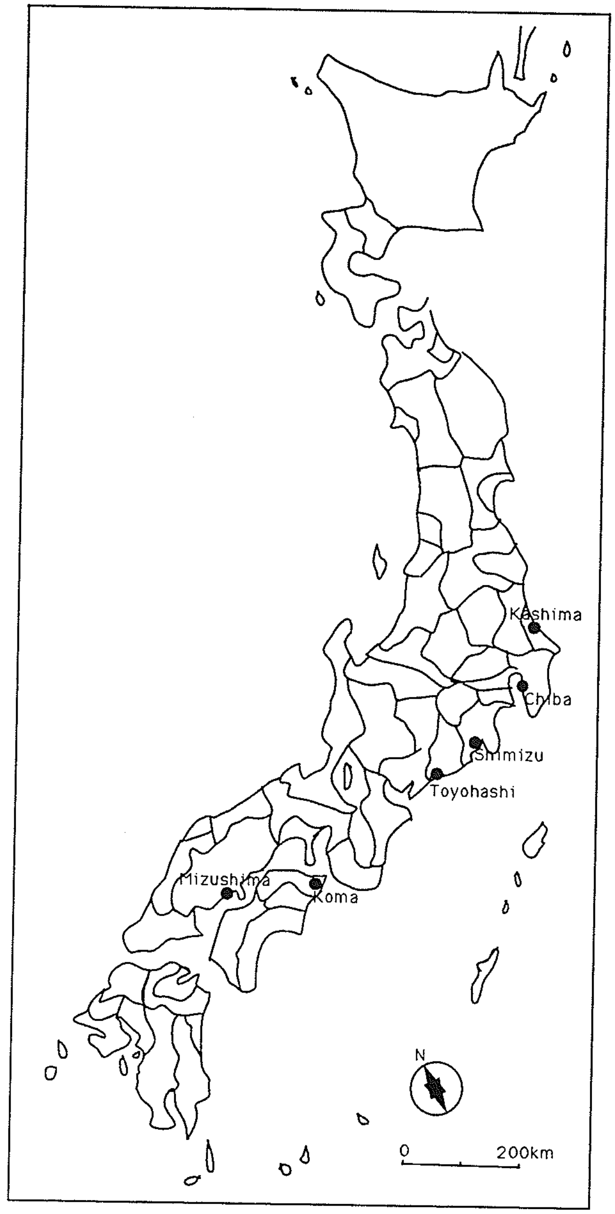

Fig.3.3, Japanese port "growth poles" after 1960.
Data sources: Rimmer, 1984 and Murata, 1980.

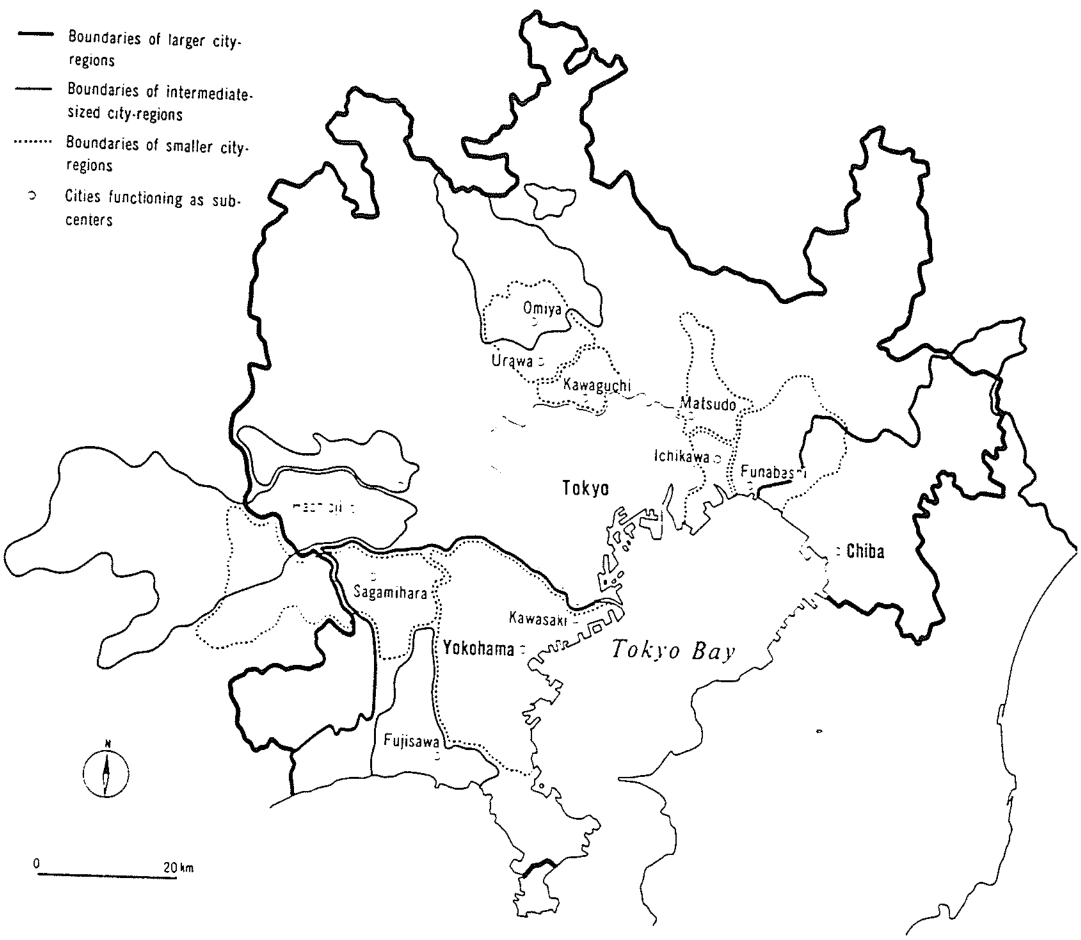

Fig.3.4, Tokyo Bay area.
Source: Murata, 1980, p349.

developments were paralleled by the construction of infrastructure connecting these nodes; namely, trunk railways and high-speed superhighways. Mizushima combined in one location the oil-refineries, thermal power plants, iron and steel plants, and petrochemical plants of the big corporations and business groups. Nevertheless, much of the growth in port activity at these first MIDAs was entirely incumbent on the effectiveness of land reclamation. Both Tokyo Bay and Ise Bay attracted large refineries and, in turn, heavy industry (steel, shipbuilding, and chemicals) to reclaimed land, whereas Osaka Bay remained handicapped by a shortage of industrial land. In 1960 port activity was focused on a belt stretching from Tokyo to North Kyushu. In particular, there was a marked concentration of activity centred on Tokyo-Yokohama (Figure 3.4), Nagoya, Osaka-Kobe and, to a lesser extent, on Shimizu and a string of Inland Sea ports (Rimmer, 1984).

As earth was brought in to fill low-lying coastal areas towards Yokohama in the one direction and Chiba in the other, the Tokyo-Yokohama channels were dredged to take ocean-going vessels. The most remarkable example of industrial expansion on reclaimed land occurred with the construction of a new plant by Nippon Kokan in order to continue competing with Japan Steel and Kawasaki after their move into the Tokyo-Chiba area. This occupied the Kashima industrial estate where 2682 ha of sandy area were developed. Kashima, in Ibaraki Prefecture, has been designed as a Special Region for the Organization of Industry. A large, man-made harbour was excavated in a sandy area on the coast in the 1960s in order to support the newly-developed industrial region. With readily available vacant land for factory sites, and an abundance of water from the Tone River and Lake Kitaura, a number of heavy industry and chemical plants were erected, together with the thermal-electric capacity. The objectives of this development project were to provide local economic growth and to avoid industrial congestion in the Tokyo-Yokohama Region (Noh and Kimura, 1983). The estate has grown around harbour facilities. Sumitomo Metal Industries moved to Kashima from Osaka. On the shores surrounding Tokyo Bay stand gigantic iron and steel factories, oil refineries, shipyards and petrochemical plants. The first large-scale heavy and chemical industries to locate in the marine sector of Tokyo-Yokohama area were those of Nippon Steel. During the rapid economic growth of the 1960s, reclamation on a large scale was commenced of the Chiba shore areas. Over a period of about 15 years, 9,000 ha of land were reclaimed and some 1,300 factories were located there. These included two integrated steel plants, six power stations and 16 petrochemical plants. The port of Yokohama recently surpassed Kobe in both exports and in imports. Yokohama is, therefore, the primary maritime gateway to Japan. After World War II, steel exports and petroleum imports increased dramatically, and Yokohama was connected with the ports of Tokyo and Kawasaki through the Keihin canal.

In the Nagoya area, 9,898 ha have been set aside for the use of industrial estates. Nearly 9,000 ha are occupied by four large coastal estates: (1) the West Nagoya Port Industrial Estate (2) the

South Nagoya Industrial Estate, (3) the Kinaura Industrial Estate and (4) the East Mikawa Industrial Estate. In the second area, Ishikawajima-Harima Heavy Industries and Daido Steel provided the initial base from which the complex grew (Fig.3.5). The complex also boasts a large industrial port. The port of Kobe was developed during the latter part of the Edo period, shortly before the Meiji Restoration (1868), and rose to prominence shortly thereafter. It has in the past been Japan's principal port, but today Kobe ranks second in importance, after the port of Yokohama. The port is equipped with modern facilities, and it was the key element in the growth and development of the industrial zone in Hanshin. Principal imports consist of iron ore and grain, while exports include steel, machines and textile products.

Compared with the Tokyo-Yokohama and Osaka-Kobe areas, the Nagoya-Toyata area is still young from the industrial point of view. During the 1960s, Toyota Motors concentrated a large number of related industries in Toyota Shi, and the integrated mill of Nippon Steel, located in Tokai Shi, has as one of its major aims the providing of steel materials to Toyota Motors (Fig.3.6) (Murata, 1980).

Generally speaking, the iron and steel industry after the War was developed around the construction of highly-advanced blast furnaces. New plants were constructed in the coastal areas of the Keihin and Hanshin regions. The Kawasaki Steel Corporation constructed its pig iron and steel plant in Keihin while Sumitomo Metal Industries and Kobe Steel built their equivalent plants in

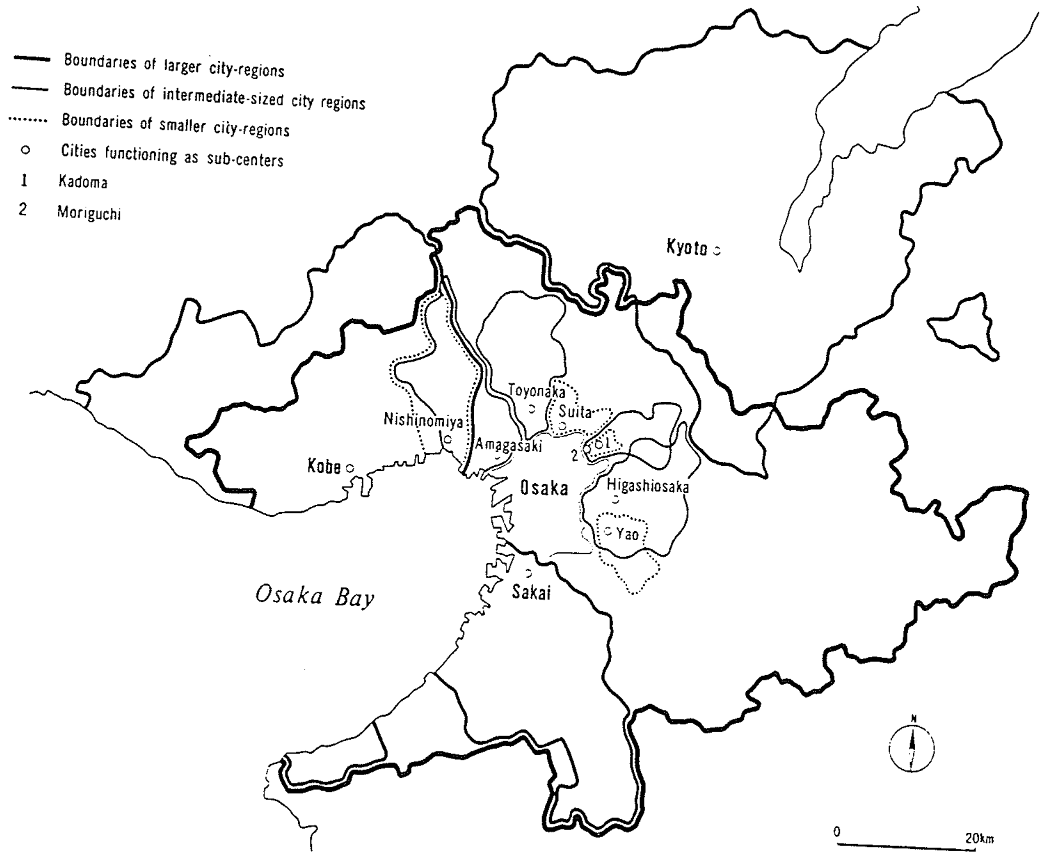

Fig.3.5, Osaka Bay area.
Source: Murata, 1980, p350.

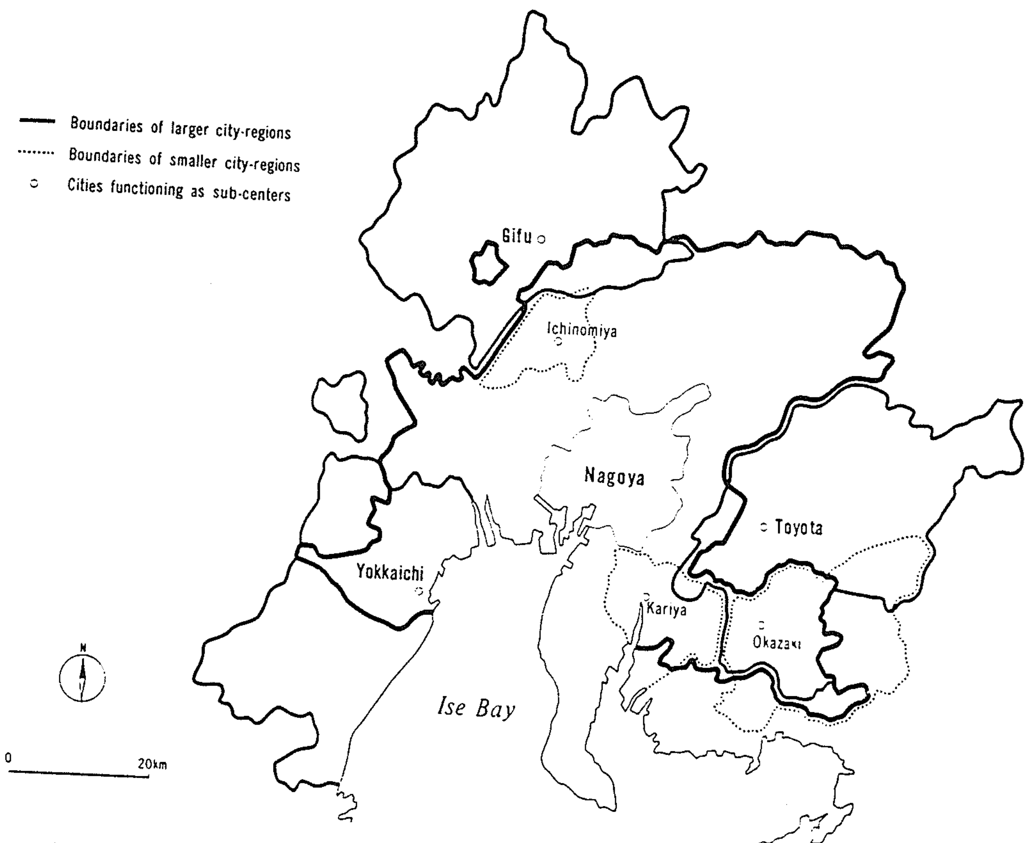

Fig.3.6, Ise Bay area.
Source: Murata, 1980, p351.

Hanshin region, and had all completed construction by the early 1960s. The development of the heavy and chemical industries followed suit, forming industrial complexes in which iron and steel, chemical, electric power, oil and other industries were technically linked. Massive expansion in the scale of production in the iron and steel industry required a vast area of land and a huge investment in port facilities. The resultant industrial and port activities are heavily concentrated in the three aforementioned metropolitan areas (Yamamoto and Murakami, 1980).

In the Persian Gulf region, shipping transportation is characteristic of the oil-led economy, and trade grants the seaports an important role. In turn, the construction of seaport facilities receives special attention by the Gulf states. Fig.3.7 shows the major seaports of the region. Many have the trappings of industrial ports. The ports in question, completed since 1970, include Khor Al Zubair (steel), Basra (petrochemicals), Bandar Khomeini (petrochemicals), Shuaiba (petrochemicals, fertilizers), Dammam (fertilizers), Jubail (petrochemicals, fertilizers, aluminium, steel, hydrocarbon-based industries), Yanbu (petrochemicals, hydrocarbon-based industries), Jebel Ali (aluminium, cables, steel, cement, hydrocarbon-based industries), Dubai (shiprepair and dry dock) and so on (Walker, 1984). While devoid of the maturity characteristic of Japanese MIDAs, these Arab and Iranian provisional MIDAs promise to unlock the door to extensive industrialization in their host states.

While this overview has touched on the features of various

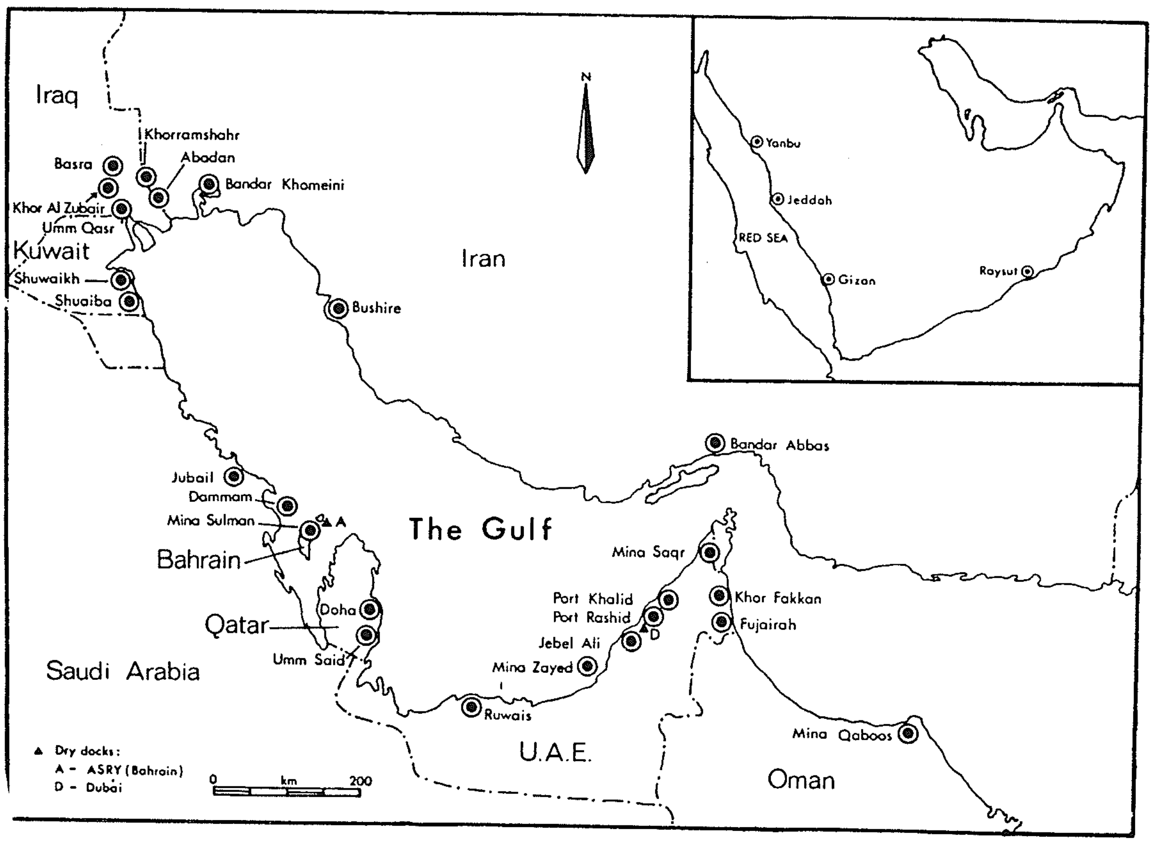

Fig.3.7, Major seaports of the Gulf states.
Source: Walker, 1984, p181.

industrials ports around the world, it is necessary to delve into greater detail into certain cases. To begin with, I shall focus on the French situation.

3.2.2 Iron and steel complex and port facilities in Fos

1, Overview

Fos is a major MIDA. A plan for the port-industrial zone was approved by the French government in 1967, and the development covers 7,290 ha of the Crau plain with firm resistant river gravels close to the surface. The area was planned around three large open docks, two of which are 4,500 m long and 650 m wide, together providing 900 ha of sheltered water. Over 1090 ha are devoted to the communications network and miscellaneous services, and 5300 ha dedicated to industrial development. The port facilities can handle bulk carriers of 140,000 dwt and crude oil tankers of 400,000 dwt. The major industrial establishments developed belong to the iron and steel industry on the one hand and the oil refining and petrochemical industry on the other. The Fos MIDA has been developed and is managed by the Marseilles port authority (Verlaque, 1981).

2, Construction Process

In 1961, the Marseille Chamber of Commerce and the port's management adopted the proposal for a combined port and industrial zone. In the following years, the central government approved this proposal and the acquisition of the necessary land reserves was accomplished. During the early the 1960s, a series of studies was conducted and the construction of the port began in 1965. Two years later government approval was given to the development plan for the complex. In 1968 the port became operational, although work on the industrial estate did not begin until 1971 and was linked primarily to the decision to build the new steelworks. Over the next four years the main phase of industrialisation occurred as Fos became the site of one of the largest civil engineering undertakings in Western Europe, employing at its peak (1973-4) over 17,000 construction workers. Since then only limited expansion of both the port and the industrial estate has occurred.

3, The Port and Port Activities

Since the port was opened, new facilities have been provided to handle a wide range of traffic. The first installations completed were the oil jetties (Fig.3.8), which are now able to accommodate vessels of up to 400,000 dwt. From here crude oil is supplied to local refineries at Fos and around the Etang de Berre, or fed into the South European Pipeline; although a small amount is re-exported to other refining centres. The port also offers a further series of specialist berths and handling equipment, either directly serving industries located on the industrial estate or available for

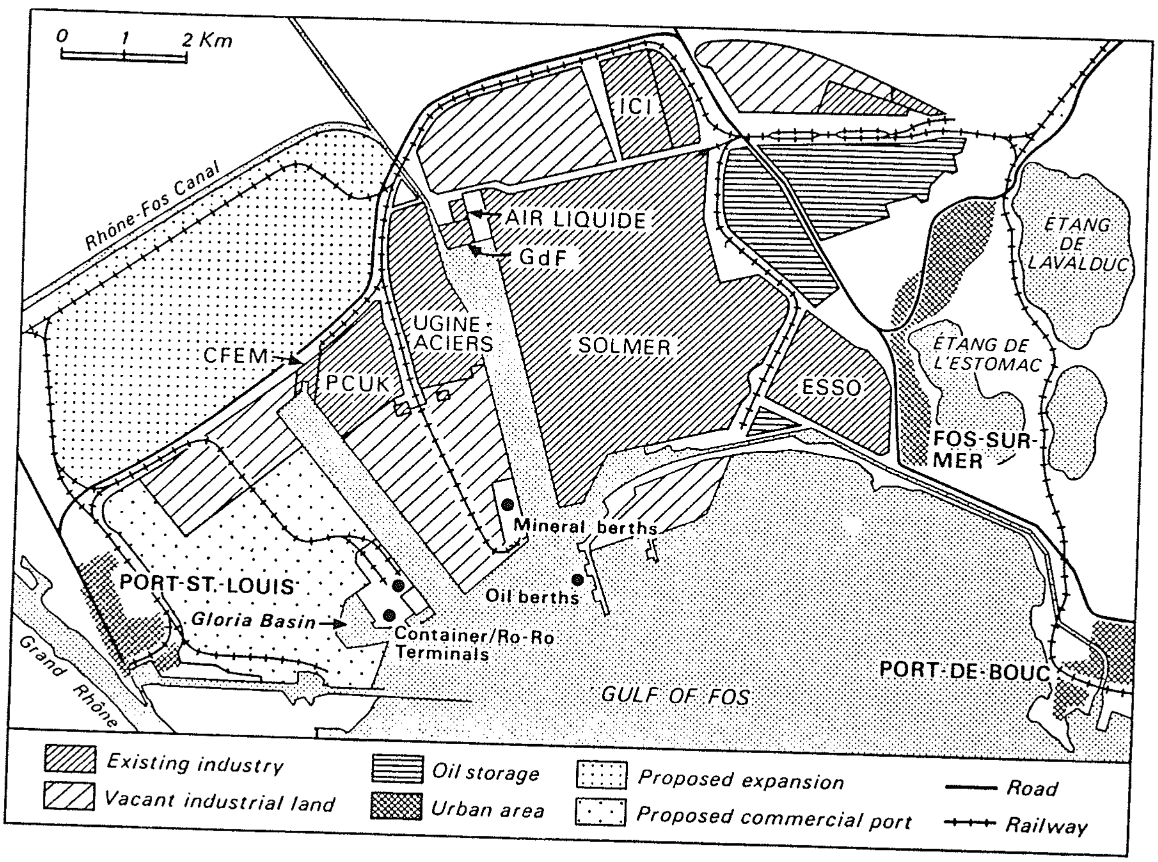

Fig.3.8, The port and industrial zone of Fos.
Source: Tuppen, 1984, p307.

general use. Investment is continuing. In the field of general cargo, for example, a substantial increase in capacity occurred with the opening, in 1980, of the first stage of the commercial port (Gloria dock); it currently handles products such as timber and cars, the latter principally for export. For the reception of bulk cargoes, the capacity of the ore terminal is being increased, principally for the import of coal. In this way the port is seeking to benefit from the greater priority accorded to coal in French energy policy which, on account of the lower cost of coal, is encouraging the conversion of certain major users (especially power stations and cement manufacturers) in south-eastern France away from oil to this fuel. The terminal is now able to accept bulk carriers of 140,000 dwt; it is anticipated that this facility will increase the port's function as a redistribution centre for other Mediterranean countries (notably Italy) unable to receive such vessels.

Once operational, the port rapidly became the main harbour area of the Port of Marseille Authority, reflecting the vital role played by oil traffic. In 1981 Fos handled over 77 million tonnes of cargo, 83 per cent of which was represented by oil products (principally the import of crude oil); this total accounted for four-fifths of Marseille's overall traffic (Table 3.1). Despite the importance of oil, the adverse effects of the recession upon industrial output, coupled with revised energy policies in France and neighbouring countries, have produced a reduction in the port's imports and exports of hydrocarbons, especially since 1979 (Table

3.2). Conversely, for bulk and general cargo the underlying tendency for the port as a whole has been towards an increase in traffic, despite signs of a reversal of this trend in the early 1980s. The throughput of containers, for example, rose from 115,000 TEU in 1976 to 366,000 TEU in 1982. The installations at Fos have played a key role in catering for both these forms of traffic, handling the greater part of the Marselle's bulk trade (notably the imports of coal, iron ore and bauxite) and approximately half of its container movements.

Table 3.1 Traffic of the port of Marseille, 1981 (million tonnes)

Harbour area	General cargo	Bulk	Crude oil and petroleum products	Total
Marseille	6.3	1.1	--	7.4
Lavera-Caronte-Etange de Berre	--	1.8	9.8	11.6
Fos	3.3	9.9	64.2	77.4
Port St Louis-de-Rhone	0.4	0.2	--	0.6
Overall	10.0	13.0	74.0	97.0

Source: Tuppen, 1984, p.310.

Table 3.2. Port of Marseille: evolution of traffic, 1973-82 (million tonnes)

	Bulk	General cargo	Oil and oil products
1973	4.4	5.5	90.6
1975	8.6	5.8	81.4
1977	11.0	7.7	78.8
1979	12.3	8.0	89.2
1981	13.0	10.0	74.0
1982	13.8	9.9	67.8

Source: Tuppen, 1984, p311.

4, Iron and Steel Industry and the Industrial Estate

The industrial estate contains iron and steel activity, oil-refining, and chemicals and petrochemical industry. As far as the iron and steel industry is concerned, although construction of the Solmer integrated steelworks (Fig.3.8) was considered crucial to the whole operation, for some time the plant's future was uncertain.

Initially, the vagaries of the world steel market delayed the decision to proceed; subsequently the financial difficulties of the then-parent group, the Lorraine-based firm of Wendel-Sidelor, threatened the project's realisation. Nevertheless, the factory was built and production commenced in 1973. Capacity stands at 4 million tonnes of steel per annum and output in 1981 totalled just over 3 million tonnes. Adjacent to Solmer lies a special-steels plant, Ugine Aciers, with a current annual output of around 250,000 tonnes. Strangely, in the light of industrial complex thinking, there are no production linkages between the two factories, although in 1982 Sacilor, joint owners of Solmer, took control of Ugine Aciers. Within the metals sector, these two major plants are complemented by the much smaller works of Compagnie Francaise d'Entrepries Metalliques, which specialises in the manufacture of structural elements in steel such as offshore platforms and bridge sections. In addition, the Esso oil refinery was the first industrial plant built at Fos, entering service in 1965 with a relatively modest capacity of 3 million tonnes. In 1973 this was raised to 8 million tonnes, but, lacking a steam cracking unit, the refinery has not given birth to a related petrochemical industry. The extant chemical industry had derived from pre-existing plants located in the region of the Etang de Berre, principally at Berre and Lavera. At Fos, chemical and related industries are centred around the factories of ICI, PCUK, Air Liquide and Gaz de France. The two latter plants, specialising in the production of gases, are of only modest size, although they are connected by a number of technical linkages. Gaz de France converts imported liquefied methane back into natural gas, while Air Liquide produces oxygen and nitrogen for supply mainly to neighbouring firms. ICI's factory was one of the first to be opened on the new estate in 1972. It manufactures polyethylene (with a current annual production capacity of 100,000 tonnes), receiving the main raw material, ethylene, by pipeline from the Naphtachimie plant at Lavera. The installations of PCUK are of more recent origin. In 1976, a chorine and soda plant was inaugurated, designed principally to supply the group's factories at Port-de-Bouc and l'Estaque, and the aluminium industry within the region. Then in 1977 agreement was reached with Shell Chimie (located at Berre) to undertake jointly an investment programme of more than 3.5 billion francs based on the Fos and Berre sites. At Fos a monovinylchloride plant was constructed (which opened in 1981), supplied with chlorine from the existing factory and with ethylene from Berre. In turn, part of the monovinylcholride output is returned to Berre for transformation into polyvinylchloride (PVC). These recent investments, together with the region's existing petrochemical industry, make Fos-Etang de Berre one of the principal concentrations of the chemical industry in France, specialising in the manufacture of base products for the plastics, rubber, and solvents industries.

By 1982, over 9,650 people were employed in the port-industrial complex. Most of this total was accounted for by the two steel companies of Solmer and Ugine Aciers, offering together more than 6,100 employment opportunities. These figures far outnumber the workers employed in the new estate. It is also estimated that up to 13,000 permanent jobs have been generated in the area around Fos by the development of the industrial zone. These have resulted principally from the creation of a variety of firms supplying or serving the main industries or from the general expansion of household and business services induced by the substantial increase in population and economic activity. The town of Fos has been radically transformed as an employment centre by these different growth forces. Over the intercensal period 1968-75, during which expansion was most pronounced, the commune's resident active work-force almost tripled from 1039 to 2911.

The growth of Fos as an important manufacturing centre is apparent in fields other than the generation of employment. Viewed in relation to output, for example, in 1982 the Solmer works produced 14 per cent of all steel manufactured in France. In the petrochemical sector the region of Fos-Etang de Berre now accounts for over one-third of French production, although the contribution to this total made by plants actually at Fos is, admittedly, relatively small.

There are also certain qualitative features which distinguish the factories located in the port-industrial zone. Their recent creation and use of advanced manufacturing techniques ensure a high level of efficiency, while considerable emphasis in the design of plants has also been placed on minimizing pollution. Thus, from one viewpoint the industrialisation of the port might appear to have been relatively successful, not least on account of the creation of a substantial number of jobs. It is when the extent of industrial development and the level of new employment are viewed in the context of the predicted scale of expansion, however, that progress begins to look less impressive. Few of the original plants at Fos have been enlarged beyond their initial capacity, while, with the exception of the Vinylfos factory, there has been no new major industrial development since the early 1970s.

The experience of Solmer offers a prime illustration of a situation where ambitions have not been fulfilled. When first built it was planned to double the plant's original capacity, implying a considerable increase in employment by the end of the 1970s. This never happened, partly, because of the depressed market for steel and intense competition between European steelmakers. However, given this latter situation a case might also be argued for focusing a greater proportion of output on a highly-efficient plant such as that at Fos, thereby increasing its capacity. With a shrinking market, this would be at the expense of older, less-productive works, which would adversely affect traditional steelmaking districts in regions such as Lorraine, already severely hit by the crisis in the industry. Thus, in contrast to the pull of market forces, there is a strong social and political justification for not expanding the site at Fos, suggesting a reappraisal of the government's regional planning priorities since the early 1970s (Tuppen, 1984, pp.303-313).

3.2.3 The industrial complex in Dunkerque

1, Overview

Dunkerque is the major port for the old industrial hinterland of North-East France to which it is linked by waterway. This hinterland, once confined to a coalfield, has been suffering from the decline of old industries and falling employment in mining (Takel, 1974). During the nineteenth century Dunkerque developed principally as a commercial port serving this region during its rapid growth phase. However, Dunkerque's role as a deep-water port and important centre of heavy industry is a recent phenomenon, linked to fundamental changes which have occurred since the early 1960s. Prior to this period, the industrial base was of only modest dimensions, although already strongly linked to the processing of imported raw materials. Major industries which grew up during the first half of the present century were grouped around the manufacture of foodstuffs and drinks (particularly the production and processing of vegetable oil), oil refining and heavy metallurgy, the latter based on the steel plant at Leffrinkouke on the north-eastern outskirts of Dunkerque (Usine des Dunes). The port itself had encouraged the development of various metal-working industries centred upon shipbuilding and ship repair. In the mid-1950s, at a time when the demand for steel plate and steel sheet was rapidly expanding, Usinor announced its decision to build a large integrated works at Dunkerque. But the important and renewed phase of industrialization really set in motion was coming with the opening of the Usinor's new steel mill in 1962. An ambitious plan to develop an industrial complex in conjunction with an new port in an area eventually extending to cover over 8000 ha was launched at the same time as these development were taking shape.

2, The Port and Port Operations

Extensive war damage necessitated the port's reconstruction, but rather than take advantage of this to adapt facilities to changing patterns of maritime traffic, the port was rebuilt largely to its pre-existing form. By the time the work was completed, new cargo-handling techniques, increases in the general size of ocean vessels and the proposals for the new steelworks already indicated the need to modify the port's installations and accessibility. Consequently, parallel with the radical transformation of Dunkerque's industrial structure, the port has been substantially remodelled and extended. During the 1960s the major works corresponded with the requirements of Usinor, involving the construction of a new maritime basin which by 1970 gave the company direct access to bulk ore and coal carriers of 125,000 dwt. The ability to accept vessels of this size also benefited oil major BP, while more recently the basin has serviced the various industries grouped around its western extremity (Fig.3.9). By the end of the decade, however, even these facilities were unsuited to the increasingly larger bulk carriers coming into service and to the needs of extensive storage space and rapid turnround of newer forms of traffic, notably containers. The creation of a new area for expansion was essential, away from the congested existing port zone. These twin objectives gave impetus to a new scheme. The first stage of the scheme was realized in 1975 with the opening of the new Western Port, which now houses the main tanker berths (capable of accepting vessels of up to 300,000 dwt) and is the centre of roll-on/roll-off and container traffic. It is surrounded by the initial phase of the new industrial estate. Inevitably this westward extension is envisaged as a long-term project, but certain doubts surround its eventual realization, in part reflecting the strong competition from rival French and European schemes. One of the more immediate consequences of the new Western Port has been the increased spatial segregation and specialization of activities, with the older commercial Eastern Port now the domain of general cargo and the ship-repair yards.

In 1978, the port handled 35.6 million tonnes of cargo, an amount ranking it as France's third major seaport. The port's traffic is heavily biased towards imports: in 1978 these amounted to 80 per cent of goods handled. Although the overall range of

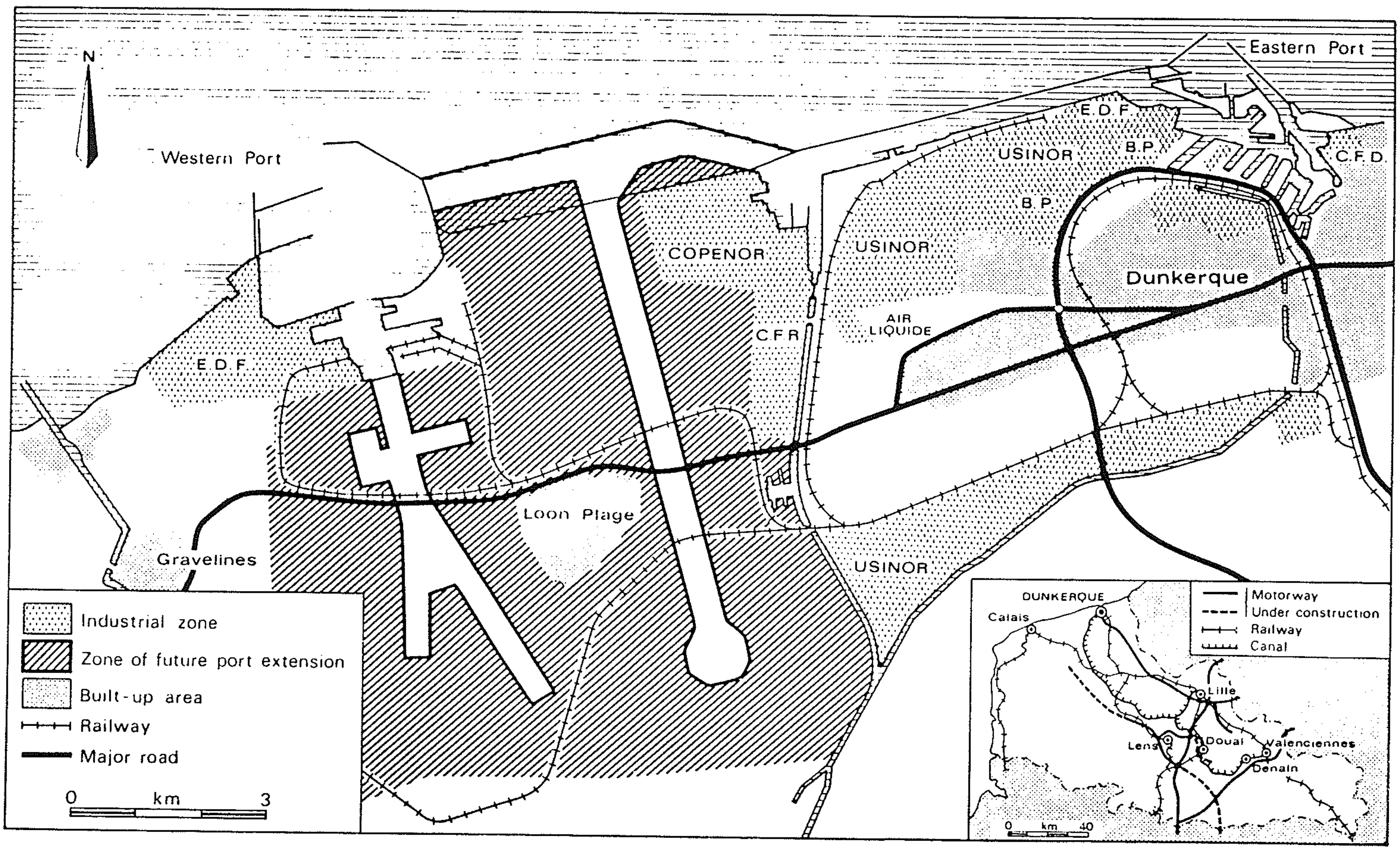

Fig.3.9, Dunkerque: local and regional infrastructure.
Source: Tuppen, 1981, p269.

imported products is wide, most traffic consists of crude oil, iron and coal, together accounting for 90 per cent of imports. Seventy-six per cent of the import traffic is consumed directly within the port's industrial zones. The only large quantities of imports to leave Dunkerque are coal, destined mainly for use in the regional power stations of EDF, and iron ore, which is transported (mostly by rail) partly to Denain and partly to Lorraine and the Saar. Dunkerque's main exports are more varied in character and origin, although refined oil products and metallurgical goods represent 54 per cent of the total. In the former instance, virtually all production originates at Dunkerque; in the latter stance, the sources are more widespread. However, for goods not originating from local factories the greater part arrives not from other areas of Nord-Pas-de-Calais, but form eastern France.

3, The Industrial Complex and Iron and Steel Industry

In contrast to the industrial complexes which grew around Valenciennes, based on coal and steel production, and Marzingarbe, where the impetus for growth came from the coal-based chemical industry, at Dunkerque the scale and rate of past expansion of the Usinor steelworks accounts for much of the driving force in the coastal city's economic expansion. Its owner, Usinor, decided to build a large integrated works at Dunkerque in the mid-1950s when the company's existing plants were already working to capacity. The new Dunkerque plant, at the time, represented a radical departure from the existing location pattern of the French steel industry, strongly concentrated around inland coal-field or ore-field sites, and reflected Usinor's intention to import the bulk of its basic raw materials. Since the inauguration of the first two blast furnaces in 1963, the plant's steel-making capacity has continued to expand. In 1968 a third blast furnace was added, followed a year later by the entry into service of the works' own coke ovens; by 1973 a fourth blast furnace had been built, bringing the annual steel-making capacity to 8 million tonnes and giving Usinor one of the most efficient and highly-automated West European steel plants. In the same year the company also opened a new complex at Mardyck, linked directly to the parent plant, where cold rather than hot rolling mills produce thin wide-strip steel and tin plate. The scale of this development contrasts markedly with the pre-existing pattern of industrialization, particularly in relation to the size of the labour force; the two factories grew to employ over 12,000 workers, a number far in excess of other local employers. Other companies have established metal-working plants since the early 1960s, although of much smaller size. For example, since 1962 Vallourec has manufactured steel pipes and in 1966 Les Constructions Metalliques de Provence (CMP), specializing in heavy boiler-making, opened a factory.

Other industrial expansion has revolved around energy production, oil refining and petrochemicals. In part these activities resemble the steelworks with their capital-intensive character and reliance upon imported raw materials, but they have created fewer jobs. Electricite de France (EDF) has constructed two power stations. The first, a conventionally-fired station able to use either fuel oil or coke-oven gas, opened in 1963 with a capacity of 500 megawatts; the second is based on a nuclear reactor and the first stage (900 megawatts) of an ultimately much larger complex entered commercial service in 1980. Although projected growth in local and regional demands for electricity partly explain the location of this nuclear station at Gravelines (Fig.3.9), the decision reflects much more the ready availability of cooling water and a relatively isolated site. Originally, this station was designed to function using fuel oil, and this partly accounts for the decision of the Compagnie Francaise de Raffinage (CFR) to construct a new refinery at Dunkerque which, when opened in 1974, more than doubled the capacity of the existing BP refinery and brought the port's total capacity to 11.5 million tonnes. Since that date the beginnings of a local petrochemical industry have been grafted on to this base. In 1978 the Copenor steam-cracking plant became operational, with an initial annual capacity of 225,000 tonnes of ethylene and 150,000 tonnes of polyethylene.

As a result of these and earlier industrial developments, Dunkerque has emerged as a leading centre of heavy industry in Nord-Pas-de-Calais. Dunkerque is now heavily dependent upon one group of related metallurgical activities, dominated by iron- and steel-making. Moreover, the nature of the manufacturing process and the form of the finished products suggest the need for external technical linkages. Certain of these links on both the input and output side of the steelworks' operations theoretically draw plants to locate in close proximity to it. In reality, the spatial attraction is less than compelling. On the input side the linkages are relatively weak as most of the major raw materials are imported. Iron ore is supplied exclusively from abroad, as is the bulk of coal for use in the coke ovens. However, energy is furnished by the adjacent refinery and power station; oxygen is also required and this is also supplied from an adjacent factory, Air Liquide. This plant has expanded with the steelworks and, in order to safeguard supply, is linked by pipeline to similar production sites in northern France, Belgium and the Netherlands.

Local downstream links are most diverse, having developed as Usinor became a principal supplier of raw materials to pre-existing industries and attracted its own series of dependent industrial activities. At the most elementary stage of production, liquid pig iron is sent to the steel plant at Leffrinckoucke, now controlled by Creusot-Loire, strongly integrating the two plants despite the difference in their period of conception and the nature of their output. Up to 70 per cent of the metal requirements of the "Dunes" works originates from this source, prior to transformation into a range of specialized products, notably railway wheels and axles. From the later stages of production steel ingots and rolled products are dispatched to several basic processing and metal-working plants. Most of the output consumed locally is taken by Usinor's Mardyck factory for transformation into thinner sheets (627,000 tonnes in 1977). The other major consumer is the adjacent

Vallourec factory (199,000 tonnes in 1977), where steel is transformed into large-diameter steel pipes. (Valloures is a subsidiary of the same parent group which controls Usinor, Denain-Nord Est-Longwy[3]). Various other of the town's industries rely upon Usinor for steel plates, including Chantiers de France-Dunkerque (shipbuilding)[4], CMP (storage tanks and boilers) and the Compagnie Francaise d'Enterprises Metalliques (oil rigs), but their requirements remain small. It is estimated that, apart from the increase of its own labour force, the development of Usinor has led to the creation of around 4500 jobs in related industries, an appreciable total but a relatively modest performance compared with similar port-industrial complexes in Japan (Tuppen, 1981, pp.265-271).

Without doubt, as an increasing proportion of the productive capacity of the region's heavy industries has become established at Dunkerque, and this region has emerged both as an important regional and a national centre of heavy industry. The iron and steel industry and the port-industrial complex have dominated in Dunkerque's development since the mid-1950s. However, it is certain that without the deep-water port Dunkerque's iron and steel industrial complex would have lost its impetus.

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[3] In 1988, Usinor and Sacilor merged to form Usinor-Sacilor; refer to Chapter 2.

[4] This shipbuilder is now closed.

3.2.4 A case from South Africa: Saldanha Bay

Started in June, 1973 and opened in September, 1976, the deep-water iron ore-export port of Saldanha Bay is located 120 km north of Cape Town and forms part of the large-scale urban-industrial development of the Greater Saldanha-Vredenburg area. It was advocated as a development centre in the National Physical Development Plan initiated by the South African Government in 1975. It was to be part of a large mineral export scheme embracing 18 million tonnes of iron ore a year in the first phase and, on the strength of that, the growth pole for the Western Cape region.

The 2.3 km causeway and the ore-loading jetty, the enormous stockpiling area for the iron ore, the quays for the loading of coasters, and the new concentrates quay are the reflections of recent rapid development at Saldanha Bay. With access for bulk carriers of up to 250,000 dwt, Saldanha Bay ranks third amongst South Africa's ports with an annual tonnage handled of about 15 million tonnes (1978) of ore shipped mainly to Japan and north-western Europe. In March 1980, a multi-purpose quay with a loading depth of up to 12 m at LWOST (low water ordinary spring tide) and ore-loading facilities for concentrates of copper and lead (160,000 tonnes a year from the Agenneys area of north-western Cape) was completed in order to augment port use.

In the north-western area of a large natural bay (Fig.3.10), the small town of Saldanha had a flourishing fishing industry and in 1970 a population of 4900. The small regional administrative

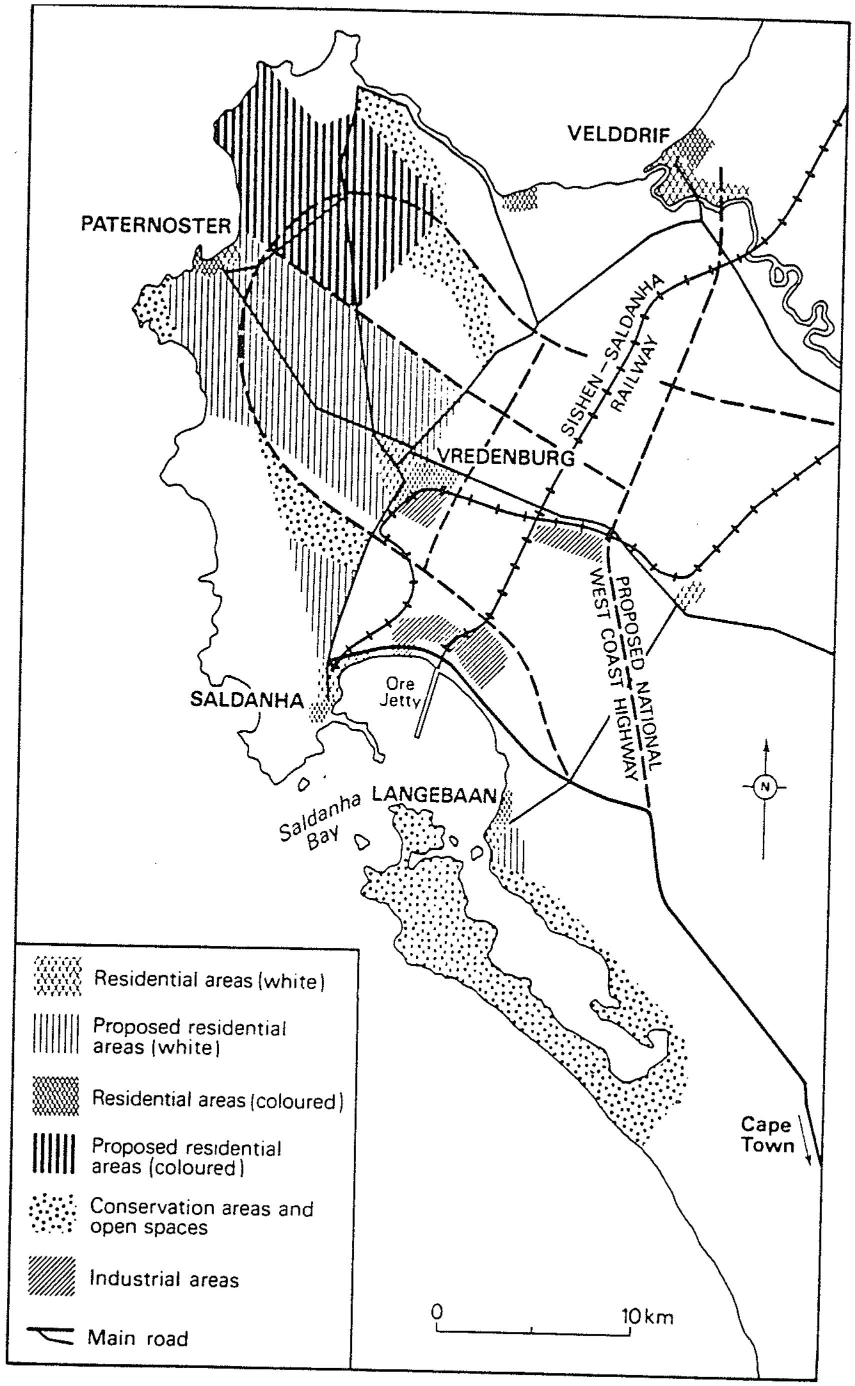

Fig.3.10, The Greater Saldanha-Vredenburg area: development proposal for the planned metropolitan region. Source: Wiese, 1984, p429.

centre of Vredenburg, 12 km north-east of the bay, had a population of 6000 in 1970. In March 1975 a Municipal Board was installed for the towns jointly with an area of 64,000 ha. As a result of the port's impact and related tertiary activity, the new municipality grew to 27,000 inhabitants in 1979. After a peak in 1975, economic and construction activities, as revealed by official approvals for building plans, have slowed down except for certain government investments.

With respect to industrial development linked directly to the port, a 3 million tonnes per annum capacity steelworks was envisaged by the South African Iron and Steel Corporation (ISCOR) during the initial studies of the early 1970s. The Department of Planning thought this fundamental for the industrial development of Saldanha as well as for the more general industrial growth of the southern parts of the country as a whole. As a node for industrial and urban development, Salhanha would have the advantage of its port for import of coal and coke from Transvaal by way of Richards Bay and for export of products, the resources of the Coloured semi-skilled labour force, the attractiveness of the area for a stabilised white labour force, and the possibilities of linkages and co-operation with Cape Town in industrial development, health, and research facilities.

During the planning phase for Saldanha Bay, two dry docks, each with a capacity for 500,000 dwt ships, were proposed and would have had strong links with the steel industry. This proposal found justification both in the large number of big tankers and bulk carriers then using the sea-route around the Cape of Good Hope and by the great distance between existing repair facilities for large vessels in Bahrain[5] and Lisbon.

It is easy to imagine the impact of these developments on employment, infrastructure, urbanisation, and regional planning in the Western Cape and, in particular, in the Greater Saldanha-Vredenburg area. However, with the deterioration of the international and national steel markets after 1974/5 and in response to world-wide recession, long-term plans for Saldanha have had to be shelved, but land has been reserved for further development of industry and transportation infrastructure.

The Department of Planning's 1975 guidelines for the future development of the Greater Saldanha-Vredenburg complex was forthcoming with five phases of growth. These are identified in sequential order below.

(1) The construction of the bulk export harbour and related facilities, an activity completed in 1976.

(2) The doubling of the port's handling capacity and the construction of the steelworks.

(3)-(5) The development of a harbour-related urban-industrial complex with a maximum of 1 million inhabitants. These were to rely on large-scale job opportunities in the port, railways, heavy industry, related light industries, services in the CBD (central business district), and services in the public sector.

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[5] The ASRY dry dock in Bahrain can been identified in Figure 3.7--Major Seaports of the Gulf States.

The Department of Planning's vision must be seen against the social-political background of the Western Cape, which has a rapidly-growing Coloured population and high unemployment rates; as well as against the trends of the National Physical Development Plan, with its provisions for a development axis north of Cape Town and north- north -east of Saldanha, with the Sishen-Saldanha railway line as a possible transportation artery (Wiese, 1984, pp.428-431).

3.2.5 Venezuela's integrated port industrial complex: dominated by the iron and steel industry

Located between Ciudad Bolivar and Puerto Ordaz (site of the port) on the lower Orinoco because of this area's special mineral and energy resource endowment, the considerations triggering the formation of this complex include the followings: (1) modern technology that was related to this region's unique resources, (2) domestic and export demand, (3) economic scale to achieve competitive output and pricing, (4) integration and complementarity with the Venezuelan economy as a whole, and (5) linkages, external economies and transportation factors. The all-weather road along the south bank of the Orinoco between Puerto Ordaz and Ciudad Bolivar continues north to El Tigre. The bridge, completed in 1964 across the Caroni, connects Puerto Ordaz and San Felix, and a highly-efficient rail line links the Orinoco Mining Company's site at Cerro Bolivar to its port at Puerto Ordaz (Soberman, 1969). The overall design of the industrial and power-generating complex is taking shape along the lines originally envisaged in 1962 (see Fig.3.11).

For its part, Fig.3.12 displays the details of this industrial complex around the port of Puerto Ordaz. The complex covers the industrial activities outlined below (Blanco and Ganz, 1969).

Guri Dam. The Guri Dam project is one of the largest hydroelectric facilities in the Western Hemisphere. Designed for 1,750 megawatts of electric power capacity on the completion of the first stage, this project is equipped with 10 generating units. It was specifically designed in order to provide abundant power for the smelting of iron and steel, aluminium, and certain other minerals and chemicals that constitute the core of the industrial complex.

The Orinoco Steel Mill. Owing to generous supplies of favourable mineral resources and energy by courtesy of easy access afforded by ocean transport, the site of Orinoco Steel Mill is potentially the most competitive location in Latin America. This mill was begun in 1956 and completed in 1963.

Enriched iron ore. Because of the resource endowment, the enriched iron ore, prereduced by a gas process to a pellet with 80 per cent iron content, is Venezuela's most competitive export product. Indeed, Venezuela is the only country able to produce and ship pellets of this quality among all the ore suppliers in Latin America, Africa and Australia. The initial capacity of the plant for enriched ore was one million tonnes.

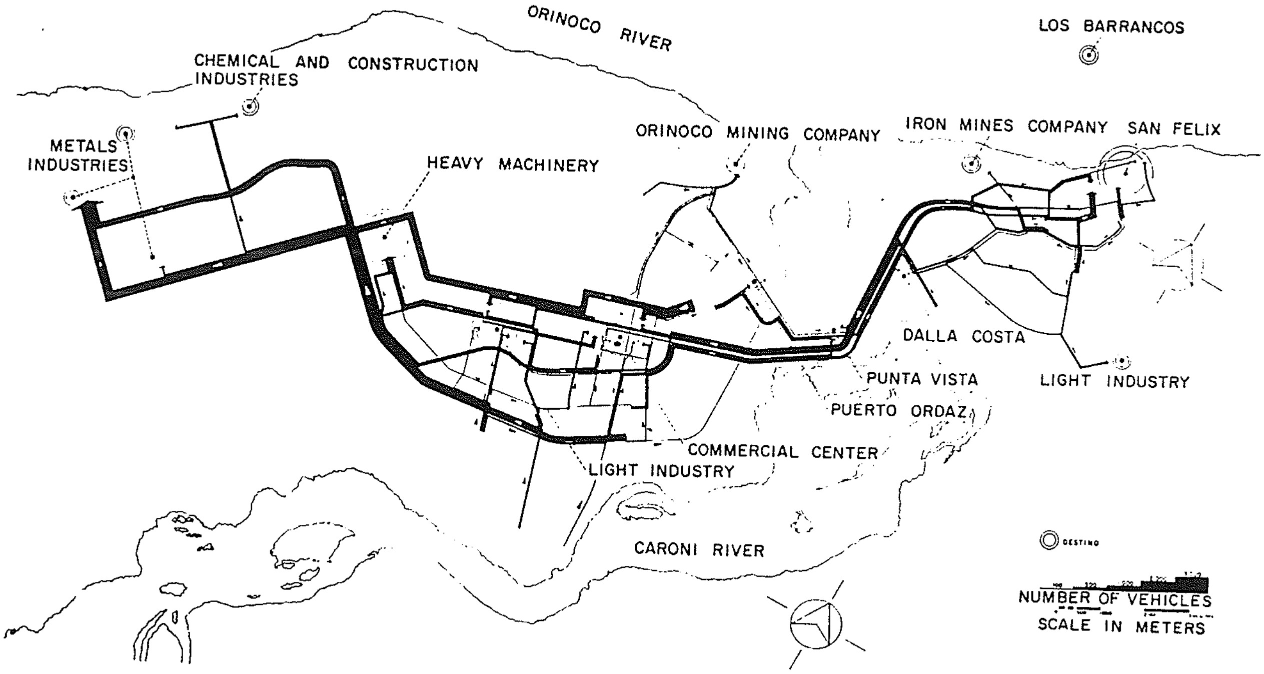

Fig.3.11, Overall layout for Venezuelan complex.
Source: Moltke, 1969, p136.

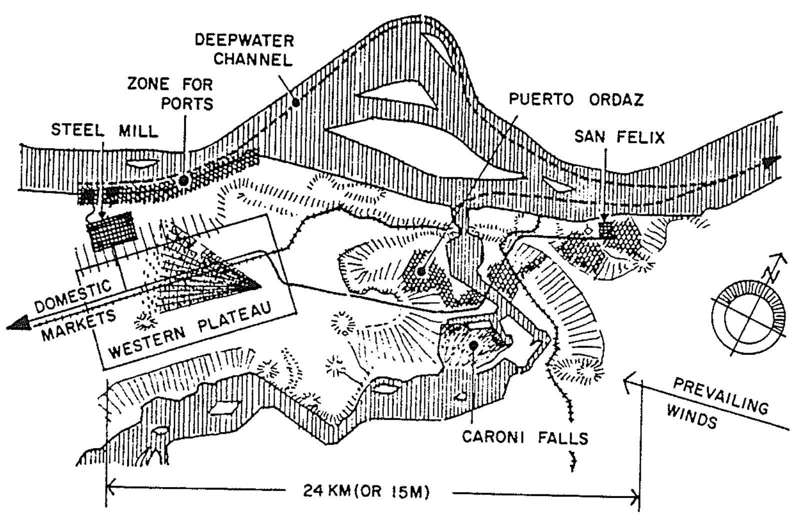

Fig.3.12, Industrial complex around Puerto Ordaz.
Source: Blanco and Ganz, 1969, p193.

Direct reduction of iron ore. With Venezuela's abundance of gas and oil and its dearth of good cookable coal, it can use the natural gas or petroleum to reduce the iron ore directly, bypassing the need for furnaces and coke to produce a product similar to pig iron.

Aluminium. In 1961 Aluminio del Caroni Sociedad Anonima was established with the object of smelting primary aluminium in Ciudad Guayana. In 1966 this plant reached the designed capacity of 10,000 tonnes, which is the lowest economic scale, and soon was expanded to 80,000 tonnes in response to growing domestic demand. Thanks to the fact that the most important single input, electric power, can be supplied at the lowest rate in the world, the product is favoured with a huge export potential.

In addition, there are plants for pulp and paper manufacture and metal fabrication.

Generously funded by Venezuelan oil money in the 1970s, the local Ciudad Guayana government has created an iron and steel complex, massive hydroelectric potential and the first fully-integrated aluminium industry in the Third World with all three stages present--extraction of bauxite, production of alumina and refining of aluminium. A small number of steel and aluminium-using industries have been attracted to the frontier towns of Ciudad Guayana and Ciudad Bolivar. In 1971, Venezuela produced about half a million tonnes of pig iron and one million tonnes of steel. Apart from the iron ore and electric power obtained from local sources, coking coal is imported from the USA (Robert, 1987).

The Ciudad Guayana complex came to be a cornerstone of Venezuela's Fifth Plan (1976-80). The plan was distinguished by the decision to invest most of the huge income reserves of Venezuela, a result of the 1973-74 quadrupling of oil price, in industry and infrastructure. Of a total budget of $30 billion, no less than $23 billion were destined for incremental additions to industry and infrastructure; and one-third of this sum was channelled into the Ciudad Guayana project. After the steel plant, the next largest investment was planned for hydro-electricity. The Guri project, which involves a huge dam, had an initial budget of $4 billion and a planned capacity of 9,000 megawatts by 1985.

It is still too early to judge the industrial success of Ciudad Guayana. This complex has had major technical and financial problems in its start-up phase and has still not significantly increased its steel production level above one million tonnes annually. As a result, imports of steel are still high and there is little locational advantage for steel-users to locate in Ciudad Guayana. One of the major medium-term problems is the lack of electricity as the Guri project has fallen disastrously behind schedule. Furthermore, the Venezuelan government of the 1980s, after witnessing so much government investment in this region in the 1970s, began cutting back on planned investment in related and new activities. Only investment in the large, unfinished projects is being maintained to some degree. With government consolidating and national enterprises prevaricating, it seems probable that Ciudad Guayana will not significantly change or achieve its planned targets (Robert, 1985, pp.115-116).

3.3 Summary

The cases studied fall into the three categories of MIDAs. The cases in France belong to the first and second generation of complexes developed in advanced-industrial countries (AICs), while the cases from South Africa and Venezuela conform to the third generation of MIDAs, typical of less-developed countries (LDCs). This review has revealed that there are pros and cons of each type of MIDA.

In the AICs, the MIDAs are based on imported raw materials and dominated by the heavy industries, such as the iron and steel industry and petrochemicals. The establishment of heavy industry can induce into existence other technically-linked activities. The attraction or creation of industries directly related to or dependent upon the basic core industries, such as a variety of metallurgical plants dependent upon the steel complex, is forthcoming with an employment multiplier. For each job in the core industry, there may be one, two or three positions in related, dependent sectors. Secondly, the marked acceleration of urban growth is equally noticeable. Between 1968 and 1975, the most difficult period in the development of the Fos complex- the initial period of construction, followed by the general recession - the seven towns located around the newly-developed port increased in population by 45,000 or 48 per cent, and that does not include the commuter influx which has also grown rapidly. However, a climate of opinion increasingly unfavourable towards the concentration of heavy industry has emerged, for a variety of seasons: pollution, tensions in the labour market, an excess of heavy industry, the need to develop available open spaces for communal urban facilities rather than for industry; not to mention the increasing cost of land reclamation needed to utilize such areas for high-value, concentrated developments. The development of industries in coastal locations has frequently had, moreover, a deleterious effect upon established inland industrial regions: for example, the migration of industry, especially the more profitable sectors, towards coastal zones has aggravated the effects of recession in the older iron and steel industries of Lorraine.

In the LDCs, the MIDAs are frequently unifunctional, possessing a simplified range of industries. Their reliance on coastal location, cheap maritime transport and a core of heavy industries bears comparison with the factors involved in the process and location of MIDAs in the AICs. The development of MIDAs in the LDCs can add value to the resources and promote industrialization, as demonstrated by the case of Venezuela. South Africa's case, however, shows that an iron and steel industrial complex deemed vital for industrialization can founder in the face of adverse world conditions. In addition, the MIDA can often be used as a mechanism to promote regional development. Saldanha Bay, for instance, is treated as the growth pole for the Western Cape region. These MIDAs of Type Three, however, often present obvious economic and spatial problems. There are risks inherent in overconcentration on a single industrial product and in the existence of a non-integrated zone based on the export of semi-finished products, a zone having no close relationships with the hinterland. More important, perhaps, is the fact that Type Three MIDAs are technically backward with respect to linkages, a reality which severely hampers their ability to spawn other industrial-complex activities.

Blending the advantages of MIDAs in AICs and LDCs, the constituents of an 'ideal' industrial complex can be formulated. First, an intermediate degree of concentration of heavy industries is needed to take advantage of technical induction; that is, the spawning of new activities. For the LDCs, an integrated area is closely involved in the chain-reaction effects of induction. Enhanced industrial activities rely on innovation, and advanced technology to maintain the momentum of induction. In the AICs, in the context of a developing MIDA, secondary and tertiary industrial activities are introduced which contrast in character with those which constitute the basic complex, so that the economic environment and structure becomes self-generating and yields a variety of increasingly diversified industrial activities. Second, both in AICs and LDCs, establishing a MIDA requires careful attention to the demands of the environment. It is claimed that tree belts around industrial zones will help reduce atmospheric pollution. Indeed, the measures to control and prevent pollution have been paramount in MIDA planning since the late 1960s. Thirdly, an industrial maritime complex should act as a regional propulsive centre, in relation to demographical mobility, technical expansion and products delivery, and in the context of the various transport networks to which the MIDA is linked.

The provision of port facilities for the enlarged bulk carriers has in all cases been the first step in attracting growth. Industry requiring these facilities for new plants is always looking for suitable locations. Decisions to site new industrial plants are often announced on the heels of proposals to build bulk carriers. Dry bulk cargoes, such as ore and coal, require vessels up to 100-150,000 dwt, and even over 200,000 dwt.

After reviewing developments in iron and steel industrial complexes and in industrial ports around the world and arriving at an 'ideal' complex, it is possible to address the Chinese case in the light of the theoretical guidelines surrounding complexes and their actual implementation. This grand objective is confronted in the next chapter.

CHAPTER FOUR. THE CHINESE CASE

From the end of World War II to the mid-1970s, rapid economic growth around the world was parallelled with the fast expansion of ironmaking and steelmaking capacity and a great amount of investment was poured into the construction of coastal ports and port industrial complexes. Similar events are now occurring in China; for not only does a rapidly growing economy demand wholesale development of the iron and steel industry, it also imposes great demands on port construction in order to promote Chinese international trade. This chapter will review the development of ports and the iron and steel industry in China and go on to contemplate the prospects for Chinese port industrial complexes, especially those centred on the iron and steel complexes.

4.1 Chinese port development

4.1.1 Introduction to China's port development

In China, the coastline amounts to more than 18,000 km, and there are more than 6,000 islands whose coasts add more than 14,000 additional kilometres. From the mouth of Yalujiang River in the north to the Beilunhe River in the south, the coast is partitioned into four parts; namely, the Bohai Sea, Huanghai Sea, Donghai Sea and Nanhai Sea respectively, all ultimately connecting with the Pacific Ocean. A coastline of this magnitude is rich in natural harbours and not so natural harbours which have been pressed into service as ports. These coastal - as opposed to riverine - ports preoccupy us for the discussion that follows.

The coastal ports can be grouped into three categories: ports located in bays, such as Dalian, Qinhuangdao, Qingdao, Lianyungang, Shijiusuo and Zhanjiang; ports located at the mouth of rivers entering into the sea, such as Tianjin, Shanghai, Ningbo, Fuzhou and Guangzhou; and ports located on islands, such as the clutch found on Hainan Island.

In administrative terms, the Chinese coastal ports are distributed among 11 provinces, municipalities and autonomous regions. In respect of the 56 ports which fall into the large and medium category[1], three are located in Liaoning province, three in Hebei province, one in Tianjin municipality, 11 in Shandong province, one each in Jiangsu province and Shanghai municipality, six in Fujian province, 18 in Guangdong province, two in the Guangxi autonomous region and the final five in Hainan province (Fig.4.1).

Ever since the founding of the People's Republic of China, the state has been improving and expanding existing harbours, and this interest has been intensified in recent years. Some advanced equipment was installed and a series of special deep-water berths

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[1] Currently, in China, the large, medium and small category of ports is demarcated by the annual throughout volume.
Large: over 10 million tonnes.
Medium: 100,000 tonnes to 10 million tonnes.
Small: less than 100,000 tonnes.

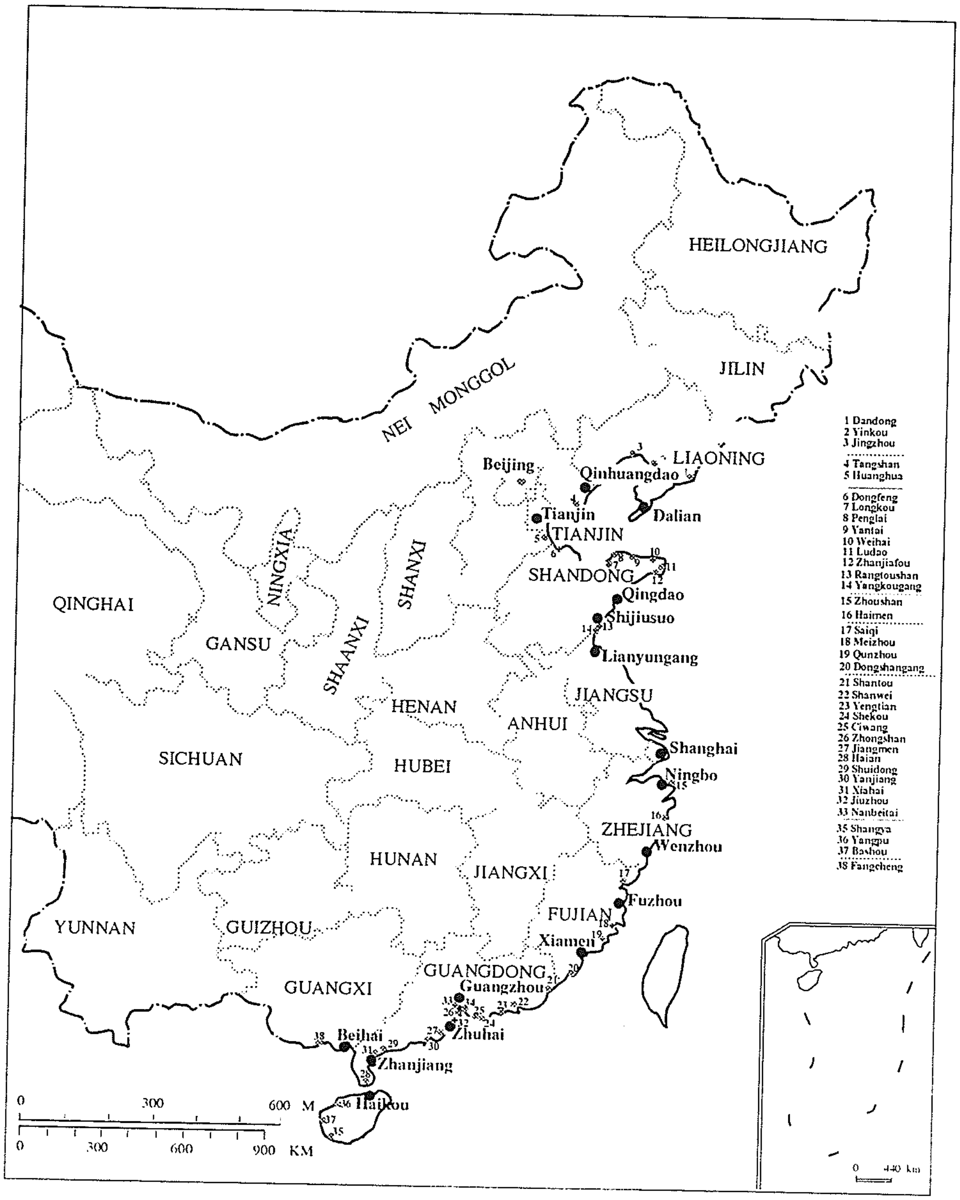

Fig.4.1, Major seaport distribution in China.

was established. For example, coal berths capable of taking ships in the 30,000 to 100,000 tonne class were built together with crude oil berths for ships of from 50,000 to 100,000 tonnes. Mineral ore berths to accommodate 'capesize' vessels of more than 100,000 tonnes were not overlooked, either. In detail, the coal loading berths with large scale were installed in Qinhuangdao, Shijiusuo, Qingdao and Lianyungang ports; and there are crude oil loading berths of large scale in Dalian, Qinhuangdao, Qingdao and Zhanjiang ports.

By the end of 1989, there were 56 ports with throughput volumes of more than 200,000 tonnes, embracing 1,002 operational berths consisting of 261 berths capable of taking vessels of more than 10,000 tonnes. In 1989, the total throughput volume for major coastal ports amounted to 490 million tonnes. There are 10,752 sets of loading and unloading machines; 11.38 million m^2 of warehouses and stacking areas adjoining more than 185 berths; 140 kms of oil transport lines and 650 kms of railways in port areas (Institute of Integrated transportation, 1991). Table 4.1 shows some basic data regarding Chinese principal seaports.

For most of the period since the founding of the PRC, the port sector has been managed solely by the state. Consequently, the state's attitude to port construction directly influenced port development. In fact, port construction followed a very complicated course. This was in direct response to the obstacles that had to be overcome, as the forthcoming discussion will reveal.

Table 4.1, China's major coastal ports (1989)

port	total volume (1,000 tonnes)	operational berths	warehouses and stockyards(m^2)		channel width(m)	depth(m)
Dalian	5091.0	55	331000	693000	300	17.5
Qinhuangdao	6565.1	25	64000	1364000	120	13.5
Tianjin	2436.9	46	197000	1270000	150	11.0
Qingdao	3112.3	35	67000	513000	120	10.5
Shijiusuo	840.5	5		174000	200	15.0
Lianyungang	1125.6	17	46000	275000	100	10.8
Shanghai	14604.4	133	373000	1186000	150	10.0
Ningbo	2209.1	31	72000	363000	700	17.2
Fuzhou	532.0	30	32000	107000	80	5.5
Xiamen	512.6	6	40000	244000	300	8.4
Guangzhou	4703.5	137	301000	656000	160	9.0
Zhanjiang	1609.5	23	134000	383000	400	11.0

Data source: Chen, 1992.

4.1.2 Port construction and its problems

1, Port construction

The history of port construction in the PRC can be divided into three stages, as the following describes.

(1) The period of recovery and improvement which extended from the beginning of the 1950s to the beginning of 1970s. Owing to the international situation, and the policy to focus economic development in the interior area of China, the construction of ports did not receive high priority. The construction of ports which did occur dealt with the improvement of navigation channels, the digging of port basins, the strengthening of protective embankments and the building of connection railways. From 1949 to 1972, the total of newly-built deep-water berths only amounted to 30. By the end of 1972, there were berth lines (frontages) totalling 60,000 m distributed among 286 berths, of which only 92 were of deep-water type. Their total handling capacities were less

than 100 million tonnes.

(2) The first period of enhanced development of ports. Since 1972, with the rapid growth of foreign trade, the attention given to port construction was of a much higher order, and this attention culminated in the reappraisal of government policy in 1978. From 1973 to 1980, 50 berths were established, and the deep-water crude oil berths of 50,000 to 100,000 tonnes capacity were built for the first time in China. Many machines were installed into 150 operational berths, with the upshot that the handling capacities climbed to 100 million tonnes (Wang, 1989).

The share of state investment in port construction rose from the 0.2 per cent of the national capital construction budget in 1962-5 to 0.6 per cent in 1973, before climbing to 1 per cent in the 1974-8 period. Chinese sources pinpointed 1973 as marking the watershed in the history of port development. A series of official announcements was made describing some of the schemes and projects for expanding the capacities of the nine major ports. The pace of berth construction under this national call for expanding port capacities may be gauged from reports of the completion of 41 deep-draught berths in the four years 1973-6, and another 19 completed in the year 1977, against the 30 constructed in the previous period of 23 years (1949-72). In addition, there were more berths constructed or renovated for ships under 10,000 dwt as well as provision of refuelling (bunkering), water supply and telecommunication facilities, and loading and unloading equipment.

Two important features about the port development programmes in this period should be pointed out. First, the greater share of investment in port construction was devoted to bulk shipping and bulk cargo-handling, especially for the oil and coal trades, such as the much-publicised oil terminal at Dalian with berths for 100,000-dwt tankers to ship Daqing oil, the 50,000-dwt and 20,000-dwt class berths for oil and coal at the energy port of Qinhuangdao, the oil terminal at Qingdao with berths for 50,000-dwt tankers, not to mention the berths for 50,000-dwt tankers at Zhanjiang where 70,000-dwt tankers could enter at high tide. The construction of general cargo berths was relatively insignificant, however, except in the port of Shanghai. There, the dredging of channels and the addition of 16 berths of deep draught from 1973 to 1975 were reported as the most important large-scale construction initiatives in the history of the port. Second, self-reliance and an independent approach to solving problems were still much stressed in port development despite the adoption of an 'open-door' policy in foreign trade.

Between 1973 and 1979, port construction programmes added 47 berths of the 10,000-tonne class in the nine major ports. By 1979, total port capacity showed an increase of 66 per cent over that of 1972. However, this still fell far short of the demand placed on port facilities, for the growth in ocean shipping was 107 per cent during the same period, having been brought about by the phenomenal rise in foreign trade. Taking advantage of the slump in the world market for oil following the energy crisis of 1973, China rapidly expanded its tanker fleet, buying surplus vessels from foreign owners. These vessels ranged in size from 20,000 to 96,000 dwt. At the same time, orders were placed for the construction of small but specialised vessels (Chiu and Chu, 1984).

(3) The second great period of port development. Since 1978, the construction of ports was regarded as part and parcel of the country's drive to faster economic development. From 1981 to 1985, the period of the Sixth Five-Year Plan, 54 newly-built berths were put into operation. Among their number were an ore berth of 100,000 tonnes in Ningbo harbour, coal berths of 50,000 and 100,000 tonnes in Qinhuangdao harbour and the container berths installed in Shanghai, Guangzhou and Tianjin harbours. The handling capacity increased by 100 million tonnes during this period (Wang, 1989).

Transport and energy have been singled out as the two weak links in the chain of factors that drive the national economy towards the target of bringing itself in line with the developed countries. Such weak links are held largely responsible for the inability to implement fully the development plans for the other sectors. Transport bottlenecks, collectively, are further identified as the main constraint on the development of energy resources. Under the Sixth Five-Year Plan, the ports were to press ahead with the expansion programmes to make sure that shipment of coal to foreign markets such as Japan would no longer be constrained. In the three-year period 1979-82, the Ministry of Communications, acting in accordance with national construction plans, channelled 50 per cent of state investment for transport development into port construction. Under this scheme to accelerate port development, 11 new berths were completed in three years, adding 6.36 million tonnes to the nation's total cargo-handling capacity at major seaports. Another eight berths were near completion by late 1982. In total, the seaports of China provided at that date 330 berths to handle about 300 vessels at one time, of which 147 conformed to the over 10,000-tonne class. Along the 18,000 km coastline, 145 ports are in active operation but only 20 of them are open to foreign ships. The Ministry of Communications directly administed 13 of these ports while the remaining seven were administered by local authorities before 1984.

China is making a two-pronged attack on the port problem, using imported advanced technology and management methods, including the use of foreign finance, and at the same time relying heavily on Chinese state resources and even resources of individual enterprises. First, China has delved into international financial sources since 1979 to support her projects to build-up rapidly advanced cargo-handling facilities such as specialised container berths and bulk coal and ore terminals. Containerisation has been suggested a means to relieve the pressure on port capacity, since one container berth may achieve throughput equivalent to five or more break-bulk-vessels' berths "even at China's breakneck working rate". The first fully-equipped container berth at Tianjin/Xingang, which began to handle standard containers in mid-1980, went into full operation only by late December of 1982. Another container berth was completed in Shanghai in September, 1979 but it had been using adapted general-cargo cranes for container-handling. Qingdao, Dalian, and Huangpu (Guangzhou) are the other ports that handle containers using conventional berths and equipment. In prospect are three fully-equipped container berths to be completed in Tianjin/Xingang, two in Shanghai, and two in Huangpu. These are part of the project financed by a loan from the World Bank, which also provides funds for investigations into solving the problems of through-transport of containers to and from inland sites. To expand the capacity of bulk-handling of coal, funding is being obtained from Japanese sources to build and equip deep-draught berths at Qingdao, Qinhuangdao, Lianyungang, and Shijiusuo, as well as bulk ore-handling berths at Beilun, which are part of the Baoshan iron and steel complex near Shanghai. On the other side of the two-pronged attack, China is speeding up the construction work at small and medium-sized coastal ports such as Zhanjiang, Shantou, Xiamen and Fuzhou which can feed directly into Hong Kong, where Chinese export cargoes are forwarded to vessels plying transocean routes (Chiu and Chu, 1984, pp.211-212).

With the deepening of economic reform in the country and its further opening to outside contacts, Chinese foreign trade rose dramatically. Yet, the lag between port development and the spurt in foreign trade still heavily impeded potential trade advances. The Chinese government, in consequence, has redoubled its attack on port problems since the mid-1980s. First, it has set about reforming the port administration system. From 1984 to 1988, the jurisdiction of coastal ports was transferred from the Ministry of Communications to the local authorities, specifically, to the municipality hosting the port. The ports in the transfer list include Tianjin, Dalian, Shanghai, Huangpu (Guangzhou), Yantai, Qingdao, Lianyungang, Ningbo, Shantou, Shijiusuo, Yingkou and the ports on Hainan Island. All the chief ports except Qinhuangdao have thus gained considerable autonomy and hope to benefit from the flexibility that such entails. Second, by means of improving the investment environment and issues of preferential policy, more foreign capital is channelled into the ports to speed up construction. Supported by the Second Japanese Loan[2], a berth in Qinhuangdao, container and general cargo berths in Lianyungang and a general cargo berth in Qingdao were completed by 1989. By virtue of the World Bank loan[3], a general cargo berth in Tianjin, and

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[2] The first loan agreement between the Chinese and Japanese governments was signed in 1979. The Japanese loaned China a total of 300 billion yen granted by the Overseas Cooperative Fund of Japan. Repayment is being spread over 30 years at an annual interest rate of 2.5 percent. Using the first loan, China built six projects which were completed and went into operation by the end of 1984. The six projects are: Rizhao/Shijiusuo port in Shandong Province, the expansion of Qinhuangdao port, the dual-track electric railway line between Beijing and Qinhuangdao, the railway engineering project between Yingzhou and Rizhao/Shijiusuo, a 300,000-tonne ethylene project in Daqing and the first-phase project of the Baoshan Iron and Steel Works.
The second loan agreement signed in 1984 granted China a total of 474 billion yen with the same repayment arrangement. With this loan, China was building seven capital engineering projects, including Bingding Dock in Qinhuangdao, Miaoling Dock in Lianyungang, Qianwan in Qingdao, dual-track electric railway lines between Zhengzhou of Henan province and Baoji of Sha'anxi province and Between Hengyang in Hunan and Guangzhou, Tianshengqiao Hydro-electric Power station on the Hongsui River, and upgrading the telephone systems in Shanghai, Tianjin and Guangzhou. All these projects were finished and put into operation by the end of 1988.

[3] China resumed full legal membership of the World Bank on May 1, 1980. Since then, cooperation has constantly developed, with China's borrowing increasing annually. By the end of 1988, the World Bank loaned China a total of US $7.26 billion. Of the total,

another in Guangzhou, and a container berth in Dalian were finished. Funds from another loan made available by the World Bank, meanwhile, rendered possible the second phase of container-berth provision in Ningbo, the second phase of the container terminal in Xiamen, and general berths in Xiamen as well. In 1989, some 68 berths were added to the Chinese port system, of which 27 were deep-water berths. The handling capacity was boosted by 49.13 million tonnes in consequence (Bureau of State Statistics, 1989). While impressive in themselves, these aggregate result hide the obstructions which hinder port expansion in China, as the following section illustrates.

2 Problems in port construction

(1) Unbalanced allocation of ports and the shortage of ports: Despite its extensive coastline, only 15 ports with large and medium-scale capacity are extant in China, the other several hundred ports are decidedly small scale. Moreover, port allocation is geographically unbalanced. For example, Jiangsu province

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US$4.447 billion are hard loans, due to be repaid over 20 years with five years of grace, and the others are soft loans to be repaid over 50 years with 10 years of grace. The money has been put into energy development (13 items, $1.578 billion in amount and 21.7% of total), transport (12 items, $1.721 billion and 23.7 %), industry and agriculture and water conservancy (19 items, $1.484 billion and 20.4%), culture, education and health (11 items and $0.954 billion and 13.1%) with the balance being devoted to environmental protection and sundry other projects.

possesses a single port of 5,000 tonnes-handling capacity along its entire 1,000 - kilometre coastline; perhaps even worse, no port at all is located along the 400 km-long coast of the western part of Liaoning province. Owing to the shortage of even small and medium-sized ports in several places, more than 80 per cent of transported goods is concentrated in a few major ports. This forces roundabout transport routing, exacerbates transfer costs and, on account of perennially congested terminal facilities in the favoured, chief ports, greatly aggravates the time and pecuniary costs associated with shipping goods within and outside China. Symptomatic of the bottlenecks, real and latent, is the fact that all major ports always operate at peak loads.

(2) The shortage of storage capacity: In the old coastal ports surrounded by built-up urban areas, storage land inevitably is very limited. For example, although the throughput of the port of Shanghai has far exceeded 100 million tonnes, it can claim only 4 km^2 of shoreside land for storage purpose. The storage space per berth in coastal ports is less than 120 m^2 which is one-half of the level in advanced industrial countries. Because of the shortage of storage capacity, deadlocked traffic movements are commonplace in the ports.

(3) The poor port equipment and dissemination facilities: Inadequate provision of unloading and loading equipment in coastal berths constitutes another major obstacle to highly-effective port operations. What is more, poor dissemination facilities, such as those stemming from insufficient railways, waterways and highways

linking the ports with their hinterlands, conspire to bestow on the ports diminished total capacities.

For the ports located on bays of the sea, such as Dalian, Qinhuangdao, Qingdao and Lianyungang, the goods are mainly dispersed by land-networks. For example, the goods conveyed by railway account for more than 50 per cent of the total of dispersed goods. Yet, because of limited distribution capacity, the goods often accumulate in the ports and miss vital delivery schedules. These factors in combination have produced a dire outcome; namely, the time for vessels staying in harbour for discharging and loading has grown longer and longer. During the 1950s, port time for vessels averaged about four days; for 1960s it had been lengthened to five days; by the 1970s it was averaging a day longer, but during the 1980s it was surpassing eight days.

4.1.3 The transport flow through ports

1 Foreign trade flows

The principal exports flowing through the ports are coal, crude oil and oil products, altogether accounting for about 60 per cent of the volume of exported goods. Through Qinhuangdao and Lianyungang, coal is shipped to Japan, Hong Kong and the Philippines; through Dalian and Qinhuangdao and Qingdao, crude oil is shipped to Japan, Singapore, the United States, Brazil and the Philippines; through Dalian, Shanghai, Zhanjiang, Tianjin, Qingdao, Ningbo and

Guangzhou, refined oil products are shipped to Japan, Singapore, the United States and Hong Kong (Table 4.2).

Table 4.2, Major Chinese ports and the international trade cargoes leaving them (1989, tonne)

	Coal	Oil products	Crude oil	Mine ore	Steel products	materials for mine construction	timber	non-metal ore	grains	others
Dalian	506370	17426861	14156653	21761	314524	21109	37456	736781	3198372	3655970
Qinhuangdao	10886239	2624153	2555779	202	107136	12406	3815	96928	942932	563114
Tianjin	1727377	244592		61475	514257	93057	13137	981966	563277	3386995
Qingdao		6712109	6530977		70514	67314	36514	559680	144020	1716250
Shijiusuo	879202									29763
Lianyungang	1845275	36288		9573	14955		13262	155839	173602	554099
Shanghai	3163	660403	71	2042	345437	28987	8296	524568	126786	3852219
Ningbo		232817						105268		241594
Fuzhou						116535	3108			447488
Xiamen	11000			2208	2719	238239		162736	82	434694
Guangzhou		178840		34690	64628	8518	7893	513482	180542	1512173
Zhanjiang	17981	721703		27445	123237	12866	139206	1397284	54705	280962

In respect of imported goods, the main items are mineral ore, iron and steel products, grain and lumber, the total of which amounts to 70 per cent of all China's imports by volume. Iron ore is imported from Australia and Brazil to Shanghai, Dalian, Qingdao, Ningbo and Zhanjiang ports; grains are imported from Canada, the United States, Australia, Argentina and Thailand to Shanghai, Dalian, Tianjin, Guangzhou, Qinhuangdao, Xiamen and Zhanjiang ports; lumber cargoes are imported from North America for discharging in Shanghai, Qinhuangdao, Qingdao, Lianyungang, Tianjin and Guangzhou ports; iron and steel is carried from Japan and the United States and landed at Shanghai, Tianjin, Dalian, Guangzhou, Lianyungang and Zhanjiang ports (Table 4.3 and Fig.4.2).

Table 4.3, Chinese major ports and the imported cargoes (1989, tonne)

	Coal	Oil products	Crude oil	Mine ore	Steel products	Cerement	timber	non-metal ore	grains	others
Dalian	12959	132949	84110	1088580	1059905		25279	72045	3402158	2730158
Qinhuangdao		84762		458242	2479	20038	429581	43455	1760385	511795
Tianjin		132098		42127	1685645		215706	80918	2892057	3824432
Qingdao		544974	165014	1472518	658186		482320	36119	1183096	1602854
Shijiusuo		24794					10081			69106
Lianyungang					1039627	17770	500588		1127377	914657
Shanghai	367819	411984	141085	6648083	2855081		1399260	53290	2161638	6256729
Ningbo	8879	1295870	1270004	2006272	3948		129389	34521	306761	446541
Fuzhou	12269			5250	76720	47996	13644		8077	506079
Xiamen		231917		5800	5996	112062		105345	554330	843170
Guangzhou	764958	2166982	457339	75591	1207774	65028	532094	70342	1117333	3687679
Zhanjiang		759393	622951	1057201	20093		40899		1046168	626275

2 Domestic trade flows

For most ports in northern China, the incoming volume is less than the outgoing volume; in contrast, for most ports in southern China, the situation is in reverse with incoming volumes predominating. The main flow is from north to south, and it is largely composed of coal, crude oil, refined oil, iron ore, seasalt and lumber. Through Qinhuangdao, Qingdao, Shijiusuo and Lianyungang ports, the coal flows to Shanghai, Ningbo and Guangzhou where some of it is then transferred to ports in Jiangsu, Zhejiang and Guangdong provinces and Guangxi autonomous region. Through Qinhuangdao port, coal is shipped directly to the ports of Longkou, Yantai and Weihai along the Bohai Rim. Through Dalian, Qinhuangdao and Qingdao ports, the crude oil flows into Shanghai, Ningbo, Guangzhou and Zhanjiang ports. Dalian, Shanghai, Ningbo, Guangzhou and Zhanjiang, for their part, are responsible for transhipping oil products to other ports (see Table 4.4)(Chen, 1992).

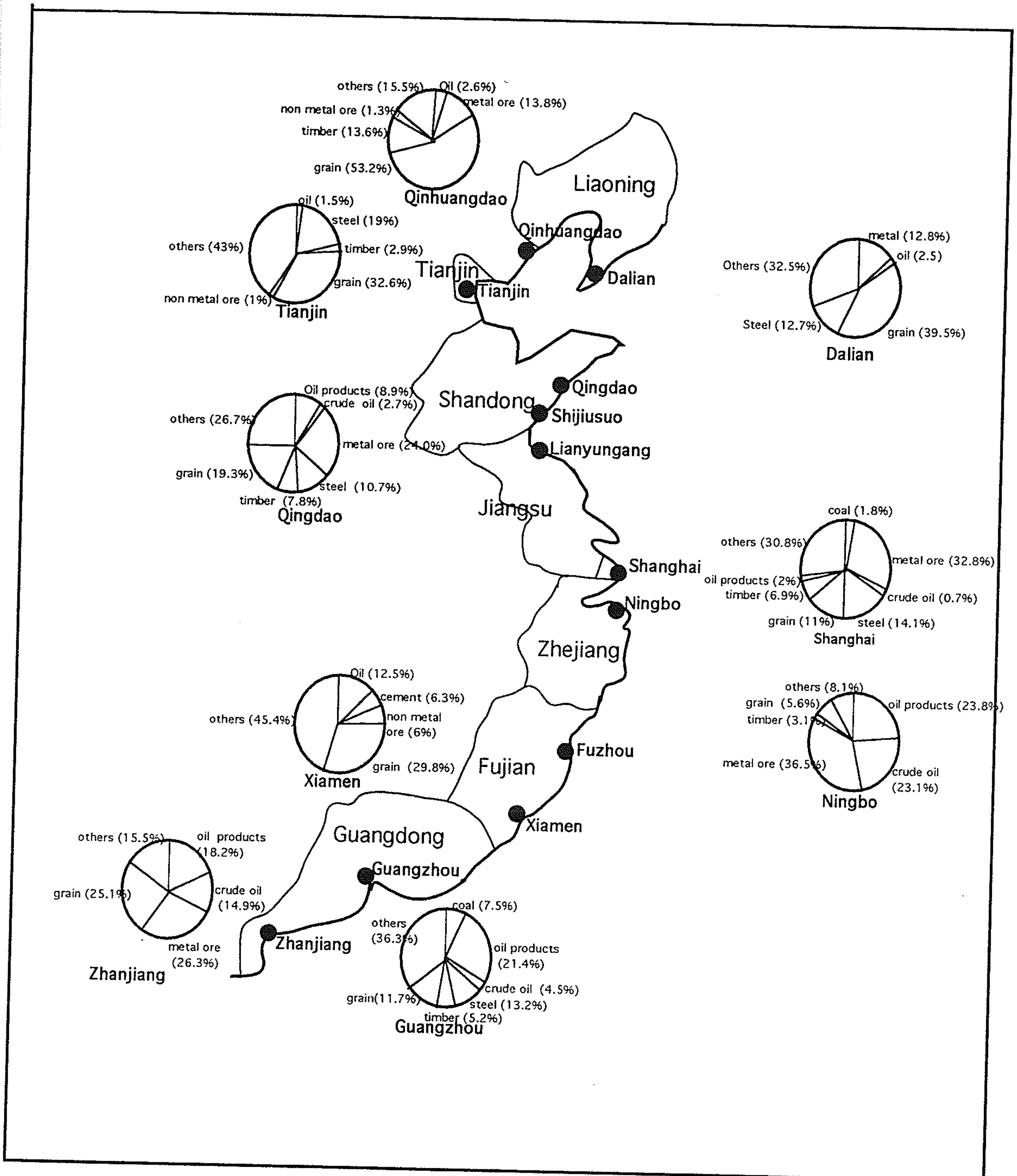

Fig.4.2, China's principal coastal ports and their shipments of imported cargoes

4.1.4 Port development plan in the future

Harbours have long served as hubs for transport, the circulation of goods and materials and the dissemination of information. As the country's economy booms, Chinese harbours, both coastal and inland, are facing increasing pressures. According to recent estimates, in order to maintain a nine per cent annual growth rate in gross national product (GNP), the handling capacity of coastal harbours must be increased by 54 million tonnes annually from 1990 to 2000. Increments to capacity have consistently fallen short of this figure: in 1992, for example, capacity was increased by only 32.68 million tonnes.

Table 4.4 Major Chinese ports and their domestic cargo volume (1989, 1,000 tonnes)

	total			coal			oil product			crude oil		
	outgoing(A)	incoming(B)	A-B	A	B	A-B	A	B	A-B	A	B	A-B
Dalian	15864	4285	11579	459	1790	-1330	7506	460	7047	3353	455	2899
Qinhuangdao	56460	122	56338	36236	0	36236	9690	743	9616	9541	0	9541
Tianjin	5783	2082	3700	4433	0	4433	28	434	-406	0	0	0
Qingdao	19250	2040	1721	6809	0	6809	5842	226	5616	5698	0	5698
Shijiusuo	7276	535	7223	7248	0	7248	12	53	-41	0	0	0
Lianyungang	4647	178	4469	3825	0	3825	1	34	-33	0	0	0
Shanghai	39772	86065	-46000	17558	40407	-23000	3069	9399	-6329	153	7439	-7285
Ningbo	8230	10347	-2117	2224	5451	-3227	1309	2201	-891	618	2020	-1401
Fuzhou	1467	2455	-987	228	593	-365	4	21	-16.8	0	0	0
Xiamen	731	1539	-808	49	135	-86	233	101	132	0	0	0
Guangzhou	11046	25723	-15000	4062	9373	-5311	2535	3568	-1033	0	2642	-2642
Zhanjiang	2453	11964	-9511	546	61	485	383	5502	-5118	179	5279	-5100

metal ore			steel products			fertilizers			grain		
A	B	A-B	A	B	A-B	A	B	A-B	A	B	A-B
0.6	172	-171	810	45	765	0	746	-746	1484	34	1450
100	1	99	25	1.6	23	0	0	0	468	3	644
1.7	16	-14	379	5.8	373	678	204	473	13	1	13
0	585	-585	44	15.3	28.7	217	277	-60	11	0	11
0	0	0	1	0	1	0	0	0	0	0	0
0	0	0	1.7	1	0.7	618	130	488	17	3	14
3503	2681	822	3306	2944	362	698	1542	-845	3030	2386	644
2891	5	2885	62	108	-47	5	103	-97	182	60	122
0	0	0	38	180	-142	17	59	-42	34	247	-214
0	7	-7	1	33	-31	123	148	-25	152	29	123
28	635	-607	204	536	-332	117	385	-268	1366	2343	-977
12	887	-874	82	0	-82	3	15	-12	210	24	186

Since the founding of the People's Republic in 1949, China has built over 300 deep-water berths for 10,000-tonne ships at coastal harbours and in the lower reaches of the Yangtze River. The handling capacity of the harbours has steadily increased and now stands at 550 million tonnes a year. However, to handle the increased tonnage, harbours have been forced to operate at maximum capacity. Unlike ports in developed countries where berths await ships, vessels arriving in Chinese harbours must wait for berths. At present, the ratio between working and waiting ships in Chinese harbours averages 1:1.2. Each day numerous ships anchor outside each of the country's major harbours waiting for berth space to either load or unload. Annual economic losses resulting from inadequate handling capacity, low collection efficiency, dispersed and inadequate transportation facilities reach into the hundreds of millions of yuan. For example, in 1992, ships carrying imported grain were unable to berth in a timely manner, and each ship anchored outside the harbour for an average of 26 days. As a result, compensation payments for the delay alone amounted to US$ 55 million.

Realizing the gravity of the situation, the Ministry of Communications made major readjustments in its Eighth Five-Year Plan (1991-95) for the capital construction of national transportation facilities. The new plan calls for China to build 131 deep-water berths and 79 medium-class berths[4] in coastal harbours, up 46 and 4 respectively over the original plan. The total handling capacity of coastal harbours will thus be expanded

[4] Chinese references to port capacity usually take 10,000 dwt and 5,000 dwt as demarcation among deep-water, medium-class and shallow-water berths.

to 720 million tonnes, an increase of 184 million tonnes. The inland river transportation systems will be strengthened both by the improvement of 3,500 km of river channels, 300 km more than the original plan, and by the building of 62 new berths, an increase of 6 on the formerly-planned figure. The handling capacity of inland ports will be increased by 31 million tonnes, up 2 million tonnes.

The main tasks earmarked for the newly-constructed water transportation facilities by the turn of the century include increasing the number of large to medium-sized berths in coastal harbours to 1,100, of which 650 will be deep-water ones; increasing the handling capacity of harbours to 1.25 billion tonnes; increasing arrivals of direct-call[5] container ships to 54 percent; and perfecting the bulk shipment of staple goods such as grain and cement. Some special major projects were incorporated into this readjusted plan, the following four being particularly noteworthy.

Four Major Projects

The Chinese government has decided to build four international deep-water ports in strategically important domestic and

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[5] It is generally accepted that the deep-sea transport of containers involves the use of large container ships calling at a limited number of ports at each end of the voyage (providing direct service from origin to destination ports). This leads to the conclusion that a network of minor feeding routes plied by smaller container vessels will be needed to service the large, deep-sea port. Cost savings for the containership line may arise from feeding cargo from one port to another and then combining this cargo with cargo at the latter port for transport on a larger containership to the destination port (feeder-port service).

international economic areas. The four are Meizhou Bay in Fujian, Beilun in Ningbo, Dayaowan in Dalian and Yantian in Shenzhen. The goal is to expand the transit trade and develop the export economy during the Eighth Five-Year Plan and these ports occupy a salient position in that goal. As of 1993, these four natural harbours, which have water depth of 15 metres, had already begun transforming themselves into commercial ports. Already, they boast 17 deep-water berths for 10,000-tonne ships, berths which have a total handling capacity of 30 million tonnes. This is but a foretaste of things to come; for example, Yantian port in the Shenzhen Special Economic Zone (SEZ) plans to construct 40 deep-water berths over the next 15 years. The new berths will have an annual handling capacity of 80 million tonnes. The total handling capacity of the SEZ, including Shekou, Mawan and Chiwan port areas, will surpass the total capacity of Hong Kong. Dayaowan, part of Dalian port, will construct 70 berths with an annual handling capacity of nearly 100 million tonnes. Symptomatic of development in the vicinity of Beilun is the oil facility at Zhoushan. In February, 1993, the 200,000-tonne oil terminal belonging to the Aoshan Base successfully unloaded *Lampas*, a 270,000-dwt British oil tanker. In only two and a half days, 190,000 tonnes of oil were transferred to storage tanks. A similarly-sized oil terminal has just been commissioned at Meizhou Bay. At present, the four international deep-water ports are accelerating the tempo of construction, and well over 100,000-tonne berths are scheduled for completion in 1994. One-third of the berths will handle shipments of oil, coal and mineral ores while half of them will handle containers. All of the docks will have state-of-the-art freight handling and transportation equipment, complete basic facilities and computerized management systems.

The aim of these four major ports is to speed up both the world-market-oriented economic development which China now strongly espouses and facilitate coastal transportation of the important mineral and energy products (Li, 1993).

From this overview, the chief features of port development in China can be easily grasped. Now the focus is switched to the development of China's iron and steel industry.

4.2 Chinese metallurgical industries

4.2.1, History of metallurgical industries

On the eve of the foundation of the People's Republic, the total output of steel production was only 158,000 tonnes (Chen, 1990). Most iron and steel enterprises were concentrated in the north coastal belt of China, mainly in Anshan, Benxi, Dalian, Fushun, Tangshan, Tianjin and Shanghai. In 1943, the smelted iron output in Northeast China accounted for 88 per cent of the country's total. As much as 94.5 per cent of China's total steel output was made in Northeast China at the same period. Following the inauguration of the PRC, the development of iron and steel industry went through four stages. These are discussed below.

(1) The National economic recovery and the First Five-Year Plan (1949-1957)

In the three years of national economic recovery (1950-52), the state poured 20.2 per cent, 7.4 per cent and 11.2 per cent, respectively, of the total industrial capital investment into the development of the iron and steel industry. In 1952, the production of iron and steel, registering 1.35 million tonnes, exceeded the historical record level. During the period of the First Five-Year Plan (1953-1957), Anshan Iron and Steel Works received special attention and grew very rapidly. At the same time, a series of small iron and steel factories was constructed and expanded. Also, feasibility studies of projected plants at Baotou, Wuhan and Taiyuan were finished. During this period, the output of iron and steel production increased by an annual 31 per cent. Table 4.5 shows the development of crude steel production in every period and the shipments of the three economic belts[6] of the country, which are shown by Figure 4.3. The works which were newly-constructed, renewed and expanded were located with access to raw materials in mind (See Fig.4.4). Anshan Iron and Steel Company, the premier producer of the day, is located next to both ore resources and coal

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[6] According to the Seventh Five-Year Plan, China was broken into three economic belts as follows:

Eastern economic belt: Liaoning, Hebei, Beijing, Tianjin, Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, Hainan and Guangxi.

Middle economic belt: Heilongjiang, Jilin, Inner Mongolia, Shanxi, Henen, Anhui, Hubei, Hunan and Jiangxi.

Western economic belt: Sha'anxi, Gansu, Qinhai, Ninxia, Xinjiang, Sichuan, Guizhou, Yunnan and Tibet.

resources. As far as the structure of the industry was concerned, the firms of small and medium scale were given only a moderate boost whereas those of larger scale were granted the highest priority.

Table 4.5, Steel production in China and its three economic belts

	China total (1,000 tonnes)	growth%	Eastern total(T) (1,000 t)	China shipments(%)	Middle T	China S	Western T	China S
1949	896.7		790.6	88.2	12.8	8.3	10.4	6.8
1957	5353.6	21.2%	4429.1	82.7	542.3	22.6	382.2	21.6
1958	8496.7		6803.1	80.1	1130.1	13.3	563.5	6.6
1965	12241.3	2.29%	8857.5	72.3	2718.0	22.2	665.8	5.4
1966	15318.8		10551.6	68.9	3901.1	25.5	866.1	5.7
1976	20464.2	1.27%	15054.7	73.6	3806.2	18.6	160.3	7.8
1977	23740.4		16097.9	67.8	5243.6	22.1	2398.9	10.1
1989	61578.2	3.51%	35435.8	57.5	18549.3	30.1	7593.1	12.3

Data source: Bureau of State Statistics of China, 1990, Collective Data of Statistics from 1949-1989, Press of Chinese Statistics, Beijing, in Chinese.

(2) The Second Five-Year Plan and the first adjustment (1958-1965)

With the onset of the "great leap forward", the development of iron and steel was accorded the highest importance. Unrealistic growth rates were insisted on; hundreds and thousands of small, inferior-quality furnaces were built and scattered through the whole

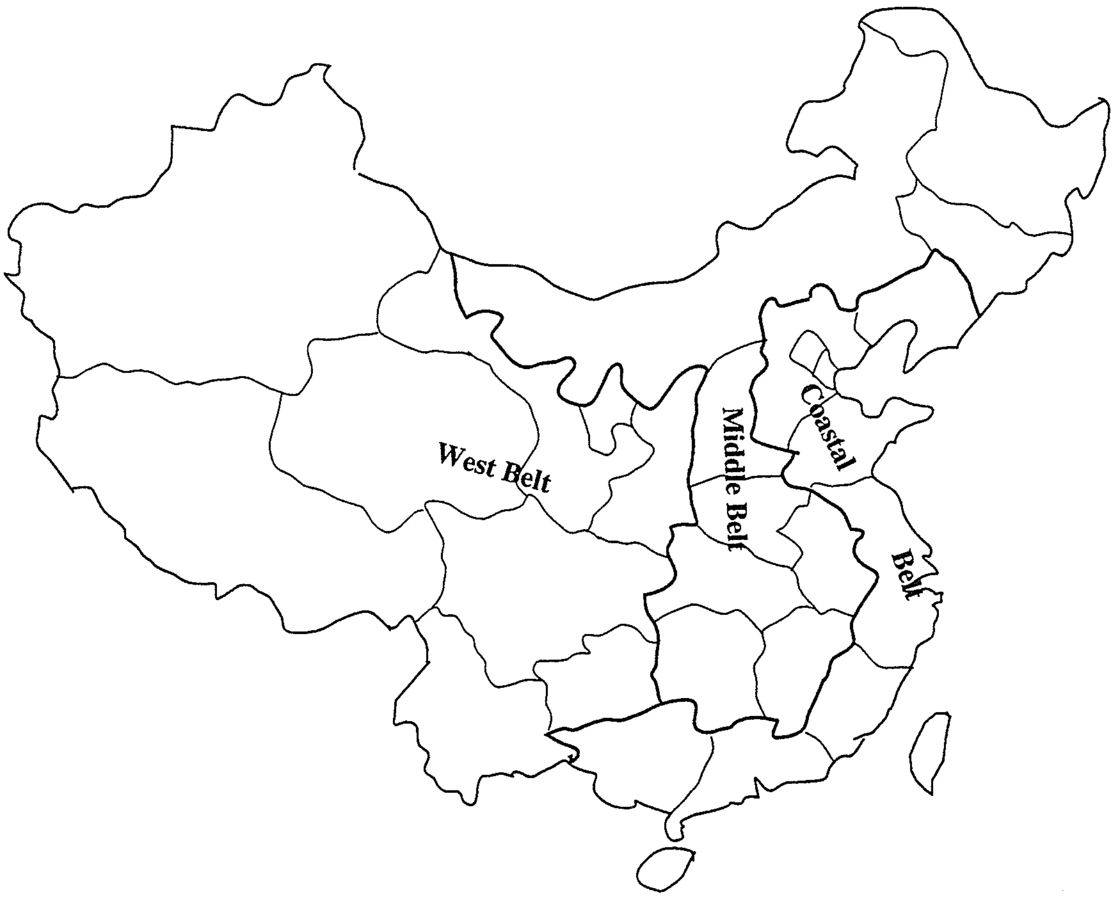

Fig.4.3, Three economic belts in China.

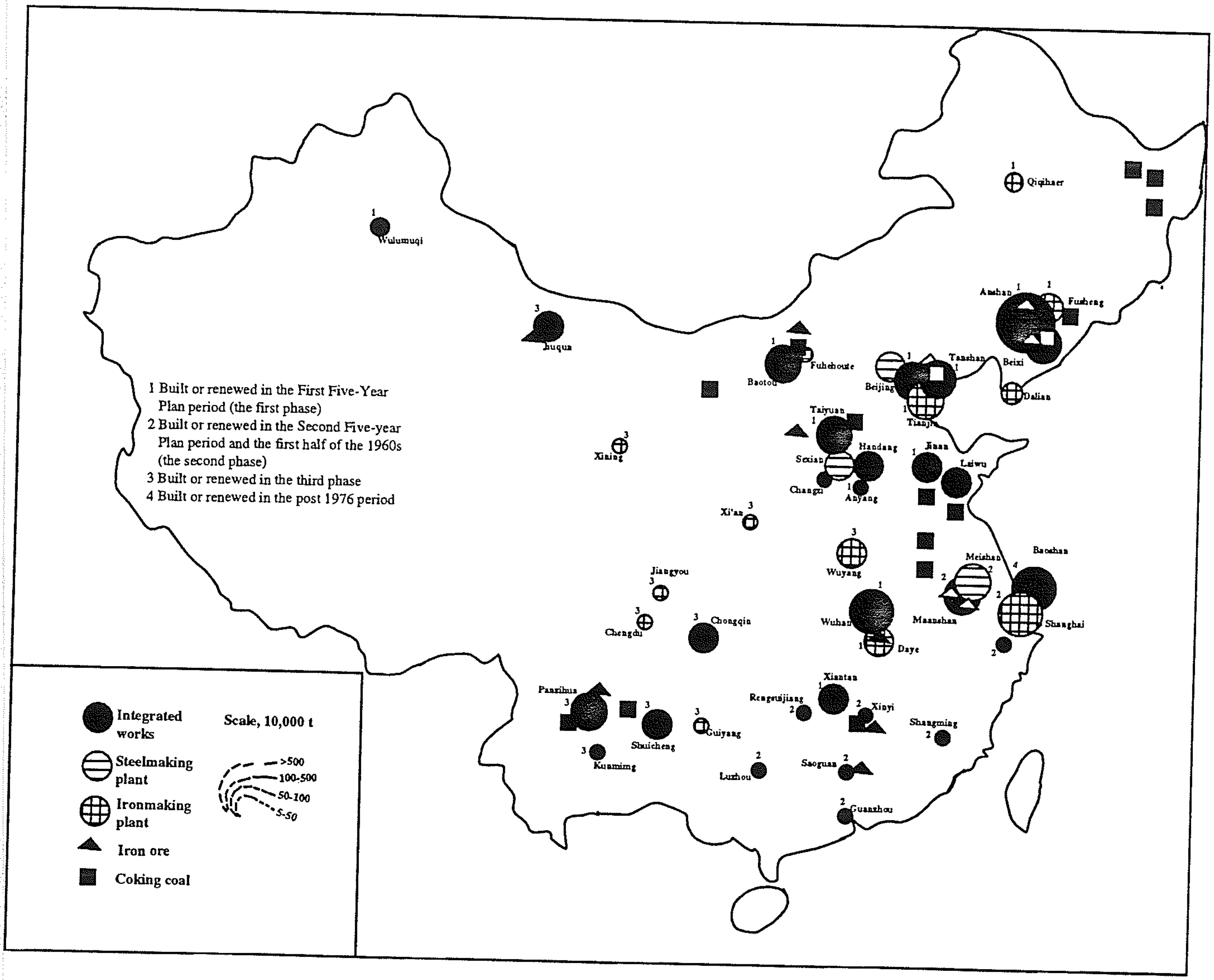

Fig.4.4, Allocation of Chinese iron and steel industry.

country. The outcome verged on the disastrous, running counter to all locational principles bearing on the iron and steel industry. The national economic structure was extremely heavily unbalanced because of the exaggerated development of heavy industries, of which the development of the iron and steel industry was characteristic. In 1961, the central government was forced to implement the policy of "adjusting, consolidating, enhancing, upgrading" as an urgently-needed remedial measure. Under this policy, most inadequately-equipped iron and steel works of small scale were closed. The state now concentrated its limited investment on the construction of Maanshan Rolled Iron Works, and the renewal of the Taiyuan Special Steel Factory.

As a consequence of this adjustment, the steel output increased by 22 per cent annually from 1963 to 1965. After 1964, however, a distinct locational tendency became discernible: increasedly, the industry was pulled into inland or interior areas of China (See Table 4.5). Although the construction of the Panzhihua Iron and Steel Company received the greatest emphasis, other works either received recuperative investment or were newly built. The Panzhihua Iron and Steel Company and Jiuqun Works are integrated, large-scale operations oriented towards raw-material sites. The western movement of iron and steel industry furnished China with an important lesson. This can be summarized as: it is advisable to avoid building too many works simultaneously and over too long a lead time because it saps the state's ability to finance the programme, especially when a lengthy time elapses without visible returns. Even today, some of these ventures remain financially shaky. According to an official survey, among the total firms built in the interior of China during the period, 50 per cent have reached design capacity and operate normally; 25 per cent have attained design capacity but cannot operate at it for any length of time; 10 per cent remain uncompleted and 10 per cent have been closed (Lin, 1987).

(3) The ten-year upheaval (1966 to 1975)

The upheaval of ten years' duration, occasioned by the so-called "cultural revolution" disturbed the development of the iron and steel industry. In the beginning, the Fourth Five-Year Plan pressed for massive, high-speed development of the industry. Not only would the new capacity of the post-adjustment phase come on stream in a big way, but a host of smaller furnaces and works sprouted to supplement it. The production of iron and steel became a political token, assuming an overwhelming role in the national economic plan. However, the economic efficiency of this production was greatly neglected. During the 1970s, total deficits incurred by these makeshift, small furnaces reached 8.8 billion yuan, while the investment waste associated with iron ore exploitation was costed at more than one billion yuan. In 1976, the output of steel production was only 20.4 million tonnes. The rate of annual growth for this ten-year period diminished to 2.9%, the worst figure since the founding of the People's Republic.

(4) The period of the second adjustment and efficient development (post-1976)

Since 1976, the central government has been compelled to resort to an adjustment policy for the second time. On the one hand, some on-going construction projects were stopped and the basic investment was cut in order to shorten the capital construction time. More than 300 small ironmaking factories were switched to other activities, closed and merged. On the other hand, investment made newly available was focused on the construction of the first phase of the Baoshan Iron and Steel Company together with renovation of other key enterprises. During this period, both enhanced efficiency and rapid growth were achieved, the output of steel production in 1985 was a figure double that of 1977 (Chen, 1990).

After a development spanning more than 40 years, the features of China's iron and steel industry are now well established. What follows is a summary of those features.

(1) It has exhibited both rapid growth and a huge increase in output, but, nevertheless, it still cannot fully meet the market demands imposed on it. In 1991, the output of steel exceeded 70 million tonnes, allowing China to claim fourth position in the world after the former Soviet Union, Japan and the USA. In 1990, the output of steel billets reached 66.35 million tonnes, rolled steel totalled 51.51 million tonnes, pig iron recorded 62.37 million tonnes and ore mining registered 179.34 million tonnes. Without any shadow of doubt, this industrial sector made a

significant contribution to China's national economic development. Yet, in 1990 the ratio of self-sufficiency was less than 85 per cent, and, for example, about 7.7 million tonnes of rolled steel were imported. According to official statistics, from 1977 to 1990, the total tonnage of imported steel products was 120 million, and $39.9 billion were expended to procure it.

(2) The variety and range of steel products emanating from China's industry has generally expanded, but the product quality still constitutes a problem. True, the operation of the Baoshan Iron and Steel Company and the installation of a 1.7 m rolling machine in the Wuhan Iron and Steel Company, to give but two examples, have partially eradicated the incompatibilities existing between the demand and supply of varieties of steel products, but rolled steel produced in China is for the most part bereft of plate with the consequence that domestic supply cannot equal demand. It is estimated that China is self-sufficient in only 42 varieties of steel products out of the 100 key varieties; it can partly satisfy the domestic demand of 47 others, but is totally deficient in the supply of the remaining eleven. Most high-quality steel products must be imported.

(3) Poor iron ore resources and defective ore-mining methods continue to impede the development of the iron and steel industry. During the period of the Seventh Five-Year Plan, the country was compelled to import 60 million tonnes of iron ore because the domestic mining sector could only meet 85 per cent of the national demand. During the early period of the Eighth Five-Year Plan, the

commissioning of a 4,063 m^3 furnace in Baoshan, a 3,200 m^3 furnace in Wuhan, a 2,500 m^3 furnace in Maanshan, a 1,200 m^3 furnace in Handan and a 750 m^3 furnace in the First Shanghai Works will only serve to heighten the acute supply-demand mismatch in ore provision. For the foreseeable future, the development of China's iron and steel industry must depend on the domestic iron ore resources being supplemented by sizeable ore imports.

4.2.2, Location of Metallurgical Industries

The major iron and steel works of China can be classified by their locational orientation into the following groups:

(1) those with a leaning towards combined iron ore and coking sources, such as Benxi Iron and Steel Company, Panzhihua Iron and Steel Company and Handan Works;

(2) those inclining towards a source of coking coal, such as Taiyuan Works, Tangshan Works and Fushun Works;

(3) those pulled towards an iron deposit, such as Anshan Iron and Steel Company, Baotou Iron and Steel Company and Maanshan Iron and Steel Company;

(4) those leaning towards a combination of markets and nearby iron ore, such as Capital Iron and Steel Company and Wuhan Iron and Steel Company; and

(5) those disposed to locate towards markets and remote from raw materials, such as Shanghai Iron and Steel Factory, Baoshan Iron and Steel Company and Tianjin Iron and Steel Factory.

The above groups were formed at different times. An appreciation of their relative importance is best obtained from a regional disaggregation of the industry's distribution. The whole of China can be divided into several steel bases and a description of each follows (refer to Fig.4.4).

AN-BEN IRON AND STEEL BASE

This base, which is the biggest and oldest in China, mainly consists of Anshan Iron and Steel Company (ISC) and Benxi ISC. In 1985 the steel output of this base amounted to one-fifth of China's total, its iron production equalled one-quarter while its finished steel accounted for one-sixth of China's total. Compared with the other bases, the area around this one is endowed with the richest iron ore reserves. The proved reserves exceed 10 billion tonnes, no less than 4.0 billion of which are recoverable. The ore-mining capacity of this zone is about 40 million tonnes per year. Complementing the advantage, Anshan ISC is only 10 to 20 kilometres away from the ore-field. A rail line directly connects the ore-field with the works. The ore-fields supplying Benxi ISC are located 25 kms to the north and to the south of the works. In addition, there are 5 billion tonnes of coal reserves in the middle of Liaoning province and these have been extensively mined. The chief coal mines are at Fusheng, Benxihu and Shenbei, about 100 kilometres away from the iron and steel works. Railway links have served the AN-BEN iron and steel base for many years and the area is blessed further with plentiful land and water, key ingredients in the refining process.

Anshan ISC has a history extending back over 60 years, being a product of Japanese interference in Manchuria. After technical upgrading during the First Five-Year Plan, it became the principal iron and steel base of the People's Republic. With incremental improvements during the following five-year plans, Anshan Iron and Steel Company enjoys capabilities in ore mining, ore dressing, sintering, coking, ironmaking, steelmaking, rolling, chemical and refractory processing. The works cover 16 km^2 and have employed up to 200,000 workers. In 1985, the output of steel stood at 7.26 million tonnes, the output of iron was put at 6.61 million tonnes, and the production of rolled steel reached 4.49 million tonnes.

Benxi Iron and Steel Integrated Company is almost as old as Anshan ISC. The location orientation of this base is weighted both towards iron ore-fields and sources of coking coal, which together afford it the advantage of short transport distances involved in obtaining raw materials. There are two separate parts to this company. One is an independent ironmaking system with two 330 m^3 blast furnaces and two 75 m^2 sintering machines. The other constitutes the main part of the company, holding title to a pair of blast furnaces of 1070 m^3 and one blast furnace of 2000 m^3, three top oxygen blown furnaces of 120 tonnes, seven electric furnaces of five tonnes, one electric furnace of 10 tonnes and two kinds of rolling facilities. In 1985, the output of pig iron reached 3.06 million tonnes, steel equalled 1.48 million tonnes and the figure for rolled steel was 0.35 million tonnes. The factor in most critical supply for this factory is land, the limits on which impede further expansion of the plant except for technical modernization.

JING-JIN-TANG BASE

This base consists of the Capital Iron and Steel Integrated Company, Tianjin Iron and Steel Works and Tangshan Iron and Steel Works. In aggregate, the base's output of iron and steel is about one-tenth of China's total. This area can point to resource advantages for iron and steel development, such as high-quality coking coal and ore resources measuring 5.0 billion tonnes of exploitable reserves; that is to say, one of four richest ore deposits in the country. Well-established railway and coastwise shipping services prove very convenient for transport of products and raw materials to and from this base. Many metallurgical research institutions located in this area further enhance the development prospects of the industry located here. About one-half of its steel and iron products are consumed in a huge local market.

For the base, as a whole, the capacity of steelmaking is bigger than the capacity of ironmaking and rolling. Nevertheless, the situation varies among the three firms. In Beijing, the capacity of ironmaking surpasses steelmaking which, in turn, exceeds rolling. In Tianjin, the capacity of ironmaking is lower than steelmaking which, for its part, is inferior to rolling. In Tangshan, the capacity of ironmaking is less than steelmaking, but steelmaking capacity is greater than that set aside for rolling. Under these circumstances, a great amount of pig iron and billets are transferred from the Capital Company to Tianjin and Tangshan.

Capital ISC engages in the whole process of mining, dressing, ironmaking, steelmaking, and rolling. Its ore-mining site is located 250 km away from the integrated works at Qianan in Hebei province. There are abundant reserves, some 1.38 billion tonnes with average grade of ore of 28.5 percent iron out of two billion tonnes of exploitable material. After mineral separation, its grade is pushed up to as much as 68.5 percent. The Capital Company is located in the Shijingshan district of Beijing City, occupying 6 km^2 of land. In order to meet the target of three million tonnes of steel output, it is speeding up the process of technical renewal. In fact, the works has exceeded this capacity. However, owing to urban encroachment and environmental protection, the scale of the works will be reigned in, with output controlled. In 1985, the output of pig iron from this enterprise was 3.26 million tonnes, the production of billets was 2.58 million tonnes and the production of rolled steel was 2.21 million tonnes. In that same year, the output of billets from Tianjin Iron and Steel Works reached 1.01 million tonnes, rolled steel was given as 1.44 million tonnes and pig iron was measured at 0.82 million tonnes. Tangshan Works, for its part, produced 1.23 million tonnes of billets, 0.83 million tonnes of rolled steel and 0.32 million tonnes of pig iron.

SHANGHAI BASE

The volume of steel and rolled steel emanating from the Shanghai base has permitted it to claim second ranking in China, surpassed only by the Anshan-Benxi base. There are three major steelmaking works and more than 10 rolling factories, to say nothing of a series of iron alloy firms. In 1985, the output of steel deriving from this base was 5.06 million tonnes, equal to 11.1 per cent of China's total; rolled steel, at 4.51 million tonnes, composed 12.3 per cent of China's total.

For a long time, steelmaking in Shanghai depended upon the utilization of pig iron brought in from outside the region. In order to reduce this import dependency, an ironmaking base was built in Nanjing during the 1960s and the 1970s, and it has supplied about 1.1 million tonnes of pig iron on a yearly basis to Shanghai ever since.

Many problems exist regarding the location of factories in the Shanghai base. Chief among these are the jumble of industrial and urban premises, an incompatible mix which adds to the cost of assembling land for steelworks' uses, not to mention the difficulties created because of the physical separation of production units (denying effective integrated production). By one reckoning, six million tonnes of materials and intermediate products must be moved - at considerable expense- between units on account of this enforced separation. Consequently, the planners must interfere on behalf of the enterprises and attempt to relocate some of their units in order to effect physical concentration and, with it, functional integration. Forming a cluster on the Baoshan-Wusong complex seems to offer the most promising solution.

The Baoshan Iron and Steel Company is a modern and integrated works with a scale of six million tonnes of output annually once its second phase is finished. The first phase was completed in 1985. It relies heavily on imported advanced equipment and scientific management. The construction of Baoshan Iron and Steel Company single-handedly ensured that the Shanghai base's future in steelmaking was secured.

WUHAN BASE

The Wuhan Iron and Steel Company, a large-scale steelmaking firm built since the foundation of the People's Republic, is located on the bank of the Yangtze River at Wuchuang. It is not only located in the midst of the large market of Wuhan municipality, but it enjoys the advantage of being located only 120 km away from iron-ore deposits in Dayue. Its 1985 output comprised 4.06 million tonnes of pig iron, 3.96 million tonnes of billets and 3.34 million tonnes of rolled steel. It is in process of being expanded to the scale of four million tonnes of pig iron and four million tonnes of billets, both to take advantage of an imported 1.7m rolling machine. Ultimately, capacity will be raised to six million tonnes of iron and an equal amount of steel.

PANZHIHUA BASE

This base, which is entirely dependent on domestically-designed and manufactured equipment, is found in Dukou City in Sichuan province. It relies on local iron ore and coking-coal resources. Magnetite ore reserves constitute one of the country's four richest ore-fields. They amount to a few billion tonnes and account for 11 per cent of the national ore total. A mere 20 km from the ore-field is a high-quality coking-coal deposit with more than one billion tonnes of reserves. The iron and steel works are positioned between the ore-fields and coal-fields, at a distance of 10 km from each of them. The railway connects the works with both fields. Construction of this base began in 1965. It came on stream in 1970 with ironmaking, in 1971 with steelmaking and in 1974 with the making of rolled steel. In 1985 its output of pig iron reached 2.07 million tonnes, its production of billets was 1.75 million tonnes and its output of rolled steel was 0.87 million tonnes. Unfortunately, its future is clouded by two unfavourable factors: a paucity of level land and restricted capacity on the Chengdu-Kunming railway. According to the development plan, the final scale of this base will be kept down to 2.5-3.0 million tonnes.

BAOTOU BASE

Baotou iron and steel base is situated in the old city of Baotou. It is a large-scale iron and steel integrated works, owing its genesis to the First Five-Year Plan and coming to fruition in the period of the Second Five-Year Plan. The following two factors were principally responsible for its construction: it was close to plentiful supplies of both iron ore and coal, with the former occurring only 150 km away from the city and the latter - holding coking and thermal coal - being 80 km away from the plant; and, it could be placed adjacent to the Yellow River where swaths of level land abounded and water was at hand. The Beijing-Baotou railway facilitates the transportation of products from the plant. Begun in 1953, the works produced its first pig iron in 1959. A year later it started to produce billets and in 1969 shipped out its first rolled steel. In 1985, the capacity of ironmaking and steelmaking each reached 1.5 million tonnes. It is intended to raise these levels to three million tonnes in due course.

TAIYUAN BASE

The Taiyuan Iron and Steel Works has been operating for more than 40 years. From the early years of the People Republic the works have been subjected to a series of renewal schemes, and technical innovations have been implemented. In 1980 the plant could boast one million tonnes of ironmaking capacity. This works is earmarked as the special-steel base of China, and plate steel is its main product. Among its positive attributes are access to the various types of coal with abundant reserves in the middle of Shanxi province and the presence of many rolling machines in eight rolling shops (10 out of 15 of which are plate steel rolling machines). Among the shortcomings are the poor-grade iron ore-fields which it must tap and the shortage of water resources. In 1985, this base produced 1.42 million tonnes of billets, 1.02 million tonnes of pig iron and 0.77 million tonnes of rolled steel. Overall, the following can be said in support of the rationale applying to the location of the iron and steel industry in China.

(1) The location of the industry is compatible with the distribution of resources. In China, the iron ore resources mainly occur in the seven ore-fields of Anshan-Benxi, Jidong, Baotou-Beiyunerbo, Wutai-Lanxian, Ninwu-Lulong, east Hubei and west Hubei. On the strength of these resources, Anshan, Benxi, the Capital, Tangshan, Panzhihua, Baotou, Taiyuan, Maanshan and Wuhan iron and steel integrated complexes were built.

(2) As elsewhere in world of iron and steel development, the trend of industrial location in China towards markets is compelling. An instance is the lower reaches of the Yangtze River which, while certainly an advanced economic area and a major steel consuming market, is none-the-less lacking in ore resources and coking coal. Integrated steelworks could be placed here on account of the advantages in transportation proffered by riverine and coastal shipping, to say nothing of the availability of foreign ore for consumption by the likes of Shanghai, Baoshan, Maanshan and Wuhan plants.

(3) In terms of organizational structure, the large-scale works play the dominant role. All the same, there is room for smaller-

scale operations where geographical conditions allow. The former are rendered feasible by being located close to rich resources and having convenient transportation links to markets. The latter have cropped up on a scattered assortment of ore deposits or coking coal-fields, but are denied the favourable combination of factors sustaining the large works.

Indeed, some of the problems confronting the industry are particularly evident when the location viewpoint takes precedence. In summary, they are listed in the paragraphs below.

(1) The development of the iron and steel industry in south coastal China is not consistent with that region's economic development. In 1990 steel production in the Guangdong, Fujian, Guangxi and Hainan provinces was only 2.21 million tonnes, equivalent to only 3.3 per cent of China's total in comparison with its GDP share of 13.7% of China's total. No large-scale iron and steel integrated works is present in the region. Furthermore, the steel supply situation is unable to meet the demand created by rapid economic development.

(2) A series of enterprises formed during the period of "great leap forward" and placed in the interior of the country is located neither at the sources of raw materials (iron ore and coal) nor at the markets. Lack of convenient transportation is a further handicap. A great economic loss has been incurred in keeping these enterprises in operation. The future of these enterprises hangs in the balance, since they can scarcely be justified in economic terms even if it is conceded that their closure would be forthcoming with

significant social implications.

(3) Some iron and steel works established in the urban built-up areas cause heavy environmental pollution and impose heavy burdens on infrastructure provision. Their future, too, is uncertain. An appreciation of the development of China's iron and steel industry is a prerequisite for pondering its future. The great demand imposed by rapid growth will lead to further expansion of ironmaking and steelmaking capacity. The consequences of this expansion on location now will be examined. This will be done from two perspectives. First, the regional demand, endowment of ore resource and existing production level will be shown to lead inexorably to coastal location. Second, analysis of the location effect will be undertaken by comparing a coastal site relying on imported ore with one depending on domestic ore. The upshot will endorse the cost-efficiency of the coastal location provided China intensifies its reliance on imported ore. The next section addresses the first of these considerations.

4.3 Chinese strategy: integrating the iron and steel complexes into the ports

4.3.1 Why new Chinese steel bases should be located in the coastal belt.

1, The existing technical level is insufficient to meet the need for high-quality steel products.

According to the programme for the ten years from 1991 to 2000 approved by the People's Congress of China, economic growth will maintain a rate of 9-10 per cent annually. Keeping this figure in mind, the total steel demand by 2000 is projected to be 90-100 million tonnes.

In 1991, China's output of steel reached 70 million tonnes. As mentioned above, the prominent problem is the shortage of high-grade steel products. No less than 51 per cent of China's total steel output came from steelmaking works with capacities of less than 2 million tonnes, plants infamous for their endowment of poor equipment. Even with renovation, these plants cannot produce enough high-grade steel products. This is why China is forced to import large amounts of high-grade finished steel year by year. In order to meet the demands of economic development, it is necessary to expand the scale of iron and steel production. Prior to 2000, the main attention will be directed to the extension and technical renovation of the existing iron and steel companies. In line with the tenets of cost-efficiency analysis, enlarging existing factories is much more cost-saving than building new ones. But with the ever increasing economic development and the spawning of more varieties of iron and steel products, building new large-scale integrated iron and steel complexes is highly recommended, especially after the year 2000.

2, Relying on both the domestic and imported ore can support the increases in steel capacity.

As a whole, according to the yearbook of iron ore statistics released by the Ministry of Geology and Mineral Resources of China, reserves of grades A+B+C+D[7] amount to 49.74 billion tonnes, although 97.4 per cent of this amount is of poor quality. Of the total, the reserves of grade A+B+C total 24.8 billion tonnes, but only 18 billion tonnes of these can be utilized. Consistent with the ratio of one tonne of pig iron to every four tonnes of ore, these ore resources can only sustain 40 years of development at the scale of 100 million tonnes of iron and steel production. During the period of the Seventh Five-Year Plan, the growth of ore-mining amounted to four per cent per annum, one-half of the steel production rate. This situation led to sharp increases in imported ore. In 1990, a total of 18 million tonnes of ore was imported, accounting for 20 per cent of China's consumed ore. To import ore for facilitating development of the iron and steel industry, thus, became a leading Chinese strategy. In terms of distribution of domestic ore resources, only three sites can provide enough iron ore for the construction of new bases with capacity in the three-million tonne range. They are Jidong, Anshan-Benxi and Panxi. However, no single resource site can support the construction of a works with a capacity of six million tonnes. Over the long term, the ore resources of Anshan-Benxi should be fully committed to

[7] A, B, C, and D, respectively, indicate proven, probable, possible and subeconomic resources of mineral reserves. The first were conceived following extensive drilling, the second were arrived at after preliminary drilling, 'possible' resources were the consequence of sketchy exploration while 'subeconomic' constituted the remainder.

supporting the expansion of existing local works; namely, those of Anshan and Benxi. The complicated variety of ore resources combined with poor transportation facilities in Panxi hinder the prospects of a large-scale iron and steel base there in the foreseeable future. Jidong ore reserves are sufficient for the supply of a new complex of no more than three million tonnes, given its prior commitments to supply the expansion of the local existing iron and steel companies. Therefore, the rationale of a new base there should rest on the practicality of procuring imported ore.

3 Regional distribution pattern of demand points to coastal location of the iron and steel industry

According to the flow of iron and steel products, China can be divided into six production-consumption regions (P-C region) (see Table 4.6) (Liu, 1992).

As far as the balance of production and consumption is concerned, huge deficits exist among the regions of the North, Middle South and Northwest of China. Owing to the geographical remoteness of Northwest China and poor conditions for construction of iron and steel plants in the area, the demand of steel in this region cannot be met by its production in a short timetable; accordingly, the deficits of steel products will be brought from North China. Among the 12 coastal provinces, Guangdong ranks the first in terms of the deficit. The deficit of iron and steel supply in all coastal provinces registers eight million tonnes, or 42 per cent of China's total. The coastal belt, of course, is the area which witnesses the most rapid economic growth. It is imperative, therefore, to locate new complexes in the coastal belt. These coastal complexes deserve the highest priority of any new iron and steel developments in China. The next section underscores why this is so.

Table 4.6, The regional balance of consumption and production of steel and projection of demand in 2000 (1,000 tonnes)

P-C region	Production	Consumption	Balance
Northeast	13280	15100	-1820
North	13830	20680	-6850
Northwest	7590	10250	-2660
East	18130	20020	-1890
Middle south	10650	14690	-4040
Southwest	7320	7910	-590
Others		1350	-1350
Total	70800	90000	-19200

Note: (1) In this table, the whole demand of steel is placed on the level of 90 million tonnes, rather than 100 million tonnes.
(2) Northeast incorporates Liaoning, Jilin and Heilongjiang provinces; North incorporates Beijing, Tianjin, Hebei, Shandong and Henan provinces and municipalities; Northwest incorporates Shanxi, Sha'anxi, Inner Mongolia, Gansu, Ninxia and Qinhai provinces and autonomous region; East incorporates Shanghai, Jiangsu, Zhejiang, Jiangxi and Fujian provinces; Middlesouth incorporates Hubei, Hunan, Guangdong, Guangxi and Hainan provinces and region; Southwest is constituted from Sichuan, Yunnan, Guizhou, and Tibet provinces and autonomous region.
Source: Liu, 1992, p34.

4.3.2 Location analysis: A comparison of a coastal site relying on imported ore with one depending on domestic ore.

The locational analysis will be based principally upon transportation costs incurred in the assembly of the significant transported materials and delivery of the finished product to the market. The first part of the analysis will be concerned with two existing plants and the actual conditions of their operations, taking material supplies and markets as known for each plant. A comparison will be made of transportation expenses and the factors contributing to these expenses. This step is to expose the advantages incident to these two types of location. Further analysis will then assume a hypothetical base, taking the steel plant which used the domestic materials to be transformed into a plant reliant on imported materials while the other factors remain unchanged. This step is to gain insights into how much transportation costs will be increased when delivering imported ore to non-coastal sites becomes unavoidable.

The steel works chosen to be compared are Capital Iron and Steel Company and Baoshan Iron and Steel Complex. As they have been amply described earlier, it is clearly the case that Capital is furnished by domestic ore sources and its location type is a combination of material-oriented and market-oriented, while Baoshan is a model of a coastal type, relying on imported ore and located at a market centre. Consumption of significant transported materials per tonne of finished steel for both complexes is shown in Table 4.7. For both steel producers, the amounts of materials obtained from each source are known for the three major transported materials, iron ore, coking coal and power coal, and the market scrap. However, the transport costs for imported iron ore for both sites must be estimated. For the ore from Australia, carried in

170,000 dwt bulkers, the transport cost from Western Australia to Japan is US$ 5.75 per tonne; the transport cost from Western Australia to Kaohsiong in Taiwan, using vessels of 190,000 dwt, equals US $6.4 per tonne. Taking these figures as the benchmarks, importing ore from Western Australia to Ningbo by Capesize vessels of 160,000 dwt is estimated to cost US $6.45 per tonne. The cost for bringing Australian ore directly to Shanghai (ore transhipped in Ningbo incurs an extra expense) and Qinhuangdao ports is estimated at $6.45 and $6.95, respectively. For the transferred ore via Ningbo, the transportation costs are calculated by adding another 3.58 yuan to the Shanghai estimate.

The ore supply and the incurred transportation expenses are shown in Table 4.8. It may be noted that the Capital works has an obvious advantage over the Baoshan site, since Capital is more readily accessible to the ore source. Most of the ore supplied to the Capital works is only 280 km off the steelmaking site. However, Baoshan relies on ore imported from Australia and, partly in consequence, it still can not compete with the Capital despite availing itself of cheap transportation cost accruing to large vessels. Per tonne of crude steel, the ore transportation cost is

Table 4.7, Consumption of principal materials per tonne of crude steel, 1991.

Company	Crude Steel Production (Million tonnes)	Iron Ore		Coke coal		Market Scrap	
		Total Con-sumption MT	Con-sumption per tonne of crude steel(kg)	Total Con-sumption MT	Con-sumption per tonne of crude steel(kg)	Total Con-sumption MT	Con-sumption per tonne of crude steel(kg)
Capital	4.90	7.80	1589	3.53	719	0.95	193
Baoshan	4.70	7.70	1636	4.25	903	1.05	223

17.1 yuan for The Capital and 62 yuan for Baoshan (Table 4.8 or Table 4.12). The position with respect to coking coal and the related transportation costs is summarized in Table 4.9. It has to be recognized that most steelmaking works turn to Shanxi for coal. With regard to coal consumption and location relative to the coal supply, the Capital works continues to enjoy an advantage over Baoshan. The freight cost of coal of per tonne of crude steel is 7.7 yuan for the Capital as against 17 yuan for Baoshan. The amount of scrap and the associated transportation fees are listed in Table 4.10. While the two plants are located at markets and the scrap is shipped to both by railway, the transportation expense per tonne of crude steel is lower for Baoshan. Overall, however, on taking into account all the raw materials (ore, coal and scrap) and calculating assembling costs, the figure for the Capital complex totals 29.3 yuan per tonne of crude steel while Baoshan registers as high as 82 yuan (Table 4.12). The weight and tonne-km of per tonne of crude steel further endorse the Capital's advantages over Baoshan in assembling raw materials. The figures are 2.51 tonnes and 1739 ton-km for the Capital and 2.76 tonnes and 13642 tonne-km for Baoshan (see Table 4.13).

As calculated in Table 4.11, the products of both the Capital and Baoshan complexes are delivered to almost the whole of China (except for Tibet). The transportation costs for per tonne of steel output in Baoshan are 15 yuan while the figure for the Capital works reached 20 yuan. The most significant factors contributing to Baoshan's privilege with respect to freight costs are found in its location relative to its market and the transport network for distributing products. The first is the market of Shanghai, where products consumed amount to 800,000 tonnes and equal 17 per cent of the total output of Baoshan. Beijing possesses a smaller local market than Shanghai, one capable of absorbing only 550,000 tonnes, or 11 per cent of the total steel output of the Capital works. The second is that a large proportion of the

Table 4.8, Ore and the transportation cost, 1991

CAPITAL	Source1	Source2	Source3	Total
Location	Qianan	West Australia	Hainan	
Amount (10,000 tonnes)	720	35	25	780
Transport mode	Railway	Ocean shipping and railway	Coastal-shipping and railway	
Distance (km)	280	9365	3588	
Freight cost/tonne (yuan)	8.3	($6.95*5.8 +9.4) 49.7	(6.3+ 25+9.4) 40.7	
Freight cost per tonne of crude steel	12.2	2.8	2.1	17.1

BAOSHAN	Source1	Source2	Source3	Total
Location	West Australia	West Australia via Beilun	Hainan	
Amount (10,000 tonnes)	400	300	70	770
Transport mode	Ocean shipping	Ocean shipping and tranship	Coastal-shipping and railway	
Distance (km)	7883	7883	2346	
Freight cost/tonne (yuan)	(6.45* 5.8) 37.4	($6.45*5.8 +3.58) 40.99	(6.3+ 21) 27.3	
Freight cost per tonne of crude steel	31.8	26.1	4.1	62

Note, the exchange rate for US$ 1 was 5.8 yuan in 1991.

Table 4.9, Coal and transportation cost, 1991

CAPITAL	Source1	Source2	Source3	Total
Location	Taiyuan	Kairan	Beijing	
Amount (10,000 tonne)	243	60	50	353
Transport way	railway	railway	railway	
Distance (km)	520	230	0	
Freight cost/tonne (yuan)	13.3	9.2	0	
Freight cost of per tonne crude steel	6.58	1.12	0	7.71

BAOSHAN	Source1	Source2	Source3	Total
Location	Taiyuan*	Kairen*	Huainan in Anhui	
Amount (1,000 tonnes)	300	85	40	425
Transport way	railway and coastal shipping	railway and coastal shipping	railway	
Distance (km)	1794 (520+1274)	1384 (110+1274)	615	
Freight cost/tonne (yuan)	(13.3+ 7.26) 20.56	(7.26+ +7.26) 14.52	15.1	
Freight cost per tonne of crude steel	13.1	2.6	1.3	17

*, the coal was conveyed on railway to Qinhuangdao then shipped to Shanghai.

Table 4.10, The market scrap and transportation cost

	Amount (10,000 tonnes)	Distance km	Freight cost /tonne (yuan)	Freight cost per tonne of crude steel
Capital	95	980	23.6	4.5
Baoshan	105	470	13.4	3.0

Note, the scrap for Capital is mainly found in North China, and the scrap for Baoshan is from East China. They are transported by railway.

Table 4.11, The delivery of products to the Capital and Baoshan works

Destination	Capital Amount (10,000 t)	Capital distance km	Capital freight cost per tonne yuan	Capital freight cost per tonne of crude steel (yuan)	Baoshan Amount	Baoshan distance	Baoshan freight cost per tonne	Baoshan freight cost per tonne of crude steel
1 Beijing	55	0	0	0	5	1458	32.9	0.37
2 Tianjin	67	137	8	1.3	4	1312	30.1	0.27
3 Hebei	57	283	10.6	1.5	4	1266	29.2	0.26
4 Shanxi	11	514	14.1	0.38	2	1497	32.9	0.15
5 Inner Mongolia	3	602	16.1	0.12	1	2120	44.9	0.10
6 Liaoning	14	844	21	0.73	7	2028	43.6	0.68
7 Jilin	3	1149	26.3	0.19	4	2333	47.6	0.43
8 Heilongjiang	4	1391	31	0.30	3	2575	50.2	0.34
9 Shanghai	10	1458	32.9	0.82	22	0	0	0
10 Jiangsu	25	1156	27.2	1.69	5	503	14.1	0.15
11 Zhejiang	12	1650	36.6	1.09	7	201	9.1	0.14
12 Anhui	5	983	23.6	0.29	6	475	13.4	0.18
13 Fujian	7	2846	56	0.97	7	1388	31.0	0.48
14 Jiangxi	1	2295	46.3	0.11	5	837	20.1	0.22
15 Shandong	16	493	14.1	0.56	16	965	23.6	0.85
16 Henan	22	693	17.5	0.95	10	1001	24.5	0.55
17 Hubei	23	1227	28.2	1.61	9	1535	33.9	0.68
18 Hunan	6	1585	34.7	0.52	5	1139	26.3	0.29
19 Guangdong	40	2311	47.6	4.72	3	1808	39.5	0.26
20 Guangxi	3	2392	47.6	0.35	2	1955	42.3	0.19
21 Sichuan	7	2046	43.6	0.76	7	4153	81.4	1.27
22 Yunnan	1	3146	61.9	0.15	2	3895	77.5	0.34
23 Guizhou	1	2437	48.9	0.12	2	3232	63.8	0.28
24 Sha'anxi	6	1204	28.2	0.42	7	1512	33.9	0.53
25 Gansu	1	1880	40.4	0.10	2	2188	44.9	0.20
26 Qinhai	1	2905	58	0.14	1	3213	63.8	0.14
27 Ninxia	1	1236	28.2	0.07	1	2450	48.9	0.11
28 Xinjiang	1	3772	73.6	0.18	2	4080	79.4	0.35
29 Works in Shanghai					60	0	0	0
30 Works in Nanjing					40	392	4.98	0.44
31 works in Henan					20	843	21	0.94
32 Wuhan Company					60	1125	10.9	1.46
33 Dayue works					40	982	9.76	0.87
34 Nanjing, Zhenjiang and Nantong					25	392	4.98	0.28
35 Maanshan, and Wuhu					15	440	5.3	0.39
36 Jiujiang					20	856	8.9	0.39
37 Wuhan and Shasi					10	1125	10.9	0.24
38 Chongqin					5	2399	41.9	0.47
total				20.21				15.16

Note, From 1 to 28 and 31, the products delivered by railways. The others are by Yangtze River waterway. From 1 to 28, and From 34 to 38, the products delivered refers to the finished steel. From 29 to 33, the products are steel ingots.

Table 4.12, The total freight cost per tonne of crude steel.

	Capital	Baoshan
Assembling raw materials		
ore	17.1	62
coal	7.7	17
scrap	4.5	3.0
Sub-total	29.3	82
Delivery of products	20.21	15.16
Total	49.5	97.2

Table 4.13, The weight and the tonne-km per tonne of steel

		Capital		Baoshan	
		weight	tonne-km	weight	tonne-km
Assembling materials					
ore	Source1	1.46	411	0.85	6709
	Source2	0.07	669	0.63	5031
	Source3	0.05	183	0.15	349
Coal	Source1	0.49	257	0.63	1145
	Source2	0.12	28	0.18	250
	Source3	0.10	0	0.08	52
Scrap		0.19	190	0.22	105
Sub-total		2.51	1739	2.77	13642
Delivery of products					
		1.00	847	1.00	890
Total		3.51	2586	3.77	14532

products of Baoshan is shipped along the Yangtze River. The freight costs associated with inland waterways are much lower than the railway which is the only mode available to distribute the products of the Capital complex. However, thanks to its great advantage in the assembling of raw materials, the total unit freight cost, including the assembling of materials and delivering the products, is 49.5 yuan in the Capital against the figure of 97 yuan in Baoshan (Table 4.12). For a tonne of steel output at Capital, the weight for assembling materials and delivering products is 3.51 tonnes and the tonne-kms amount to 2586 (Table 4.13). However, comparable values for Baoshan are 3.77 tonnes and 14532 tonne-kms. It is easy to conclude, then, that the Capital was great advantages over Baoshan regarding ore access.

However, when it is taken into account that no further ore-fields are available to support the Chinese iron and steel industry and that the development of the industry must more and more rely on imported ores, the situation changes. The advantage of the coastal site over the inland site, when both are compelled to turn to imported ore, be comes apparent. Since the grade of ore in Qianan provided to the Capital works is almost the same as that of ore imported from Australia (57.55 per cent to 58.37 per cent), we replace the Qianan ore with the imported ore by the same amount of 7.2 million tonnes in order to calculate the freight cost per tonne of crude steel. Unit transportation costs from Western Australia to Beijing has been shown in Table 4.8. The provision of coal and scrap and the delivery of products is immutable. Under this circumstance, the freight cost is shown in Table 4.14. The freight cost of ore dramatically rises to 78 yuan and the total for the assembling of raw materials amounts to 90.8 yuan. Adding the freight cost of delivery of products, the sum climbs to 111 yuan. By comparison with Baoshan, the freight cost of ore applying to the hypothetical Capital is 16 yuan more and the total transport cost incurred in assembling raw materials and delivering the products is 19 yuan more than Baoshan's figures. This exercise demonstrates that the coastal sites have the edge in assembling raw materials and delivering products over the sites away from the coastline as long as imported ore is the only ore in contention.

Table 4.14, The freight cost per tonne of crude steel of the Capital works

Assembling of materials	Yuan
ore	78.6
coal	7.7
scrap	4.5
sub-total	90.8
Delivery of products	20.21
Total	111.0

4.3.3 Chinese strategy: integrating the iron and steel complexes into the ports.

The above two sub-sections have fulfilled two objectives: first, they have shown that the Chinese iron and steel industry will focus on the coastal belt and, secondly, they have demonstrated that, in the event of reliance on ore imports, the coastal orientation is decidedly advantageous.

It will be recalled from Chapter two that, in theory, owing to the reality of imported ore, the cost of sea transportation plays a pivotal role in deciding the price of raw materials under conditions of comparable prices of ore at source and equivalent haulage distances. Nowhere is this more apparent than in the oil trade, a reasonable analogy to the ore trades. For distances of 8,000 kms and a port stay of 10 days, the cost per tonne of cargo carried in a tanker is $2.92 for vessels of 25,000 dwt, $1.33 for ships of 100,000 dwt and $0.86 for ships registering 300,000 dwt. The bigger the vessel size, the lower the unit transportation cost. On the other hand, ore, crude oil and other raw materials, of course, are bulk cargoes. Because bulk cargoes consist typically of raw materials requiring further processing, and arrive in shipments far too large to be transferred directly to land transportation modes, it makes sense usually to terminate their journey in the port area, dumping the vast consignments of oil or minerals into large capacity storage vessels for insertion at convenient times in a manageable flow, either to be hauled inland in smaller instalments by barge or train, or (increasingly) to be refined or treated by giant processing industries conveniently located on the spot. In integrating the industrial complexes into the ports, the advantages accruing to firms and port authorities alike can be taken into account, besides saving on transhipment costs. This is the merit of port industrial complexes.

It is concluded that transportation of materials by large vessels, integrating complexes into the ports, and employing ironmaking and steelmaking works of large scale (in conformity with the best economies of the iron and steel industry itself) are the foundations for Chinese coastal iron and steel industrial development. After a series of surveys, the ports able both to handle 250,000 to 300,000 dwt vessels and host iron and steel complexes were identified. In detail, if dependence on a mix of domestic and imported ore is permitted, the preferred site is Jidong (Wangtan). If dependence on imported ore is the prevailing rule, access proximity to both to that ore and consuming markets must always be taken into account when choosing new iron and steel bases. Those sites meeting these requirements are Beilun, Zhanjiang, Rizhao/Shijiusuo and Meizhou Bay (Li, 1993). Upon examining the construction conditions for port and iron and steel complexes among the four sites, some impression of the prospects attending each site can be gained.

(1) Beilun port is regarded as to be most promising. An area of 20 km^2 of level land, enough to accommodate a ten-million tonnes' capacity iron and steel integrated works, is available; but a stretch of outer channel (water depth, -17.6 m) in Beilun port is in need of dredging. Since Beilun port is close to the Baoshan Iron and Steel Company, it is advised that the third phase of Baoshan ISC be resited to the Beilun port industrial zone so that the transhipment of imported ore for Baoshan third phase can be curtailed in this port. At the same time, with more deep-water berths in operation, this port will better serve as a transhipment node for the imported ore needed to supply the iron and steel works along the Yangtze River.

(2) In Zhanjiang port, the level land can support construction of an iron and steel complex boasting a capacity of ten million tonnes. Like Beilun port, the channels here need dredging if the harbour is to be entered by vessels of 200,000 dwt.

(3) Satisfactory conditions for port and port industrial construction seem to exist in Rizhao/Shijiusuo port, although the suitability of rock conditions for construction in the port area remains to be determined.

(4) Meizhou Bay is a deep-water port, but the existing port facilities, geographical location and the economic level in its hinterland are all inferior to their counterparts in the other

three ports.

In summary, the site for the first new iron and steel base should be chosen from the four candidates presented above, provided that the central government is prepared to rely completely on imported ore. A fifth site, Wangtan, is also worthy of consideration. This has the advantages of nearness to both ore resources and land for port developments. It is ideal for constructing a new iron and steel base once it is conceded that imported ore is needed to supplement the local supply. In the following chapter, each case will be analyzed in some detail with the purpose of arriving at feasibility studies of port-iron and steel industrial complexes.

CHAPTER FIVE. A MODEL INDUSTRIAL PORT FOR CHINA

As emphasized earlier, the development of the iron and steel industry in China will rely heavily on imported iron ore. Integrating the iron and steel complexes into the ports is the prevailing trend in the location of the contemporary industry, and China is no exception on that score. In fact, there already exists the example of Baoshan Iron and Steel Complex, located near the Shanghai port. In China, the construction of iron and steel complexes in conjunction with ports presents a number of possibilities. First there is the existing port precedent, one already enjoying an accompanying industrial complex. The aforementioned Shanghai port conforms to this class. Second, there is the case of extant ports that possess all the attributes of industrial ports, save the actual industrial complex. Beilun, Rizhao (Shijiusuo) and Zhanjiang stand out in this respect. Third is the instance of latent ports, those with the potential to assume the trappings of industrial ports but which are only now acquiring the barebones of complexes. Wangtan and Meizhou Bay fit the bill here. This last class, collectively, can be termed "incremental ports". The purpose of this chapter is to consider the merits of each possibility, describing specific examples of actual or would-be industrial ports. To this end, it is appropriate to begin with the existing port that comes closest to making the stipulated requirements of an integrated port-industrial complex, that is to say, Shanghai.

5.1 The existing port and iron and steel complex: Shanghai port and Baoshan Iron and Steel Complex.

5.1.1 The construction process

Located half-way up China's coastline and positioned in the northern suburbs of Shanghai, with the highly-developed Yangtze River Delta as its backdrop, the Baoshan Iron and Steel Complex is firmly ensconced within the port operation of Shanghai. Ice-free through all four seasons, this chief harbour of China boasts 80 km of shipping frontage along the Huangpu River. Today the harbour has 12 operational zones.

The ignition of the No. 1 blast furnace on 15 September, 1985 marked the completion of the first-phase construction of the Baoshan Iron and Steel Complex. The complex's power and coking plants, steelworks and rough rolling mill had begun trial production earlier.

It was China's first major project to import complete sets of equipment since 1949. Construction began in December 1978 but was suspended in 1980 because of China's economic readjustment and the resultant shortage of foreign exchange. Continuation of the two-phase construction at the complex was approved by the State Council in August, 1981. In the event, investment in the first-phase construction totalled US $11.56 billion, and the total weight of the equipment installed on site came to 406,000 tonnes. The weight of advanced imported equipment controlled by computers reached

367,000 tonnes. The No.1 blast furnace, with a daily output of 10,000 tonnes of iron, was imported from Japan. The cold rolling mills, composed of 18 production lines that can roll various kinds of steel plates continuously, were imported from Germany and four other countries. Among the imported technologies are two continuous rolling mills, which annually can produce 3.04 million tonnes of steel plates and billets a year, and hot and cold rolling mills, which can roll 4 million tonnes and 2.1 million tonnes of various kinds of steel plates and billets respectively.

As originally envisaged, the complex's first-phase production scale registered 3 million tonnes of iron, 3.12 million tonnes of steel, 500,000 tonnes of seamless steel tubes and 2.12 million tonnes of steel billets annually. After the completion of the second-phase construction, the Baoshan complex was forecast to turn out 6.5 million tonnes of iron, 6.7 million tonnes of steel, 4.22 million tonnes of steel products and 1.22 million tonnes of steel billets annually, a level of output second only to Anshan Iron and Steel Complex in Northeast China (Beijing Review, 1985). At the outset, the estimated cost of the first phase was placed at yuan 12.8 billion (US $3.46 billion) and of the second phase at yuan 30 billion (US $ 8.1 billion), inclusive of the first phase. Funds were to be provided by the central government, either directly or through the auspices of the China Construction Bank and China Industrial & Commercial Bank, at interest rates of less than 10 per cent. The second phase is to be partially funded from the complex's own earnings. In the light of soaring domestic demand, the production from the complex is earmarked for domestic sales only. Because such sales are priced lower than export sales, the payback period was expected to be prolonged to about 15 years. As indicated above, however, these plans did not proceed smoothly.

The Baoshan project, carried out with the co-operation of Nippon Steel and other Japanese companies as well as some German and American ones, went through considerable troubles. In 1979 and 1980, the project was strongly criticized in China and also by foreign observers on the grounds of poor design and site layout. The first contract had only just been signed at the end of 1978 when the government decided to slow-down the economic expansion of the country; this exacerbated both the timing and the costs bearing on construction at Baoshan. In view of the escalating costs (in 1980 they composed about 7 per cent of central government investments), Beijing suspended construction at the end of 1980. It was resumed only in August 1981, after studies had shown that to give up the project would involve much greater losses than to proceed further. Not only did cost escalate, but so did delays. Baoshan went on stream only in September 1985, three years later than scheduled. In spite of large training programmes for Chinese engineers and technicians in Japan and West Germany, the erection of this very modern complex relied mostly on imported machinery; a process in itself accompanied by many difficulties. No less than 1690 Japanese and West Germans, physically stationed on site, took part in the first phase.

5.1.2 Operation of Baoshan Iron and Steel Complex

Despite being hounded by critics during construction, the Baoshan complex, once operational, proved to be quite successful. The investment cost of Baoshan, around $1000 per tonne of capacity seems, now, quite reasonable and is comparable to similar plants around the world[1]. The following points greatly contribute to its smooth operation.

-- It was a large capacity plant to start with, and it will increase to about 10 Mt/year of crude steel or more.

-- It was implemented in phases, keeping in view the availability of funds.

-- The plant is equipped with the latest state-of-the-art equipment with large unit sizes and with appropriate automation and computerized control.

-- The bulk of the equipment was imported (mostly from Japan and West Germany and to a lesser extent from the USA and other countries) and thus conforms to international standards.

-- Unlike other steel plants in China, the manpower of the plant was kept to the minimum- closer to that of developed countries. Also, for the sake of both flexibility and economy, it was decided to dispense with captive iron ore mines and a refractory plant.

-- It possesses its own 700 MW (2*350 MW units) thermal power plant

[1] Under the rubric of 1980s technology, the yardstick for a 3-million tonnes-capacity integrated works is a capital cost of $1276; for the scale of 5 million tonnes in an integrated plant, the capital cost is $1147.

(imported from Japan). This will ensure that the company is not dependent on outside sources for power right through to its third stage. Its present power requirements are about 220 MW.

The company also sent a large number of its engineers and operators, about 10 per cent, for training abroad. Furthermore, a large number of experts from foreign companies supplying equipment also came for the purpose of erection, commissioning and providing training to Chinese personnel.

In order to ensure adequate involvement of domestic manufacturers of plant and machinery, a memorandum was jointly prepared and agreed to which defined the scope of the indigenous supplies but accorded to foreign suppliers the right to ensure satisfactory performance of the indigenous equipment supplied. It was intended that, in the process, the domestic manufacturers would have an opportunity to upgrade their technology and that later they would be able to meet requirements for spare parts and replacements from capacity available within the country.

An interesting aspect of the implementation of the project was that Baoshan's first phase was confined to the blooming mill, with the hot rolling and cold rolling mills reserved for the second phase. This was to enable the company to meet the pressing demands for the semi-products and to start earning profits as quickly as possible.

The list of production facilities, phase by phase, is given in Table 5.1 and the year by year initiation of major facilities is found in Table 5.2. Some of the technical aspects and parameters are given in Table 5.3. The second stage of the Baoshan plant is now in an advanced stage of implementation. It will have a capacity of 6.7 Mt/year of crude steel and the planned sequence of its development is shown in Table 5.1 (Etienne, et al, 1990, pp105-110).

Table 5.1, Baoshan phase by phase plant facilities

first phase: capacity 3.2Mt/year, commissioned Sept. 1985
-- unloading facilities for receiving imported iron ore and for domestic coal from ships up to 100,000 dwt (most of the equipment from Japan)
-- one sintering machine, 450 m^2
-- two coke oven batteries, 100 ovens each 6 m tall
-- by-product plant for coke-oven gas
-- one blast furnace, 4063 m^3 (from Japan)
-- two-oxygen converters, 300 t capacity each (3.2 Mt/year)
-- two-strand 1300 mm blooming/slabbing mill
-- one seamless tube plant, size up to 140 mm, cap 0.5 Mt/year
-- one 700 MW (2*350 MW) power plant (from Japan)
second phase: capacity 6.7 Mt/year, due for completion in 1992.
-- second sintering machine, same size, 450 m^2
-- two additional i.e., 5 coke oven batteries, 100 ovens each, 6 m tall, identical as 1st phase
-- 2nd blast furnace, same size, i.e., 4063 m^3
-- 3rd oxygen converters 300 t cap- same as 1st phase- to increase steelmaking capacity to 6.7 Mt/year.
-- two continuous slab casting machines 2 strands each, 1900 mm width, capacity 4 Mt/year
-- one hot rolling strip mill 2050 mm-wide strip, 4.1 Mt
-- one cold rolling strip mill 2030 mm-wide strip, 2.1 Mt

Note: In 1992, the steel output amounted to 6.48 million tonnes.
Source, Etienne, et al, 1990, pp105-110.

Table 5.2, Start-up of major facilities at Baoshan

1983	power plant
1985	coke ovens (from May), sintering, Blast furnace No 1 (15th Sept.)
1986	2nd converter & cold rolling strip mill
1988	3rd converter & cold rolling strip mill
1989	2*2 strand continuous casters hot rolling strip mill
1990	Blast furnace No.2 along with 2nd sintering machine and two additional coke-oven batteries
1991	plate mill (likely to be second-hand)

Source, same as Table 5.1.

Table 5.3, Baoshan: some of the technical parameters and features of its major facilities

-- The port facilities can handle ships up to 100,000 dwt. For bigger loads transhipment essential at Beilun near Ningbo
-- Power plant designed for using coal, heavy oil or gas
-- Coke-oven batteries provided with dry quenching, coal briquetting, coal preheating
-- 1st blast furnace with bell, 4 tap holes, 4063 m^3
  - Coke rate 435 kg + 50 kg of oil injection
  - Productivity 2.2t/Cum/day of blast furnace volume but aiming to achieve over 2.3 t soon
  - Hot metal analysis
    Si -0.5
    S - 0.023
    P - very low
  - for the time being Si is kept higher to use more scrap. Propose to have a desiliconization plant later.
  - No provision for coal injection but the same to be provided in the 2nd blast furnace
  - Casthouse granulation facilities provided with the blast furnace
-- 2nd blast furnace to be similar to above but with bell-less construction and with provision for coal-injection oxygen converters- mostly using Magnesia carb bricks though not entirely so far
  - lining life 1100 heats -said to be on lower side on account of high silicon at present in the hot metal
  - combine blowing
  - using 20 % scrap
  - provision for gas recovery and use for the converters

Source, same as Table 5.1.

For the third phase of 10 Mt/year, Baoshan intends to add the following facilities, not only to augment its capacity but also to balance it, so as to obtain optimum finished and high-value products:

-- third blast furnace of the same capacity as the earlier two, i.e. 4063 m^3;

-- additional coke ovens and sintering capacity;

-- matching additional oxygen plants;

-- plate mill;

-- additional hot rolled strip capacity;

-- two more cold rolled strip mills; and

-- hot dip galvanizing and electrolytic tinning lines.

Completion of this phase, however, is not expected before 1998.

5.1.3, Port facilities and the transportation of iron ore

Most steel plants in Shanghai received their pig iron from outside of the area; that is to say, the ironmaking plants were geographically remote from the steel plants. By contrast, Baoshan is modelled after Japanese coastal integrated plants. Like them, it relies on imported iron ore mainly from Australia and Brazil. Domestic ore constitutes only 5 per cent of Baoshan's ore intake. Iron ore consumption, compatible with the first-stage production of 3.0 MT/year of pig iron came to about 4.9 Mt/year. About 10 million tonnes of ore is required to fulfil the revised output of 6 million tonnes of steel.

In so far as coal is concerned, it will come from domestic sources. The coking coal originates mainly in Shanxi province. The coal is conveyed by the railway to Qinhuangdao port, then transhipped into coal carriers for onward transfer to Shanghai. However, in the event of any transport bottleneck, provision has been made for receiving coal from overseas.

As part of the infrastructure, the company has put up modern unloading facilities for iron ore and coal, with belt conveyors for the transport of the minerals to the plant. There is provision for maintaining a stock level of 15 days of coal supplies for the power plant, one month for the blast furnaces and two months for iron ore. There is also provision for dispatching about one-third of the plant's finished products by barges and ships.

In order to provide access for vessels bringing the iron ore, the raw materials' berths in Baoshan, designed exclusively for the Baoshan Iron and Steel Company and the biggest of all China's exclusive industrial berths, were built while the construction of the plant was in progress. Adding the products' berths, the total berth length amounts to 2,750 m, and embraces a 100,000-tonne berth, two 25,000-tonne berths and six 1,000-5,000-tonne berths. Because of shallow water in the approaches to Baoshan it was not possible to build the berths capable of accommodating ships exceeding 100,000 tonnes. An entirely new deep-water port called Beilun in Ningbo (130 nautical miles from Baoshan) was established to serve the ore transhipment. This port was designed expressly to serve "capesize" bulk carriers in excess of 100,000 dwt. At Baoshan itself, unloading facilities for receiving imported iron ore and for domestic coal were imported from Japan. As for Beilun, its facilities are reserved for attention later in the chapter. Figure 5.1 shows the relative locations of the Shanghai-Baoshan complex and the Ningbo-Beilun port.

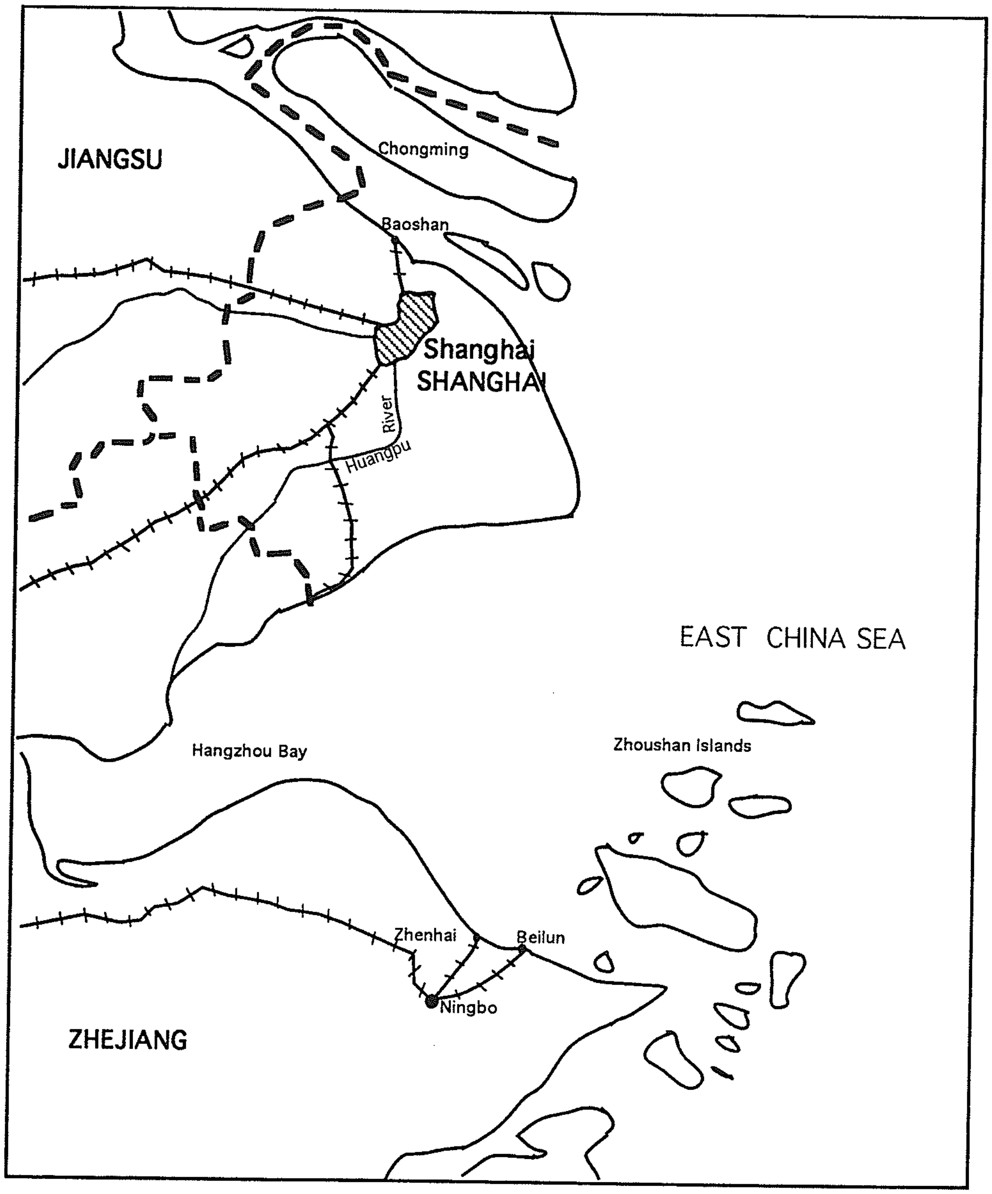

Fig.5.1, The Baoshan-Ningbo situation.

5.1.4 Port industrial layout and some comments

Before describing the layout of the port-industrial complex, it is necessary to give an overview of the industrial location in Shanghai. Located at the north and south end of Shanghai are two counties called Baoshan and Jinshan, both under the jurisdiction of Shanghai Municipality. Baoshan Iron and Steel Company owes its name to that of the county containing it. This complex grants Shanghai a heavy-industrial zone in the north. Balancing it in the south is the Shanghai General Petrochemical Company, the biggest enterprise of its category in China. The refining capacity of this industrial base in Jinshan county is put at 2.8 million tonnes per year (see Fig.5.2).

Shanghai port is the biggest in China. Its cargo volume exceeded 110 million tonnes in 1990. More than 91 per cent of this figure is handled by the operational berths along the two sides of the Huangpu River. The entire riverfront is devoted to port activities in and about the city. Cargo throughput is expected to attain 200 million tonnes by the year 2000, however, and the planners have anticipated it by earmarking new areas for development. In this respect, Outer Gaoqiao is a priority choice. It is tucked in back of the Pudong Economic and Technical Development Zone. This last is visualized as the impending financial and trade centre of China, and possibly all of East Asia (see Fig.5.2).

Figure 5.3 for its part displays the layout of the Baoshan Iron

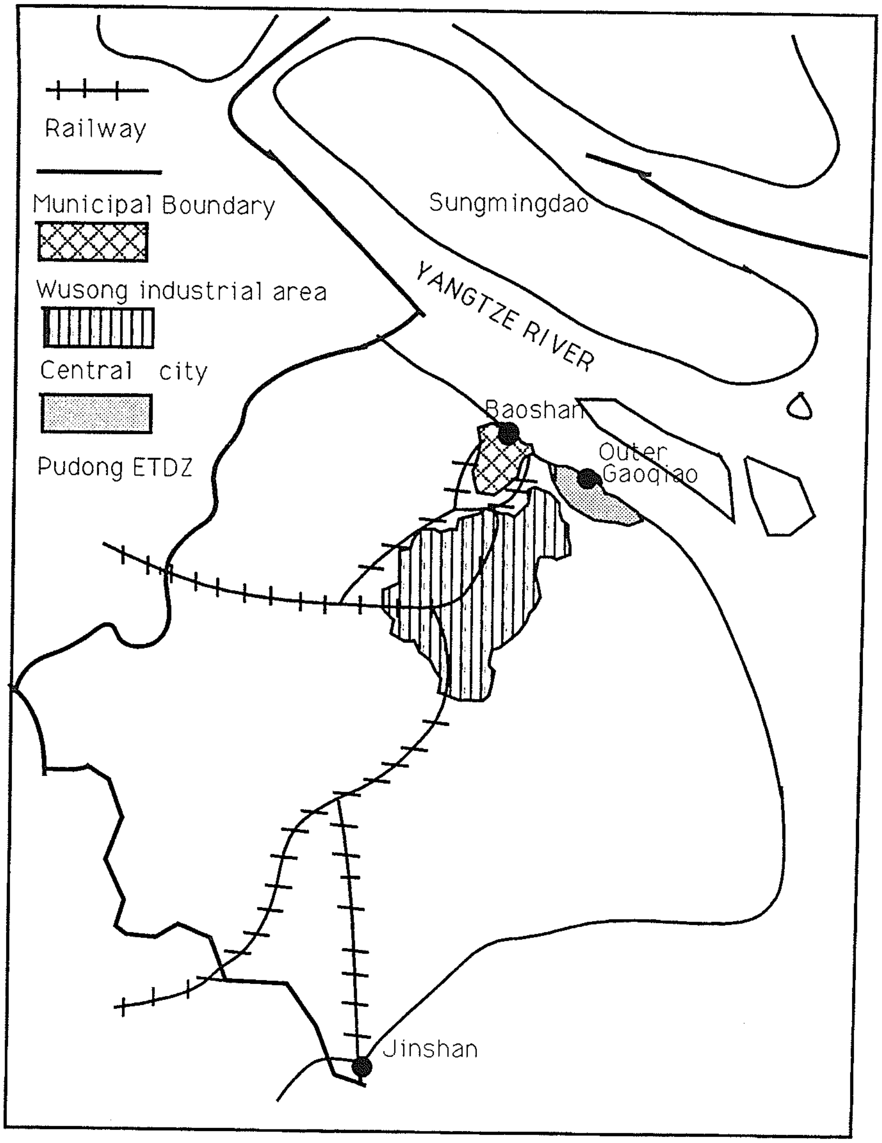

Fig.5.2, Shanghai city region.

and Steel Complex. The whole complex is arranged along the banks of the Yangtze River. The raw materials' berths and the heavy-oil berth are to be found in the northeast. The raw materials are unloaded at the berths and then transferred to the stacking area for the storage of ore, storage of coal and storage of coking coal. Next to the three storage areas are the coking plant, sintering works and a chemical factory. Behind these plants are the ironworks, power station and iron-casting plant. Then come the steel workshops, the cold-rolling plant and hot-rolling plant and the seamless-steel tube factory. The final constituents of the site are the warehouse and open storage of equipment areas, the latter connecting to the finished-product berth. Surrounding this core are some management centres and residential and recreational facilities. The layout of the plant is quite modern with large avenues, a green belt, a large number of trees and an unobstructive railway track. This is an obvious example of a port industrial complex designed from the outset as a coherent unit.

As mentioned above, the final capacity will be 10 million tonnes after the third phase and the site has ample room to accommodate any expansion of facilities that this may entail. Nevertheless, the complex occupies a compact site, benefiting from several advantages. These are listed in point form.

(1) It possesses modern and large-scale equipment with higher productivity and lower energy consumption per unit of output in comparison with older, smaller-scale equipment.

(2) It occupies a coastal location where good quality imported

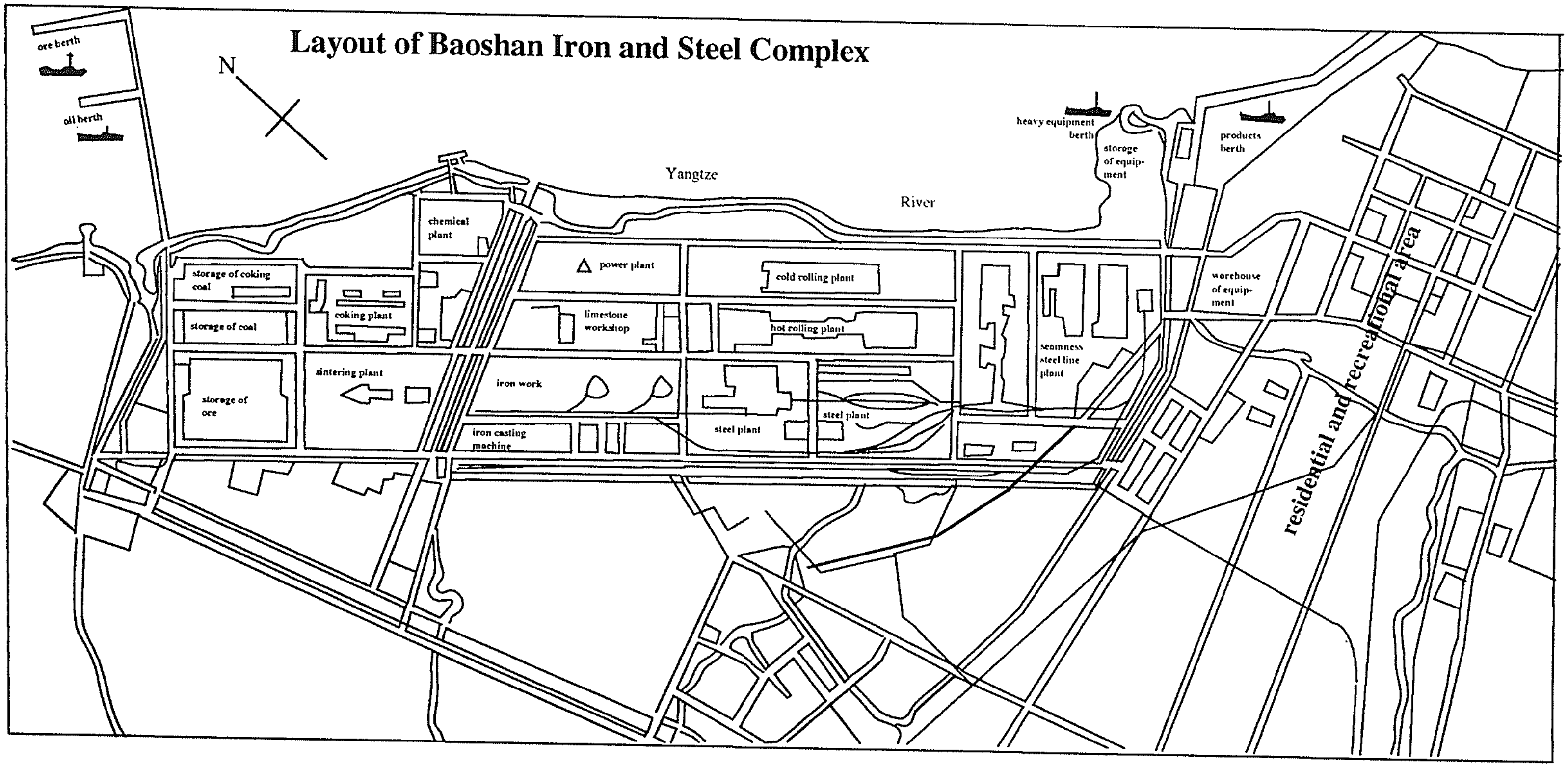

Fig.5.3, Layout of Baoshan Iron and Steel Complex
Source: Baoshan Iron and Steel Company, 1990, p357.

iron ore can be obtained.

(3) It is relatively sparing (by Chinese standards) in manpower (about 35,000 at the 6.7 Mt stage); owing to the fact that several activities such as refractory plant, iron ore mines, etc., have been deliberately excluded from its remit.

(4) It can capitalize on the advantage of its location, one with a large market in Shanghai itself. During the period of the Sixth Five-Year Plan, the steel consumed in Shanghai recorded 13.6 million tonnes, or 6.7 per cent of China's total. Adding the steel consumed in the adjoining provinces of Jiangsu, Zhejiang and Anhui, these figures were adjusted upwards to 38.9 million tonnes and 19.2 per cent respectively.

However, some ominous factors cloud the complex's prospects and the most important of these stems from the site-selection process. Inadequate or too rapid pre-investment surveys led to mutual complaints from the Chinese and the Japanese. The Baoshan site, by virtue of its position adjacent to the Yangtze river, consists of soft river mud soils so that huge quantities of concrete piling were needed to support the heavy structures of the plant. Then came the necessity to build the entirely new deep-water port at Beilun, 130 nautical miles away, to unload the iron ore imported from Australia in ships exceeding 100,000 tonnes. 'Capesize' ore carriers, those rising to about 170,000 dwt are the preferred means of conveyance for this ore. Not only can Baoshan not accommodate them, but it cannot take vessels up to its designed capacity of 100,000 dwt. Enforced usage of Beilun imposes an extra cost burden on ore imports. Not only are per tonne costs increased from 37.4 yuan to 41 yuan (if the storage fee is added, this figure will rise to 51 yuan), but time costs are incurred since the transhipment operation from Beilun to Baoshan takes over three days. Evidently, erecting a complex alongside the deep-water berths at Beilun would suffice to eradicate this wasteful transhipment operation. That possibility is considered below.

5.2 The possible modifications of extant ports

5.2.1 Beilun harbour and iron and steel complexes

Beilun, one of China's few deep-water harbours, is backed by Ningbo City. Lying southwest of this deep-water harbour is the Ningbo Economic and Technological Development Zone founded in October 1984. Currently, it covers an area of 29.6 km^2, making it larger than many other zones in China. The most attractive plot is the 2.3-km^2 Ningbo Free Trade Zone. The FTZ enjoys the benefits of the preferential policy granted to Special Economic Zones and Economic and Technological Development Zones, but it enjoys other benefits besides. These can be characterized by freedom to import and export goods, exchange foreign currency, and exchange personnel, all without excess bureaucracy. Between Zhenhai and Beilun harbour area (see Fig.5.4), a maritime industrial development area has formed. Located in this MIDA is a series of industrial projects. The Petrochemical Project was established by the Concord Group of the

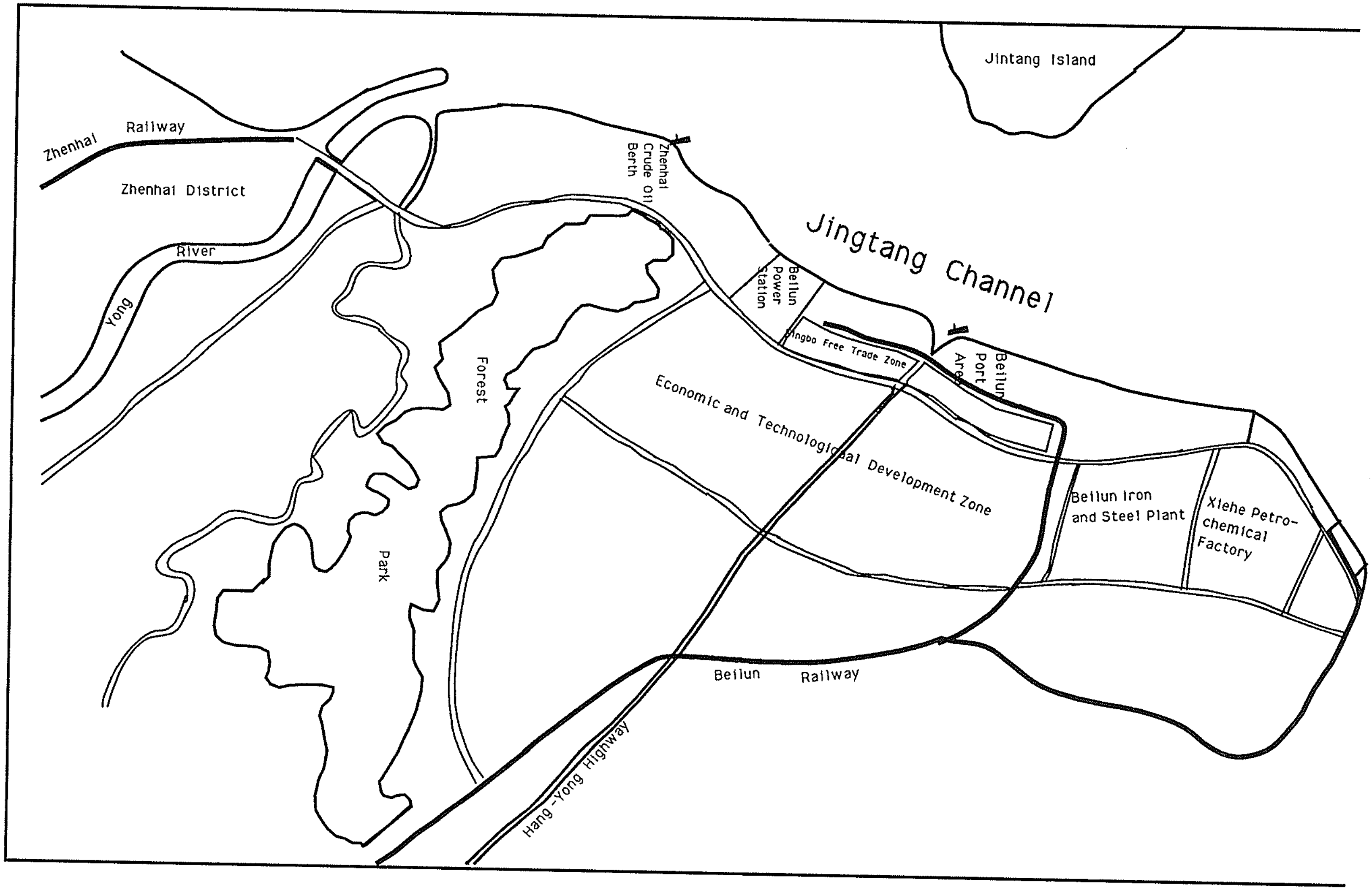

Fig.5.4, The Port Areas of Ningbo and Beilun MIDA

United States. At the end of May, 1993, the US side and the Beilun District Land Administrative Bureau of Ningbo formally signed a contract to transfer the right of use of 6 km^2 of land in Beilun district to build a 5 million tonne-capacity oil refinery and a 300,000 tonne-capacity ethylene plant, plus a 45,000-spindle chemical-fibre factory and associated dock and other project facilities. About US $ 1 billion will be invested in the first phase. The China National Paper Industry Co. Ltd., set up by an Indonesian group, plans to spend US $ 1 billion to build a 1 million tonne-capacity copperplate-printing paper scheme. Of particular relevance to us is the Beilun Steel Plant. With an initial production of 1.5 million tonnes annually, this enterprise was jointly conceived by the Concord Group of the United States, the Baoshan Iron and Steel Complex and the Ningbo Development Zone. In 1992, the contract for the first phase was signed with total investments of US$ 1.96 billion (You, 1993). The heavy industries are most decidedly aggregating around Beilun port. What of the port itself?

Beilun harbour is located at the mouth of Hangzhou Bay, about 130 nautical miles away from the Wusongkou in Shanghai. The water depth amounts to 17-20 m. In 1978, in order to serve the Baoshan Iron and Steel Complex, this harbour was constructed with the capacity to handle 20 million tonnes of ore transhipment annually. In this deep-water berth complex, iron ore from a bulk carrier berthed at a 100,000 tonne-class wharf was unloaded onto a conveyer belt stretching over several kilometres. Not far from this base, a

200,000-tonne-class ore transit wharf was put into operation in November, 1994. On the other side of the harbour is a group of docks for amassing up to one million tonnes of ore and coal. From this location, iron ore from Australia is held for Baoshan, where a feeder service is maintained using vessels usually of about 25,000 dwt.

Although Beilun was initially conceived as an ore transhipment port for Baoshan, its function has grown to greatly exceed this role. Nowadays, it serves three major roles. First, it is a national transhipment port for goods, lumber, and international containers for long-distance (over 3,000 nautical miles) oceangoing ships. Secondly it is the external port of Shanghai economic zone, sharing in the handling of the goods from Shanghai and areas in the middle and lower courses of the Yangtze River. Thirdly, it is the port serving the local economic development of Zhejiang province as well as the city of Ningbo (Lo and Song, 1992). The immediate hinterland of Beilun harbour consists of the lower reaches of the Yangtze River by dint of its monopoly on deep-water access. Thus, Ningbo port is the linchpin of sea transportation in Middle China and the connection node between inland navigation and ocean transportation. The distance between this harbour and the chief Asian ports, such as Hong Kong, Busan and the major Japanese ports, is within 1,000 nautical miles. The port has links with more than 20 countries. Domestically, Ningbo port has established connections with 16 provinces and municipalities either through coastal shipping or by Yangtze River water routes. Very importantly, it fulfils the role of transhipping cargoes from large-sized sea-going vessels to middle- and small-sized inland river vessels, compensating for the incapacity of Shanghai port to undertake comparable functions. As intimated, without this capability, the Baoshan metallurgical complex would find life far more difficult. The transhipment role is not solely of benefit to Baoshan, however. With the expansion of Wuhan, the Maanshan Iron and Steel Complex and other ironmaking and steelmaking works along the Yangtze River, it has become necessary to contemplate the import of a great amount of iron ore to meet their new requirements. Beilun steps into the breach; for the ore in question will be discharged there prior to onward transfer in vessels capable of river navigation. To expedite matters, the state is going to channel more funds to speed up the construction of deep-water berths able to take vessels up to 150,000 tonnes in Beilun. Of course, by making use of these port-related discharging facilities, the on-site Beilun Iron and Steel Complex not only consolidates the benefits of a MIDA but can acquire a competitive edge in transport costs over its Shanghai and upriver rivals. Given the general conditions applying to the impending complex at Beilun, it is appropriate to proceed to enquire into particular conditions-- especially with respect to infrastructure provision-- which underscore the attractiveness of the MIDA.

It was stated in Chapter One that site factors play an important role in determining the location of the iron and steel industry. The site factors at issue involve the supply of water and power, the availability of level land and, critically, the installation of a transport network for assembling raw materials on the one hand and distributing the finished products on the other. In addition, an improved urban infrastructure is judged to be a significant accessory, since not only does it aid in housing the labour used in construction (including those associated with foreign participation), but it also gives the permanent work-force an assortment of amenities. During the period of the Seventh Five-Year Plan (1986-1990), the Ningbo port was subjected to intensive construction. Twelve berths with capacities of more than 3,000 tonnes were built, nine of which could take ships of more than 10,000 tonnes. A total of 49.69 million tonnes of handling capacity was installed in the port. In 1989, the actual total cargo volume outgoing and incoming achieved by the port was 20.2 million tonnes, although this figure was surpassed in 1990 to reach 25.53 million tonnes. Yet, the throughput amounts to only half of the designed capacity. This situation differs markedly from what occurs in other Chinese ports where the situation is characterized more by under-capacity than by over-capacity. Supplementary transport infrastructure-- roads, railways and airline connections-- have also been attended to. For example, the rail lines have been newly built from Ningbo to Beilun.

Nor have power facilities been neglected. Zhenhai power plant, with an annual capacity of 1,050 MW, is 20 km from the planned Beilun Iron and Steel Complex. Furthermore, the first phase of the Beilun power plant was finished during 1993. With it came 1,200 MW of installed capacity. A second phase will double that capacity. This power plant is placed only 7 km from the site of the Beilun Iron and Steel Complex. The power will be enough to guarantee the operation of all the developments envisaged for the complex.

Water resources in Ningbo are plentiful. The run-off volume is about 2.5 billion m^3, with only 18 per cent being tapped. The abundant fresh-water resources will meet the demand of an iron and steel plant of six million tonnes' capacity without undue trouble, to say nothing of the demand imposed by other industries in the MIDA and domestic users. A project to install the urban water supply network is under way with the benefit of a loan from the World Bank. This project will furnish the water supplies to the Beilun Complex, too.

Telecommunications have not been ignored. A 7,000-line computer-controlled telephone exchange in the Beilun area allows the user to switch through Ningbo Municipality and reach the world.

Since Ningbo ultimately falls within the Shanghai economic zone, with all that is thereby entailed in terms of advanced industrial development by Chinese standards, the construction of Beilun Iron and Steel Complex will not be impaired through lack of skilled workers and management. These can be deployed fairly easily from the Baoshan Iron and Steel Complex. In a word, the external environment is conducive to the inauguration of this iron and steel complex. Let us describe the scope of the planned complex, beginning with the question of materials supply.

The first phase of the Beilun venture is centred on an output of three million tonnes of steel. To meet that target, 5.18 million tonnes of ore will be required. Completion of the second phase for a total of 6.64 million tonnes of steel, calls for 10.33 million tonnes of iron ore to be supplied annually. As mentioned above, 10 million tonnes of ore is already being imported annually to meet the demand of China's iron and steel development. The industry as a whole will steadily increase its reliance on imported ore when coastal plant locations become prominent. Thanks to its big berths, Beilun has become the biggest base for imported ore transfer. That is the situation obtaining for ore, but how do things stand in respect of basic fluxes?

For the first phase, an estimated 1.1 million tonnes of limestone is needed, together with about 0.6 million tonnes of dolomite. After the second phase is brought to fruition, the demand for limestone will rise to 2.2 million tonnes, whereas the supply of dolomite will amount to 1.2 million tonnes.

The limestone reserves at Dashandian in Fuyan county have been surveyed and found suitable to be the limestone source for the Beilun Iron and Steel Complex. The reserves of B and C-grade materials total 63.81 million tonnes. Their average chemical content is 54.46 per cent CaO and 1.58 per cent SiO_2. The limestone can be transported by inland waterway to Ningpu station and then transferred by Zhe-Gang, Xiaoyong and Beilun railway to the iron and steel plant (see Fig.5.5). The total transportation route registers 252 km, of which railway equals 199 km and waterway makes up the balance of 53 km. The scale of mining for the first phase is

1.2 million tonnes per year and will finally reach 2.4 million tonnes. The investment estimated to accomplish the venture is 100 million yuan, 80 million of which is for the mineral mining and the rest for the construction of transport links.

For its part, the dolomite can be supplied from Yihang city. The reserves of B and C-grade material are put at about 92.95 million tonnes. Their average chemical content is MgO 21 per cent, CaO 30 per cent and SiO_2 1.52 per cent. The dolomite is procured via an 11 km-long highway and a 242 km-long railway which, in combination, convey the material to the iron and steel plant (see Fig.5.5). The scale of mining for the first phase is 750,000 tonnes annually, rising to 1.5 million tonnes a year when the second phase comes on stream. The total investment is expected to reach 50 million yuan, 15 million of which will be dedicated to the construction of transportation facilities (such as the highway from the dolomite site to Yihang, and so on) and 35 million of which will be channelled into mining operations. Overshadowing the flux materials is coal, especially the coking variety.

The total demand for coal for ironmaking and steelmaking at Beilun is estimated as 3.12 million tonnes for the first phase centred on a 3 million tonne output scale and 6.2 million tonnes for the final scale of 6.64 million tonnes' capacity. Beilun, like other steelmaking complexes, can turn to Shanxi province for its needs regarding high-quality coking coal. The Gujiao mineral field is the main source of coking coal. There are five mines (see Table 5.4) in this field with a combined capacity of eight million tonnes

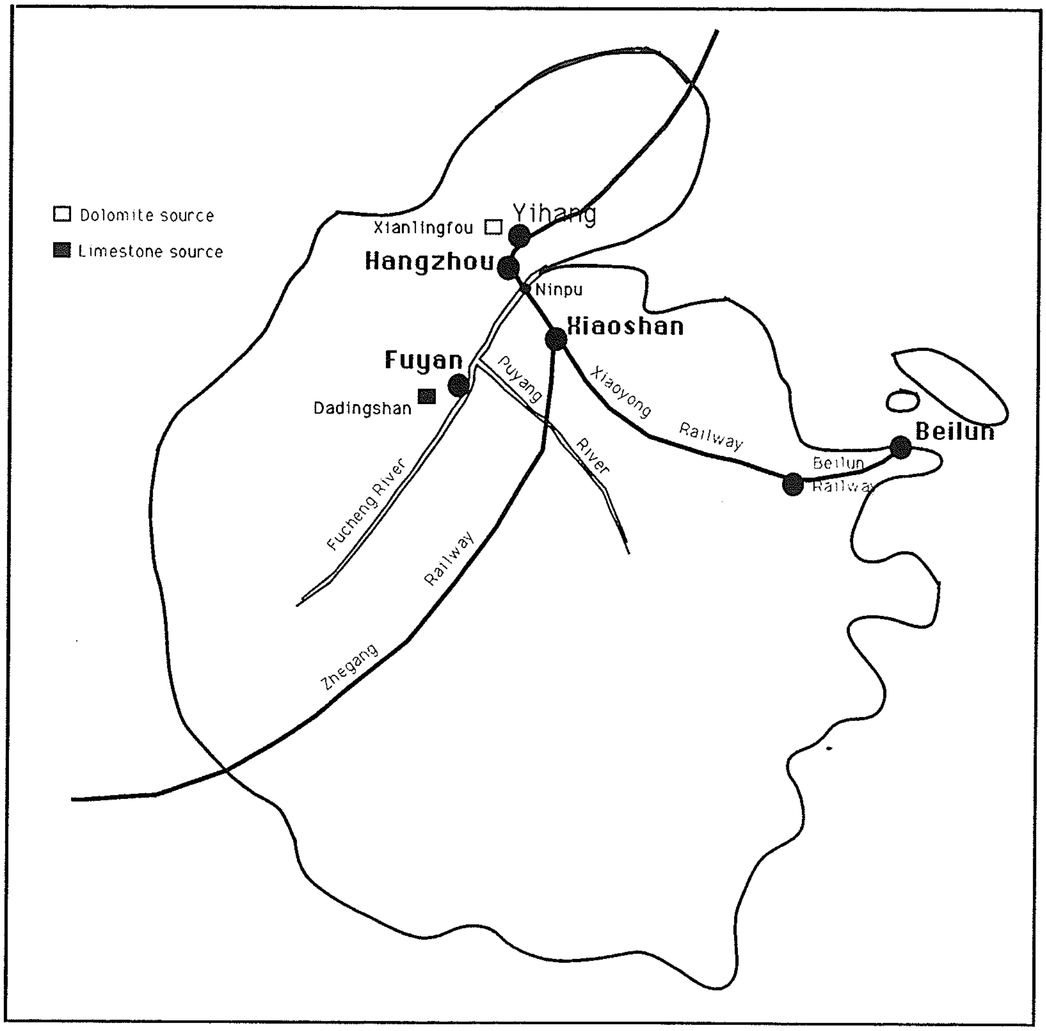

Fig.5.5, The supply and transportation of basic fluxes for the Beilun complex.

of coking coal and two million tonnes of rich coal. The coal mined in Xiqu and Zhenchengdi is supplied to Baoshan and Anshan iron and steel complexes. The other three mines are available for serving nascent iron and steel complexes, such as the one at Beilun.

Table 5.4, Designed capacity in Gujiao mining field

Mine	mining reserves (100 m tonnes)	designed capacity (tonnes/y)	type of coal	Year of operation
Xiqu	5.33	3,000,000	coking	1985
Zhenchengdi	2.43	1,500,000	rich, coking	1987
Malan	10.20	4,000,000	coking	1989
Tunlan	7.73	900,000	coking	1989
Dongqu	5.71	3,000,000	lean	1989
Total		12,400,000		

Normally, the coal from Shanxi province is transported by railway to the coast at Qinhuangdao or Rizhao before transhipment via collier to the point of consumption. In practice, the coal from Gujiao would be conveyed over the Datong-Qinhuangdao heavy-load railway to Qinhuangdao and then carried to Beilun by 30,000-50,000 dwt vessels. The state is planning to install more unloading berths for coal in Beilun. The discharge port will also become one of the key coal transhipment bases, specially serving the lower and middle reaches of the Yangtze River. This latter situation can only be regarded as favourable for the construction of Beilun Iron and Steel Complex because it should effectively cross-subsidize the shipment of coke for the MIDA. Coal needed for power generation both on-site and for the MIDA at large will be obtained from Datong, Shanxi province, using the same transportation line as that set up for coking coal (see Fig. 5.6).

All these materials will be brought to the site of the Beilun Iron and Steel Complex itself. This is located 38 km away from the old urban built-up area of Ningbo. To the east of the site lies the Beilun harbour, to the west is the railway linking Beilun with Ningbo. The Jintang water channel is in the north and state highway No. 329 goes through the southern extremity of the site. In the east of the works site, the storage of waste materials is planned. The second phase of this complex will expand towards the south to meet the state highway. Altogether, there are 12 km^2 of level land available for this iron and steel complex and this area is ample for a scale of operations of 6 million tonnes. Table 5.5 summarises the land allocated for the constituent parts of the complex.

Table 5.5, The land use of Beilun Iron and Steel Complex

item	unit	first phase	second phase	total
production scale	10^4t/a	356	308	664
product. land	ha	650	550	1,200
storage land	ha	50	50	100
construct. land	ha	200	0	200
resident. land	ha	200	100	300
total	ha	1,100	700	1,800

The importance of building the Beilun complex is acknowledged in a series of reports dwelling on themes such as the Ningbo economic development plan, the economic strategy of Zhejiang Province, and the industrial adjustment plan of the erstwhile Shanghai Economic Region. Its importance has also been conceded in

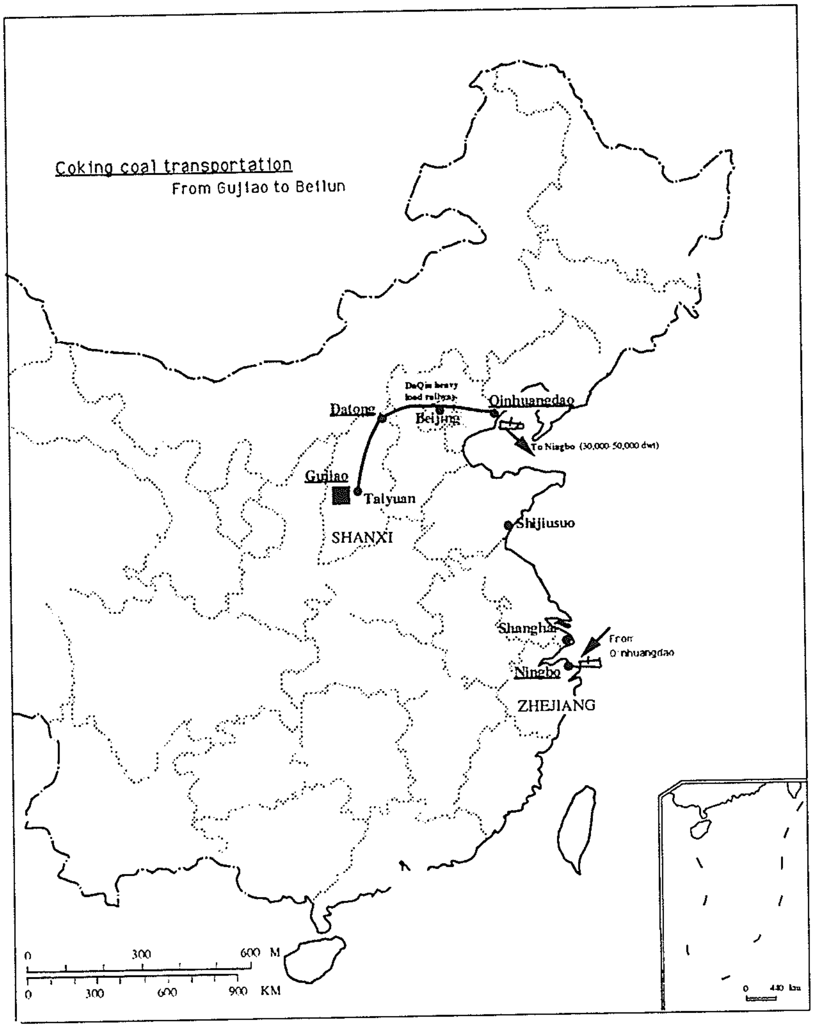

Fig.5.6, Coking coal transportation from Gujiao in Shanxi province to Beilun.

the outline of an integrated regional plan of China drafted by the State Planning Commission. According to the plan for the adjustment of Ningbo's industrial structure, for instance, iron and steel and petrochemicals are singled out as the principal industries to be developed by taking advantage of the city's favourable location and deep-water port. The overall urban plan of Ningbo approved by the State Council in 1985 has clearly stated that it is imperative to speed up the construction of the port, its assembling and the distributing networks, and to develop the iron and steel industry and petrochemical industry. Without doubt, then, the establishment of Beilun Iron and Steel Complex is an important item in the overall urban plan.

In terms of the proximity to the Baoshan Iron and Steel Complex, especially given the fact that Baoshan's ore is transhipped in Beilun, it is deemed advisable that the construction of the Beilun complex should be dovetailed into the third phase of the Baoshan Iron and Steel Complex. That way, the port deficiency plaguing Baoshan would not be exacerbated and, with much of the actual capacity embedded at Beilun, economies of deep-sea ore movement could at last be more fully utilized at a MIDA free from "Capesize" draught limitations.

5.2.2 Zhanjiang port and its iron and steel complex

As mentioned above, among the coastal provinces, Guangdong province ranks at the top in terms of shortfalls in iron and steel production capacity. Quite simply, there is no integrated iron and steel works of large scale in the whole of Southern China. Guangdong province accords high priority to remedying this defect. In order to take advantage of integrating the industrial complex into the port, the presence of a deep-water harbour is the factor deciding the preferred site. Zhanjiang port comes to the fore in this respect, as the following discussion will assess.

Zhanjiang port accesses the South China Sea through Guangzhou Bay. It has long been an important sea-land transportation gateway for foreign economic trade in South China. After steady expansion during the past 30 years, it has become the eighth largest port in China and the deepest one in South China. It handled more than 12 million tonnes of cargo in 1990. At present Zhanjiang is open to ships from about 70 countries. The makings of an integrated transport network, including seaport, air, railway and highway elements, have been implemented by the planners and are already contributing to the region's economic development. Among the principal seaports of China, this port is closest to Europe, Africa and Southeast Asia. The harbour is navigable year round and three small islands flanking the anchorage serve as a natural protective screen. A natural channel, 35 km long and 1,000 m wide, leads into the harbour.

Guangzhou Bay near Zhanjiang affords the deepest water. Its channel, which reaches 26-40 m in depth in places, is only 200 to 300 m away from the shoreline. Berths capable of taking ships from 100,000 to 300,000 tonnes can be built in Zhanjiang port. At the present time, however, the channel depth is only dredged to about 11-12 m, permitting vessels of 10,000 dwt access at any state of the tide and those of 50,000 dwt entry on high tides. By 1986, there were 16 berths, among which were 13 with a capacity range of 10,000 to 50,000 tonnes. Deliberations on 'strategic' location and deep water have a practical bearing on ore imports, to say nothing of the acquisition of other materials used in steelmaking.

As previously pointed out, China imports ore mainly from Australia. In comparison with the ports in East China and North China, there is a distinct advantage of shorter transportation distance when ore is imported reaching through Zhanjiang. For example, the transportation distance is 600 to 700 nautical miles shorter through Zhanjiang than is the case when Beilun is the destination for ore vessels from Australia. This distance reduction is equivalent to a 50 cents per tonne saving in freight rates. For a plant with a steel capacity of 6 million tonnes, the transportation-cost saving resulting from shorter-distance-routing would amount to US $ 4 million each year. Factors affecting coal transport are very different, however.

In China, coal is conveyed from North to South, a process which imposes a heavy burden on China's railways and water transportation. The coking coal used in most of China's iron and steel plants is obtained from Shanxi, a province far removed from Zhanjiang. Consequently, the iron and steel works installed in Zhanjiang could make better use of coal derived from Guizhou Province (Fig.5.7). Rich reserves of a variety of coals are found in the Lupanshui area of Guizhou. The Nannin-Kunming Railway, due for completion in the Eighth Five-Year Plan, will greatly improve coal transportation from Guizhou to Zhanjiang. In view of the reduced haulage distances involved, Zhanjiang should benefit from far better freight rates using Guizhou coal than would be the case if it is compelled to rely on Shanxi coal. After dealing with the position of minerals, it is opportune to turn to power and the 'ubiquitous' materials of water and land.

The on-going construction of Zhanjiang power-plant will be forthcoming with 600 MW of installed capacity in 1995, and 1,200 MW by the year 2000. This level of provision is sufficient to fulfil the demand of a Zhanjiang Iron and Steel Complex. Plentiful water resources can also ensure the development of this type of industry. The annual rainfall in Zhanjiang is 1,613.4 mm. There are six rivers whose collecting water area exceeds 1,000 km^2. The annual ground run-off volume records 8.301 billion m^3. The annual run-off volume passing Zhanjiang registers 8.47 billion m^3. The total ground run-off volume reaches as high as 16.7 billion m^3. Despite such impressive figures, the water resource actually exploited is only 3.0 billion m^3, less than 20 per cent of the potential; and this does not take into account an underground water reserve of 2.81 billion m^3. With respect to level land, there exists a large area of sandy ground near the existing port area which can accommodate a large-scale iron and steel complex with room to spare.

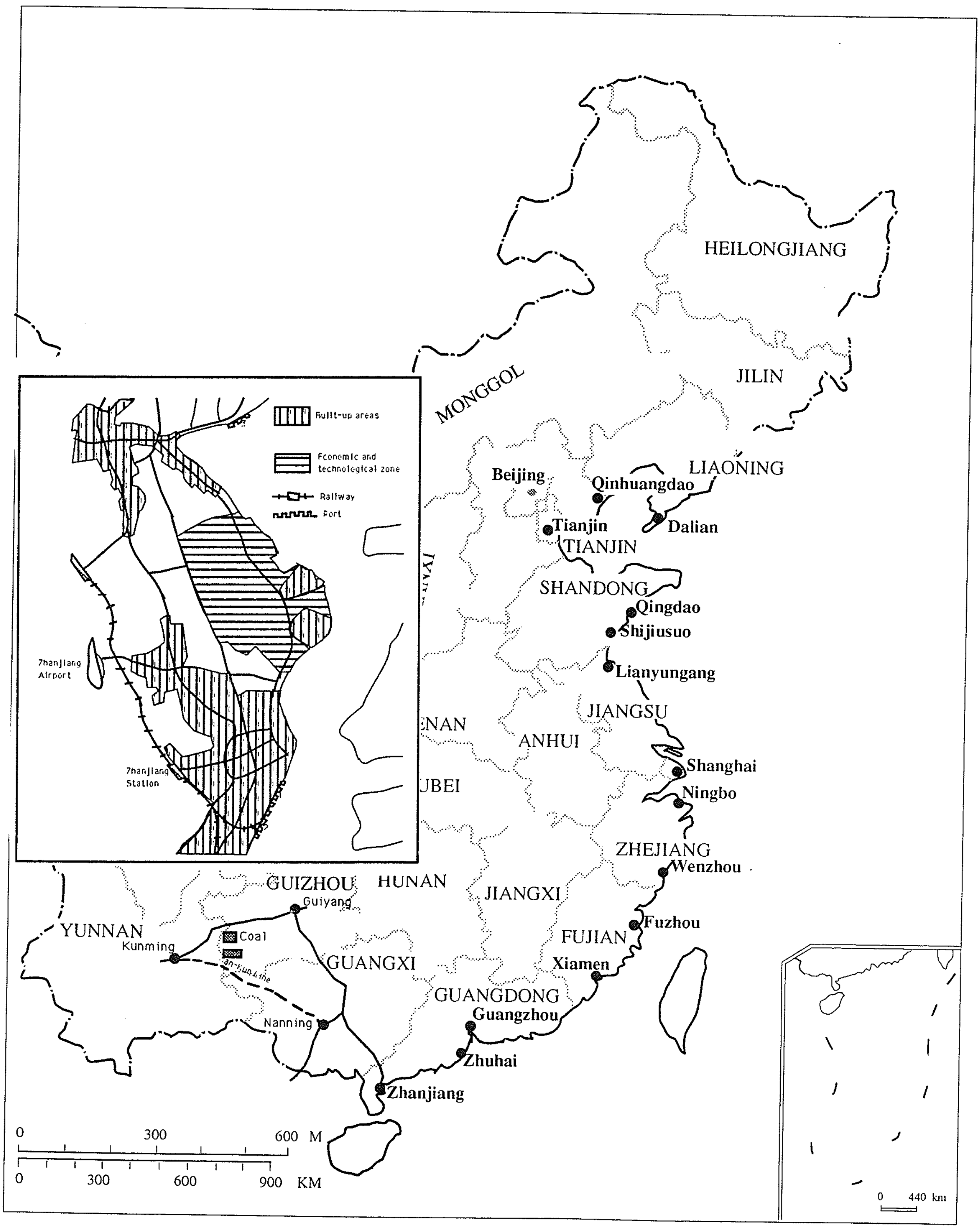

Fig.5.7, Coal supply to Zhanjiang and Zhanjiang Port

Finally, a comment about external cultural ties is in order. Owing to its favourable geographical location for easily accessing Hong Kong, Macao and Southeast Asia together with the fact that many overseas Chinese came from this region, Zhanjiang can attract investment from outside mainland China, thereby importing international advanced technical equipment and management expertise. Cultural ties might also help establish marketing ties for steel products throughout South-East Asia.

5.2.3 Rizhao Port and Iron and Steel Complex

Located in the coastal city of Rizhao in the south of Shandong Province, construction of what was then called Shijiusuo port, began in 1982 and was finished in 1986. The purpose of the port was to serve as a transhipment node for Shanxi coal bound for Shanghai and South China. In parallel with this port construction, a railway from Yingzhou was laid. Port works were undertaken on firm block rock. The natural water depth is up to 10m. No river empties into the port area, so there is no sedimentation. At the same time, the port is ice-free throughout the year. After dredging, the port was provided with a variety of berths, including one for 10,000-tonne ships, one for 100,000-tonne vessels and one for 25,000-tonne ships. These are specially geared for coal loading. The total berth length is 691m and storage volume is 238,000 m^2. As yet, though, the port lacks a good protective mole, since it opens directly to the sea. Plans exist for diversifying traffic. Stretching out 440m from the coal berth, a new berth will be established for imported ore, one which will be able to accommodate vessels of 150,000 dwt. The proposed strip conveyor, installed east of the existing bridge, would carry more than 10 million tonnes of ore to the iron and steel plant directly. Two factors are cited for pressing ahead with this expansion: first, incremental port costs for construction are said to be modest and, secondly, transhipment of ore can be avoided because large bulk carriers ('capesize' class) will be allowed to dock directly at the port within conveyor-belt distance of the steel complex. Moreover, it may be possible for these bulkers to avail themselves of "back-haul" cargoes, namely, return cargoes of export coal. If this latter prospect were to be realized, freight costs for procuring ore would be significantly lowered.

In fact, land links are also of vital importance, especially as they come to bear on coal supplies. As mentioned above, attention was given to railway connections from the inception of the port.

The Shijiusuo-Yingzhou Railway stretches westward to Yingzhou and then connects with a route of national importance, the Jinpu line running from Tianjin to Shanghai. In a westward track the Shijiusuo-Yingzhou line links with Jilin, Hezhe and Houma and ultimately extends to Xian in Sha'anxi province. The line to Yingzhou is 307 km long. Along it are rich reserves of coal, limestone and dolomite, which can be supplied to the projected iron and steel complex at Rizhao. As estimated by railway experts, this railway's carrying capacity can meet the traffic demands compatible with the first phase of three million tonnes for an integrated iron and steel complex. In the future, this railway is planned to connect with the Jiaohua railway in the north and Lianyungang port in the south.

These rail developments are critical for obtaining coking coal from Shanxi, but other kinds of coal van be found much closer to the port. Indeed, there are rich reserves of coal in Shandong province itself. By the end of 1989, the accessible reserves numbered 20.2 billion tonnes, among which 15.3 billion tonnes can be used in various industrial activities. In 1988, the coal production reached 55.16 million tonnes, the output of washed coal was 9 million tonnes. Bituminous coal is particularly abundant, more than enough to satisfy the requirements of iron and steel industrial development.

Rizhao city, its average annual rainfall registering 917 mm, is one of the best endowed water-resource areas in Shandong Province. There are nine rivers running through Rizhao city, of which the Futong River is the biggest. Twenty kilometres away is a reservoir built to hold 270 million m^3 of water. The underground water resources in Rizhao can be reserved for residential use while the water volume of existing reservoirs can meet the demand arising from the first phase of the proposed Shijiusuo iron and steel complex. What is more, water from reservoirs in Ningyi county can be diverted to Rizhao city when the second phase of the complex is given the go-ahead. In a similar vein, electricity can come from the Shijiusuo power plant which will be built in conjunction with the construction of the iron and steel complex. That complex is visualized as having the characteristics discussed below.

The total demand of iron ore and basic flux materials is shown in Table 5.6. This iron and steel complex in the main can depend on ore imported from Austrian and Brazil. If need be, local ore from Shandong province can be substituted for the imported variety, although its generally low grade makes it less attractive. The locations for local ore are Dongping, Guangli, Chunyi and Hanwangwoufushan. The total potential deposit of three of them, Dongping, Hanwangwoufushan and Gangli, is 1.32 billion tonnes and explored reserves equal 852 million tonnes. Mineral deposits in these ore-fields are close to the surface. For example, the depth is about 400 m in Dongping. The average iron contents in Gangli, Dongping and Hanwangwoufushan are 46.3 per cent, 30 per cent and 36 per cent respectively. It is conceivable that output could be raised to 12.5 million tonnes of crude ore and 4.5 million tonnes of washed ore (with grade of 63-64 per cent) annually. First costs associated with such levels of output are put at 1.85 billion yuan and from three to seven years would be required to effect production. The locational aspect is much more promising with respect to limestone and dolomite supplies. Regarding the former, the Changshan limestone range in Pingyi is about 9 km from Pingyi Station on the Yingzhou-Shijiusuo line (see Fig.5.8). The mineral site is connected to the railway by road. Explored reserves there amount to 24 million tonnes, with potential reserves put at 100 million tonnes. This range is characterized by quality composition and is easily exploited by mineral stripping. For the first phase of three million tonnes of steel production, the mineral capacity of limestone should be one million tonnes per year. First cost for mining will come to 43.9 million yuan. For the second stage of six million tonnes of steel, the limestone mining capacity should reach two million tonnes, requiring total investment of 83.2 million yuan for mining expansions.

Table 5.6, The demand of iron ore and basic flux materials

items	3 million tonnes(mt)	6 mt
Washed ore	4.86 mt annually	9.72 mt
Limestone	900,000 tonnes	1.8 mt
Dolomite	160,000 tonnes	320,000 tonnes
Serpentine	130,000 tonnes	240,000 tonnes

Note, 3 million tonnes refer to the scale of this iron and steel complex.

Considering the latter, Shandong province holds abundant dolomite resources. Changshengzhang, in Guixian county, has reserves of 71 million tonnes, all of high-quality composition. The distance between the mine site and Yanwaizhang Station on the Yingzhou-Shijiusuo line is only 3 km (see Fig.5.8). For the complex's first phase, the annual output of dolomite should be 150,000 tonnes, costing 5.15 million yuan in first cost. For the second stage, the dolomite mining capacity should reach 300,000 tonnes a year, with a further allocation of 8.48 million yuan required to install an extra mining plant. We should not forget serpentine, for it is also a key flux material. About 147 million tonnes are said to occur in Shandong province. The principal site is the Shouroushu Range in Rizhao Municipality with reserves of 128 million tonnes. This site is only 9 km from Jifeng Station on the Yingzhou-Shijiusuo line and a mere 40 km from the site which would house the proposed iron and steel plant. Annual serpentine output should be 200,000 tonnes for the first phase of the steel complex and associated first costs would be 19.4 million yuan. For the second phase, the serpentine output should reach 400,000 tonnes a year, requiring another 26.7 million yuan in inauguration costs.

We have already remarked on the presence of coal in the province, but an additional comment is useful at this juncture. In 1990, provincial coal output amounted to 60 million tonnes. Most of the coal demanded by the proposed complex thus can be met by Shandong suppliers. In particular, the gaseous coal and power coal can come from Yingzhou, Jilin and Tengnang mines. Only the coking coal should be brought from Shanxi Province (see Fig.5.8). The total coal demand anticipated for this complex is shown in Table 5.7.

Table 5.7, The demand of coal in Shijiusuo iron and steel complex

	3 Mt	6 Mt
Coking coal		
gaseous coal	1.9	3.8
rich coal	0.76	1.52
coking coal	0.57	1.14
lean coal	0.19	0.38
power coal	0.8	1.5
anthracite	0.4	0.8
total	3.1	6.1

What about the site itself? It is located at Wangpingkou in the east of Rizhao Municipality, 7 km away from the city and a mere 1

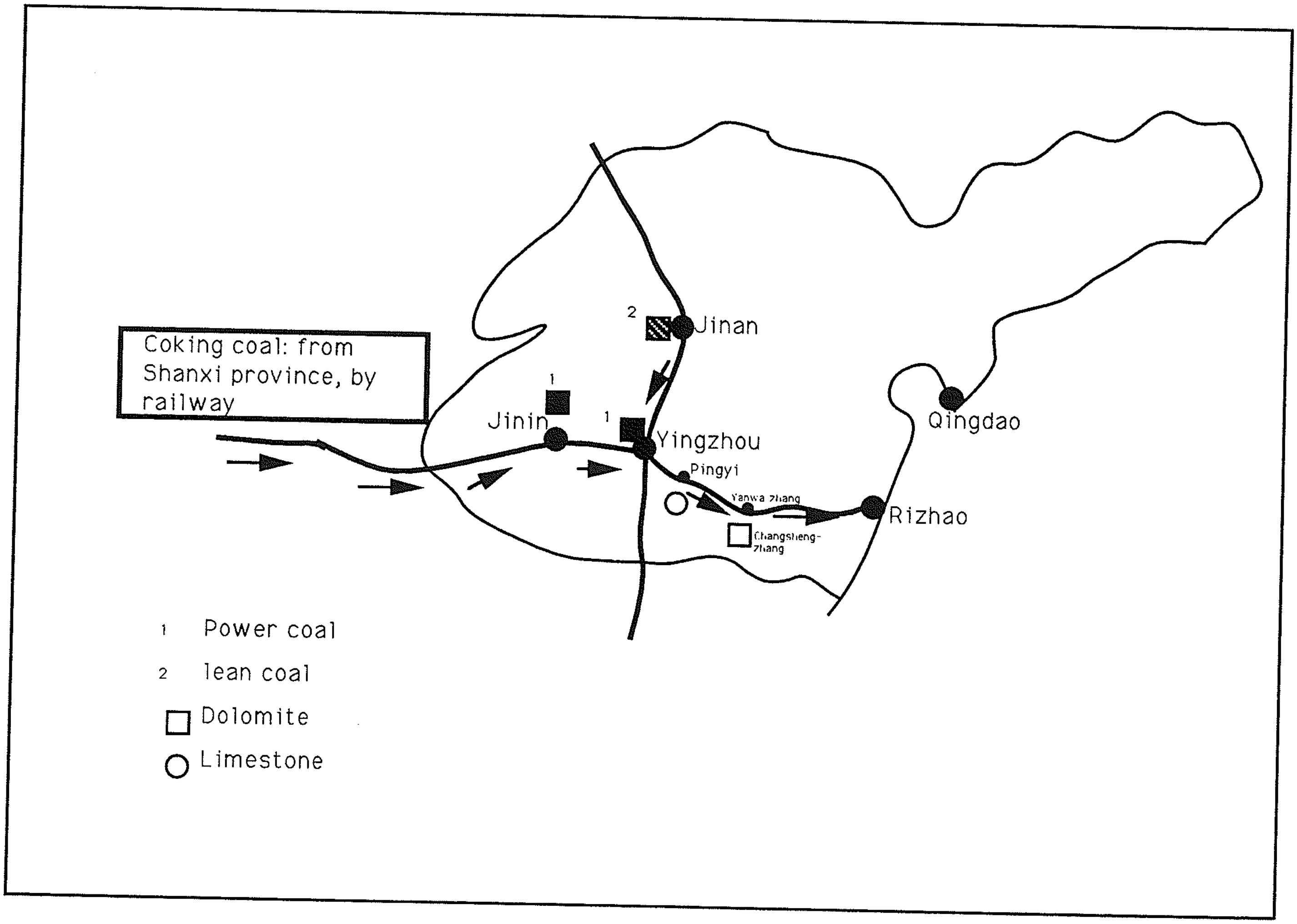

Fig.5.8, Coal and basic fluxes' supply to Rizhao complex.

km from the port. On its north side is Xiaotan village; to the east is the shore of the Huanghai sea; to the west are the villages of Maojia and Lijia. The zone covers a total of 18 km^2: from east to west is 3 km, from south to north is 6 km. Upon completion of the second phase, 12 km^2 of level land will be taken up. Although this site is 2.5 km away from the ore berth, the ore can be carried to the plant directly from the berth by conveyor belt. One recommendation is to have a product berth installed on the east side of the plant (shoreline) to distribute the products to other provinces of China.

Westward from the central plant area, the elevation rises at first before gradually subsiding. A hill serves as a water divide. To the west of this demarcation line, the rain accumulates and flows to Guhe river; to the east, the rain flows directly into the sea. The whole 12 km^2 should be free of flood damage, but high tides may affect other parts of the zone. Some characteristic tide values in Shijiusuo Port are recorded below:

(1), average sea level: 0.05 m

(2), recorded highest tide: 2.88m

(3), recorded lowest tide: -3.15m

(4), annual average high tide: 2.58m

(5), annual average low tide: -2.85m

(6), average tide lag: 3 m

(7), recorded tide lag: 4.9 m.

The land reclamation is estimated to cost about 53 million yuan. Geological treatment in order to support the heavy structures of the iron and steel complex will cost 70 million yuan.

Given these preliminaries, all concerned with existing ports of one kind or another, it is now appropriate to venture into a new realm: that of totally-new ports and attendant complexes. The example that best fits the criteria stressed throughout this thesis is Wangtan, and the next section outlines the grounds for choosing this location.

5.3 Wangtan as a Possible Incremental Industrial Port

5.3.1, Introduction

For the most part, China's iron and steel industry, especially developments in the coastal belt, will increasingly count on imported iron ore. But when weight is given to a combination of domestic ore and imported ore, Wangtan offers great promise. What domestic ore is in question? The answer lies in the Jidong area of Hebei province where there are 5.6 billion tonnes of ore reserves boasting an average Fe content per tonne of ore of 30 per cent. Indeed, it is China's third ore resources' base, following those of Anshan-Beixi and Panxi. Currently, the level of output from this area has reached 22 million tonnes, and the iron ore is provided to Capital Iron and Steel Company and Tangshan Iron and Steel Company. The potential maximum annual mining capacity is put at 50-60 million tonnes, an increase of 20-30 million tonnes. Shijiaying ore-field with reserves of two billion tonnes is the only one in

China which is ready for utilization but has not been mined. The first phase of a possible Wangtan Iron and Steel Complex, providing a capacity of 3 million tonnes, can rely on the Shijiaying ore. Should this complex ever expand to above the 6 million tonne-scale, it would have to resort to imported ore and, as a result, would need the service of a dedicated ore-discharging port. To be sure, clear advantages accrue from pressing ahead with the combined complex and port. First, it would be able to rely on both domestic and imported iron ore resources. Secondly, it is near to both markets and coal resources. Thirdly, it can make use of port facilities to import raw materials on the one hand and export steel products on the other. This complex, therefore, combines aspects of "resources-oriented location" with "market-oriented location" as they come to bear on the iron and steel industry.

In respect of utilizing the Jidong ore source, a sharp dispute arose in academic and industrial circles. As mentioned above, the possible maximum output in this area is 50 to 60 million tonnes a year, enough to sustain ironmaking capacity of 10-12 million tonnes a year. The existing requirement for ore has reached 28 million tonnes for the Capital, Tangshan and some smaller local ironmaking works. Capital and Tangshan together rely on the Jidong ore base for 4.5 million tonnes. How to deal with the rest of the ore resource is a critical issue for the iron and steel industrial development in this area. One proposal is to expand the existing plants on the strength of the potential locked up in Jidong. Another proposal is to build a new complex of large scale by using what remains of this ore source when the needs of the existing customers have been met. Pragmatically speaking, the expansion of existing works is more cost-saving than building greenfield sites. However, in respect of the extant complexes in this area, the fact is that the burden of heavy environmental pollution, to say nothing of water and land shortages, severely hinders any expansion at the Capital and Tangshan locations. What is more, further development of the iron and steel industry in Beijing is incompatible with the overall urban plan of the Municipality. Congestion arising from boosted material flows in the Beijing-Tangshan-Tianjin triangle is deemed unacceptable. Under this circumstance, to hold down the scale of activity at the three sites and, instead, reserve the ore resources for a totally new iron and steel complex is recommended. Only in this way - that is, through the establishment of a Wangtan production complex and the simultaneous control of activity levels at existing works- is it conceived possible both to improve environmental quality and moderate the heavy usage of energy and water which derives from the extensive developments carried out in Beijing, Tianjin and Tangshan.

5.3.2, Physical Conditions Affecting Port Construction

There are stretches of level sandy land that are not suitable to farming, but are available for port construction. Around the port construction area, the -5 m contour is about 1.5 km offshore, the -10 m contour is 4.8 km away from the shoreline, the -15 m contour is 11 km away and the -20m contour is 24 km away. Other ports along the west Bohai Rim have -10m contour lines more than 10 km offshore, so the Wangtan site has a decided advantage in this respect. No less than 6 km of coastline can be pressed into use for berth installation. At Xiaogang to the west, the construction of two general cargo berths able to take ships of 15,000 tonnes is already under way. The channel depth reaches 10 m here. At Dagang, to the east, depths are conducive to the installation of deep-water berths. Two 'capesize' (100,000 dwt-class) berths are envisaged, both of which would be equipped to handle imported ore. On first appearances, then, Wangtan has distinct advantages as a site for a port. This should not blind us to its shortcomings, however. These are listed in point form.

(1) While only limited wave action affects Xiaogang harbour because of the protection of a mole, further development there is strictly limited because of the narrow water area. In truth, there is a 4-km stretch of coastline with deep-water to the east of Xiaogang harbour, but for that to be effectively developed, an extensive breakwater must be built.

(2) When the influences of wind, rain, fog, waves and ice are aggregated, the time in which the port cannot operate totals 60 days a year.

(3) The average height of level land is less than 2m; much land assembly is required in consequence.

(4) Effective measures for safeguarding the consequences of earthquakes are needed, since this area is well within a severe

earthquake zone.

(5) The sand and stone for construction must be brought from outside this area, requiring haulage over 50 to 100 km.

5.3.3 Projected Port Volume

Assuming that physical constraints can be overcome, what sort of traffic would the port generate? Projections centre on ore and its derivations.

The first phase of the Wangtan Iron and Steel Complex will be wholly dependent on local ore. When this base grows to more than 6 million tonnes, much of the iron ore will need to be imported in order to sustain this scale. Furthermore, some imported ore will transfer through this port to feed the iron and steel works in Inner Mongolia, Shanxi and Hebei provinces. The total volume of iron ore will reach 15 - 18 million tonnes per year, some 3.05 million tonnes of which will be consigned to Wangtan's second-phase addition. Regarding domestic ore, as stated, there are rich reserves in the hinterland of the port. Quantities of washed ore puddle are conveyed to North China either by the Tianjin- Shanghai Railway or by water carriage from the Yangtze River. The volume of washed ore puddle which could be brought into Wangtan port is put at one million tonnes. Table 5.8 shows the projected volume in this port.

Table 5.8, Throughput projections for Wangtan port
(x 1,000 tonnes)

Items	The first Phase T	I	O	The second Phase T	I	O	The third phase T	I	O
Total	2500	300	2200	5000	350	4650	25800	18500	7300
ore							12000	12000	
washed ore puddle	500		500	1000		1000	1000		1000
cement	500		500	1000		1000	2000		2000
salt	300		300	500		500	800		800
coal	500		500	1000		1000	1000		1000
steel				700		700	2000		2000
others	700	300	400	800	350	450	1000	500	500

Note: the first phase of port construction is in progress; the second phase relates to the first phase of the Wangtan Iron and Steel Complex, the third phase is compatible with the second phase of the Wangtan Iron and Steel Complex.
T: total volume; I: Incoming volume; O: outgoing volume.

By the end of the first phase of construction, Wangtan port will achieve medium scale and be characterized by bulk cargoes. Following the second and the third phases, it will function as an industrial port. At the end of the first phase, its total volume will be 2.50 million tonnes; for the second phase, the throughput will attain 5 million tonnes; and, finally, completion of the third phase will see throughput climb to 25.8 million tonnes. In China, generally speaking, a berth designed to accommodate 10,000 dwt vessels handles annually 300,000 to 350,000 tonnes of cargo. Applying this yardstick to the case means that, when the volume is 2.5 million tonnes, 6-7 bulk cargo berths of the 10,000-tonne variety are needed. When the volume is 5 million, a cement berth with dimensions for 30-40,000 dwt ships and two 10,000 dwt general cargo berths should be added. When the volume reaches 25.8 million tonnes, however, provision of a 100,000 tonne-class deep-water berth to unload imported ore will be urgent. Finally, two 100,000 tonne-class berths will be installed in the latter part of the programme, as well 10-12 general cargo berths in the 10,000 tonne-class. The cement berth should be expanded at this stage as well.

5.3.4 Planning for the Wangtan Iron and Steel Complex

As stated early, the Jidong area is one of China's three main iron ore bases. However, it is also a prime source of coal, cement and other fluxes. These resources are highly concentrated in an area within a radius of 80 km of Wangtan (see Fig. 5.9). For the complex's first-phase production level of 3 million tonnes, 80 per cent of all raw materials can be procured from an area no more than 100 km away from Wangtan. No less than 87 per cent of all raw materials are available from the area encompassed by the 150 km radius, while 95 per cent of all raw materials can be obtained when the radius is pushed out to 550 km. All told, this first phase calls for a volume of transport of about 1.82 billion tonne-km. The transport volume per tonne of steel production is about 610 tonne-km whereas the average material transport distance is 173 km (see Table 5.9). These indices compare favourably with world and domestic iron and steel works. For the second phase of 600 million tonnes, the complex can procure most of its raw materials from the

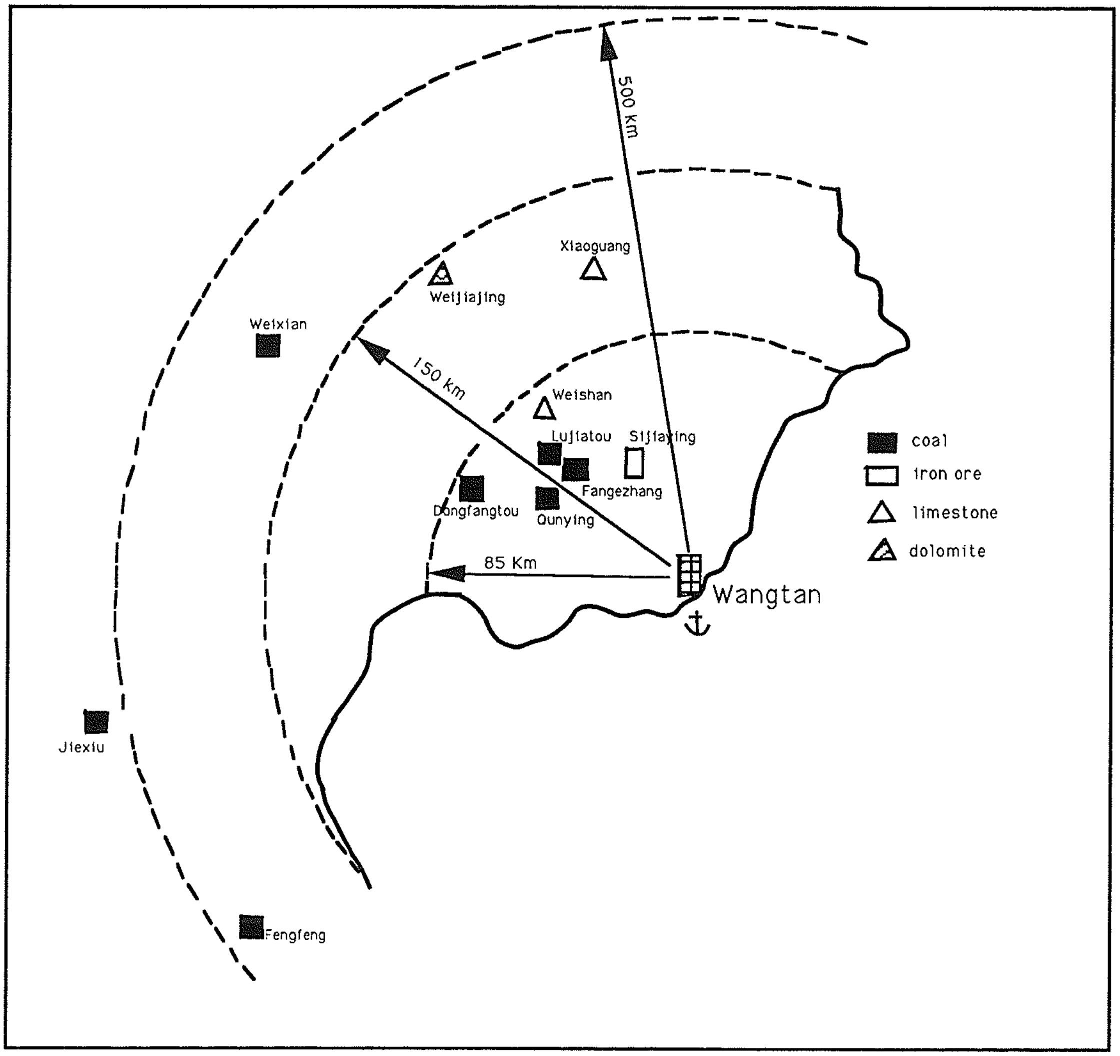

Fig.5.9, Assembling of raw materials for Wangtan complex.
Source: Liu, 1992, p112.

same belt (Liu, 1992).

Table 5.9, Transport volume for the first phase of Wangtan iron and steel complex

Site	Raw materials	Distance (km)	Volume (tonnes)	Transport volume (tonne-km)
Shijiaying	washed ore puddle	66	4,420,000	295,400,000
Kairan	coal	98	1,800,000	176,400,000
Weishan	limestone	106	640,000	67,840,000
Xiaoguang	limestone	155	480,000	74,400,000
Weijiajing	dolomite	198	160,000	31,680,000
Weixian	coal	545	300,000	163,500,000
Fengneng	coal	794	400,000	317,600,000
Jiexiu	coal	883	400,000	353,200,000
	others	176	1,900,000	334,600,000
	total		10,500,000	1,814,620,000

Note: railway is the only mode of transport.
Source: Liu, 1992, p109.

The Jidong area is located close to the terminus of the Beijing-Tianjin-Tangshan electricity network and also touches on several strategic railways, the Beijing-Shanhaiguan line, the Datong-Qinhuangdao line and the Beijing-Qinhuangdao line. They either pass through or approach within striking distance of this area. For their part, local railway lines, such as those linking Tangshan to Zhenghua, Peijiadian to Shuichang, Tuozhiwang to Wangtan, and Hangu to Nanbao, are integrated into the national network via connections with the Beijing-Shanhaiguan and Beijing-Qinhuangdao lines. When completed, Wangtan port will form a node in an integrated transportation network consisting of railway, shipping and road modes.

Altogether, 10.5 million tonnes of materials will need transporting in each year of the first phase of Wangtan Iron and Steel Complex, but only the incoming volume of 3 million tonnes bears on the state's principal railways mentioned above. The remainder can be conveyed by the local railway network. Since the principal railway lines are overloaded and incapable of keeping pace with economic developments, collectively they have become a "bottleneck". The overburdened main lines should still be just about able to accommodate the demands placed on them by the Wangtan project. Similar constraints afflict power generation, but they too may be circumvented in the case of Wangtan.

For the first phase of the project, 300 MW of power must be provided; the basic electrical power requirement of the rolling mill alone is about 150 MW. The network of Beijing-Tianjin-Tangshan already furnishes power to many large firms in this area. In 1989 the total installed power was 8,450 MW, by 2000 it is expected to be 15-17,000 MW. Jidong is the main base for the Beijing-Tianjin-Tangshan electrical network. In 1989 its installed capacity amounted to 2,200 MW, about one-third of which is used to provide for the needs of the Beijing, Tianjin and Chengde areas. There is a series of sites or existing electrical plants awaiting building or expanding, such as Wangtan, Lulong, Funin, Tuhe, Fengyin and Qinhuangdao. By the year 2000, installed capacity in the vicinity of Jidong should exceed 4,000 MW. Accordingly, the provision of electrical power for the iron and steel complex should not present difficulties.

Most parts of northern China, especially the Beijing-Tianjin-

Tangshan area, suffer from severe fresh-water shortages. But in the Jidong area water is relatively abundant. The water comes from the Ranhe River valley. In its upper reaches, the Pangjiakou and Daheding reservoirs have captured 61 per cent of the available water. The construction of Taolinkou reservoir on the Qinlonghe River during the period of the Eighth Five-Year Plan will enhance the water collection. Water for the first phase of Wangtan will come from the upper reaches of the Ranhe River. The water source area in question covers 60 km^2, and can provide flows of 2.0-2.5 m^3/second. When the complex expands to 6 million tonnes, another 235 million m^3 annually can be added from the reservoir at Taolinkou. Having dealt regional factors, it is necessary to turn to site-specific concerns.

As mentioned above, there are 6 km of coastline set aside for construction of deep-water berths. This stretch, together with the land lying behind, is ample to justify the creation on it of a MIDA. The site is actually placed in Reting county, 22 km from the county seat. The cornerstone of the plant is just 1-1.5 km from the Dagang ore berth site and 2.5 km from the station on the Touwang Railway (Fig.5.10). The closest ore
site, Shijiaying, is a modest 60 km away (Fig.5.9).

If this complex is raised to the scale of 10 million tonnes, it will occupy land of 18 km^2. For each of the first and the second phases, land of 6 km^2 is needed (totalling to 12 $km^{2)}$. Another 1.5 km^2 of land should be provided for construction engineering. The land for this complex is but one part of an integrated whole

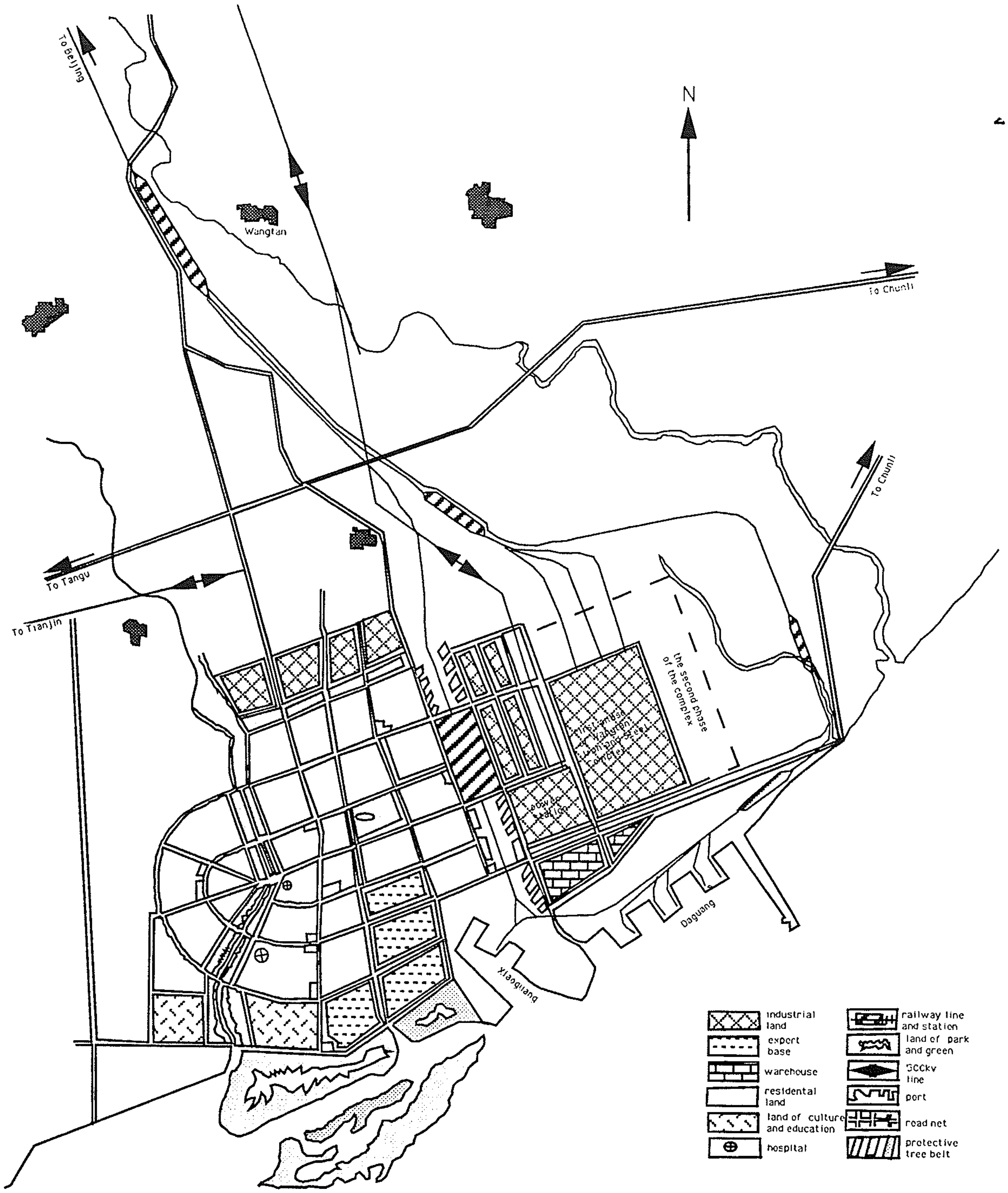

Fig.5.10, Layout of Wangtan complex.
Source: Liu, 1992, p119.

embracing the industrial complex and its attendant port city. The area of 18 km^2 reserved for the iron and steel complex stretches 4.5 km along the coast from east to west and extends 4 km from south to west. Taking into consideration both geological conditions and external transportation links, the production processing flow should be aligned from the south end to the north part. In other words, the south end should contain the storage facilities for raw materials; and it should be followed, in order, by coking plant, sinter plant, blast furnace, steelmaking and steel rolling mills until the north is reached (Lu, 1992).

The south end of this plant faces the sea. As stated, operationalization of the complex's second phase is dependent on ore imports brought by ship. A belt conveyor from the berth will handle this material, but transfer of products to the port will require a new rail line through the south side of the plant. Until that line is laid, resort must be had to heavy trucks. Other trucks will be needed to access the storage area for ore, coal and other materials. A generating plant will also occupy land in the south, thereby easily procuring sea-water.

The north end of this plant connects directly with the inland transportation corridor. A special 2 km line can link the railway station and the plant site. Seventy per cent of the plant's products will be delivered through inland transportation to clients in northwest China. During the first phase of this complex, the raw materials brought by railway can be transferred into the plant by belt conveyor from the north end.

The west part of the plant abuts on Wangtan city. Residentiary-related industries should be allocated to this part. In addition, the complex's management centre and service facilities will be placed here. Other infrastructure, such as the heat provision system, electrical-power system and gaseous system, which combine the function of, first, fulfilling plant requirements and, second, serving urban residentiary needs, would also be assigned to this section of the site.

The east part of the plant is held in reserve pending further expansion of this complex.

It will be recalled from the last chapter that the shortfall in production exhibited by North-Northwest China amounts to 9.51 million tonnes, that is, fully one-half of the country's total steel deficit. Of that shortfall, 3.66 million tonnes are attributed to steel plate (constituting 79 per cent of China's plate deficit). Wangtan is designed to make good this shortfall. In conjunction with works in Beijing (Capital), Baotou, Tianjin and Tangshan, it promises to fulfil all the needs of Beijing, Tianjin, Hebei, Shanxi, Henan, Sha'anxi, Inner Mongolia, Gansu, Ninxia and Qinghai municipalities and provinces. What is more, should the second phase of Wangtan come to fruition, it would offer markets along the Yangtze and in Southeast China the opportunity to take about 30 per cent of its output. This opportunity arises solely on account of the ease of transportation provided by coastal shipping from the new port.

5.4 Conclusion

In this chapter, four cases were scrutinized. In terms of port infrastructure already in place, Ningbo proves to be the most promising because of its advanced deep-water port facilities and the advantages to be gained from its geographical setting. The deep-water properties of Rizhao tell strongly in its favour as a site for the construction of a new iron and steel complex. In Zhanjiang's case, besides its deep-water attributes, it has the advantage of filling a void; for there is no integrated iron and steel complex of any consequence in South China. Much also can be said for the Baoshan complex, not least the investment sunk into plant and port equipment. Moreover, it is located in the biggest market in China. Its major drawback, however, is the fact that it cannot give entry to 'capesize' bulkers bringing imported ore. It has no option but to make use of cargo transhipped through Ningbo's Beilun. The final case study, Wangtan, conforms to an entirely different category. Not only is it an incipient port, unlike the others, but it is totally different from them in being designed for a complex that intends to use a combination of local and imported ores. These case studies establish the ground on which a comparison between China and the developed and other developing countries can be made. The implications arising from these studies constitute the essence of the next-and last-chapter.

CHAPTER SIX. CONCLUSION

From the general world situation to the specific Chinese case, this work has assessed the locational development of the iron and steel industry and the evolution of the port industrial complex, especially that branch of it preoccupied with iron and steel. To be sure, the MIDAs in China, existing and latent, are the descendants of those in developed countries. Together, they lay claim to coastal location, deep-water ports, and industrial complexes intimately interacting with those ports. In this chapter, the conclusion of this thesis, the main concern is the question of whether the Chinese model can be extended to other contexts. Although Chinese MIDAs have inherited the common features of Western MIDAs, they have evolved in a fashion peculiarly their own. This is owing to the remarkable changes under way in the Chinese iron and steel industry. A summary of how that situation has arisen, and what consequences it has for China and elsewhere respecting industrial ports, is now in order.

6.1 The iron and steel industry in China: significant growth towards the year 2000

The steel industry in the twenty-first century will be significantly changed from the industry that existed in the 1980s. The developing countries will increase their share of steel production, while the industrialized countries will reduce production. Among the developing countries, the predominant increment will stem from China's growth. As mentioned in Chapter four, by the year 2000, at least 100 million tonnes of crude steel will be needed merely to service current rates of economic development. This projected target was first announced as early as 1980 when production was 37 million tonnes. Judging by the growth of the industry up to 1980, which had moved from 18 million tonnes in 1970 to 37 million tonnes a decade later, production in the 100 million tonne-range by 2000 seemed impossible. However, in 1986, the Chinese steel industry passed the 52 million tonne-mark. From that point on, it grew rapidly to 80 million tonnes in 1992. The world industry had not witnessed such growth since the Japanese industry moved from 22 million tonnes to 93 million tonnes between the beginning and the end of the 1960s (Hogan, 1994). As a consequence of this rapid increase, the goal of 100 million tonnes by the year 2000 now seems to be readily obtainable. This dynamism contrasts markedly with the sluggishness besetting steel operations in the West.

Remarkably, China increased its steel exports from 150,000 tonnes in the mid-1980s to three million tonnes in 1992. This growth in exports partly reflects growth in domestic steel production. However, the domestic demand for steel production is huge, growing and evidently unmet, as the following points duly attest. First, China is set to maintain its record of above-average growth in GNP, which, in turn, will force the rapid development of the iron and steel industry. Secondly, when the domestic market in China is investigated, it is apparent that the rural market is often neglected. Yet rural areas contain more than 800 million people. Actual rural consumption of steel per capita, currently, is even less than the city figure, but this is bound to change. The development of the rural market will considerably boost demand for steel. Thirdly, attention must also be paid to the change in the structure of the future market; for example, the motor vehicle industry is just unfolding in China. Following from this, road construction, car parking, service stations and also traffic control systems must all be set up as a matter of course. This can only serve to add yet further impetus to steel production.

6.2 The superiority of coastal locations over inland sites comes with reliance on imported ore.

The emergence of maritime industrial zones in less-developed countries now in the early stages of industrialization is, of course, only one aspect of a far wider phenomenon; but the technological evolution of MIDAs in LDCs is at least partly dependent upon modern shipping fleets, especially large bulk carriers, and is clearly related to the fact that large quantities of raw materials are normally available for domestic industrialization programmes in addition to the tonnages exported to advanced countries. For the developed countries, with the exhaustion of domestic materials, coastal locations assume more and more importance in proportion with increasing reliance on imported materials. This is not only because the port, whose large vessels allow the import of raw materials at economic rates, becomes a surrogate source of raw materials, but it is also because the port can facilitate the export of manufactured products. The industries interlinking with imported materials are located adjacent to the port so that the unnecessary transfer moves of both raw materials and products delivered to overseas markets can be avoided.

With the Chinese iron and steel industry's increasingly greater reliance on imported ore, the coastal sites hold the edge over inland sites. The case studies all pointed in this direction. The comparison of the Capital and Baoshan complexes, for example, showed that the former held the advantage of assembling raw materials over the latter because the Capital's location permits easy access to ore and coal sources. The freight cost per tonne of crude steel incurred in assembling ore, coal and scrap is about 29 yuan in the Capital while Baoshan's figure amounts to 82 yuan. However, thanks to the large local market and marine transportation, Baoshan wins out over Capital in delivering products. The distribution cost per tonne of steel in Baoshan is 20 yuan against the 15 yuan applying at Capital. More importantly, it is proven that, once both sites are dependent on imported ore, the coastal site-Baoshan-holds both the advantage of accumulating raw materials and that of distributing products. Under the circumstance of both complexes totally relying on imported ore from Australia, Baoshan's assembly cost per tonne of steel incurred in conveying ore, coal and scrap is 82 yuan while the Capital's cost rises to 111 yuan. Much of the extra cost obtaining at the Capital is incurred through the transfer of ore by railway to the plant after it has been discharged from capesize vessels anchored at Qinhuangdao. With regard to the fact that China's coastal belt is the main steel product market, it follows that steel plant sites at some remove from the coastal ports will be severely disadvantaged in comparison with port steel complexes. This occurs is because of the combination of transfer costs for the imported ore on the one hand and enlarged costs of distributing products from sites positioned some distance away from the coastal market on the other. Not to be overlooked, too, is the fact that port complexes can indulge in exporting products without the bother of intermodal transhipment.

6.3 Port-iron and steel industrial complexes in China, responding to the market orientation

Mindful of the cases of MIDAs elaborated on in Chapter three, it is evident that both the establishment of iron and steel complexes and the integrating of them into the ports are often treated as kinds of planning tool. In short, the ports and the industrial complexes assume "growth pole" roles in regional strategy.

As case at Fos demonstrated, the relative lack of industry had created a number of weaknesses in the labour market of the region around Marseille, weaknesses reflected in low activity rates, high levels of unemployment, and an inadequent number of jobs for women. These problems were exacerbated by the heavy influx of foreign migrants into the region and by the decline of various staple, port-related industries at Marseille such as food processing. Thus, the prospect of encouraging industry represented a response to a series of economic difficulties. Accordingly, the scheme was perceived in terms of the creation of a major regional growth-pole, a "Europort" of the south, implying the attraction of a series of basic propulsive and interrelated industries. Central to the concept was the idea of establishing a large steel plant at Fos.

In Japan, as a means of spreading "growth impulses", port-centred industrial complexes were designed as "growth-poles" to produce a more "balanced" regional development- the Ministry of International Trade and Industry's "thorough industrial policy".

In South Africa, the deep-water iron-ore export port of Saldanha Bay, with the large-scale urban-industrial development of the Greater Saldanha-Vredenburg area of which it was to be a part, was promoted for a propulsive centre in western Cape.

By contrast, rather than relying on the developing strategies or regional policy grounded in the growth pole, the port industrial complexes, actual and impending, in China result from the dictates of the economy. Critically, the deep-water ports, together with possible iron and steel complexes which might arise in them, were not originally promoted as growth poles for conferring agglomeration effects on surrounding areas. This was on account of the favourable economic circumstances already present in the areas surrounding them. For example, the coastal belt in which all these ports are to be found belongs to the most economically-advanced area in the country. In terms of economic development, Zhanjiang (Guangdong province), Ningbo/Beilun (Zhejiang province), Rizhao/Shijiusuo (Shandong province) and the Wangtan (Hebei province) rank in the upper level in their host provinces. Shanghai, for its part, is China's biggest economic centre. Furthermore, the coastal belt is the biggest market for steel products in China. During the Sixth Five-Year Plan period (1981-1985), the crude steel consumed in Shanghai alone amounted to 13.6 million tonnes, fully equal to 6.7 per cent of the total crude steel consumed in the country. By 2000, the steel demand in Jiangsu, Zhejiang, Anhui and Shanghai is projected to reach 20 million tonnes, equalling 20 per cent of China's total. Liaoning province, dominant in terms of heavy industry, is another key market for steel products. All told, the coastal cities of Shanghai, Tianjin, Guangzhou and Dalian are biggest markets for steel products in China. Although the output of steel products in the coastal belt accounted for more than 60 per cent of China's total, a huge supply deficit persists, one that is much bigger than that occurring in inland areas. Guangdong province ranks at the top in respect of this deficit. Besides owing their creation to natural conditions for the deep-water operations, the port iron and steel complexes are mostly motivated by this alarming supply shortfall.

6.4 Port-iron and steel complexes in China and the issue of import-substitution

In developed countries, the creation of MIDAs has reflected a response to the shift of heavy industry towards coastal sites, particularly where such industries depend upon imported raw materials or energy products. The development of an iron and steel industry located in coastal sites and hosted by the deep-water ports is motivated by the demands of the domestic market and exports, to say nothing of the growth-pole consideration. In Japan, although the domestic market rather than exports was the driving force behind Japan's high-speed growth, the obsession with industrial expansion led, in the 1960s, to steel capacity doubling to satisfy domestic demand, an outcome which provided large tonnages for the growing export market. Japan, the leading exporter, shipped 23.3 million tonnes of steel in 1988. France, the fourth leading export country, provided 11.4 million tonnes of steel to the world market (Hogan, 1991). As made clear in Chapter three, the standard cases of iron and steel complexes integrated with deep-water ports are from France and Japan. This seems to demonstrate that the port-iron and steel complexes serve both to promote steel export and provide it with the necessary intermodal transfer facilities.

In the developing countries, the MIDAs and the port-iron and steel complexes display a different operational pattern. In South Africa, the emphasis on export promotion of minerals resulted in the inauguration of the deep-water iron-ore export port of Saldanha Bay. It was to be part of a large mineral export scheme, 18 million tonnes of iron ore a year in the first phase. Industrial development was to be linked directly to the port and a 3 million tonne per-annum capacity steelworks was envisaged. Although the plan went awry, the logic remains sound; namely, the MIDA should fulfil a dual role of exporting raw materials in the main, but supplemented by value-added products processed in the port area. In Mexico, too, the MIDAs are to be part of a strategy aimed at adding more value to raw materials prior to exporting them.

In China, it has been made clear that the shortfall in the provision of steel products is the driving force behind the development of the Chinese iron and steel industry to the year 2000. The port-iron and steel industrial complexes, notwithstanding their reliance on imported ore, are regarded as key elements in the nation's strategy of import substitution. Evidently, then, China's MIDAs are to serve the import-substitution goal while the MIDAs in the developed countries are there to promote exports. Notably, MIDAs in China and in developed countries both depend on imported raw materials. China's MIDAs differ from those in other developing countries in one important respect: the latter generally tap indigenous ore supplies whereas China's increasingly do not. They share the import-substitution objective, however.

6.5 Port-iron and steel complexes in China, diversifying the model of MIDAs

As Bird (1971) pointed out, on the demand side, ports are sources of raw materials for industry; on the supply side the primary-processing industries located in ports are sources for the secondary-processing and manufacturing industries; in other words, seaport industries have backward and/or forward linkages. The other reason for the location of industries in seaport areas is compelling: large amounts of low-value but bulky raw materials are uneconomic to transport long distances overland and are best processed at point of discharge, the port. The optimum size of primary-processing plants has become increasingly larger, demanding large flat sites for basically one-storey plants. If the plant engages in export activities, the seaport site adds a further advantage. Finally, there are external economies in industries technically linked together or occupying the same prepared site, perhaps a reclamation area, which then functions as a marine industrial estate. The MIDAs in the industrilizated countries and the less-developed countries almost always aspire to this linkage between port and industries. The Chinese cases of Shanghai/Baoshan, Beilun, Zhanjiang and Rizhao also fit into this generalization. However, the case of Wangtan and its attendant planned iron and steel complex serves as an exception. It does this for several reasons. First, for the initial stage, the iron and steel works will rely on local raw materials fetched by inland means of transport. Locating the plant adjacent to the port is merely to share the infrastructure centred on the port. The port installations consist of infrastructure works-reclamation, dredging, quays, back-up area consolidation-and superstructure works-the unloading and loading appliances, the factory itself and all its ancillary plant. In Wangtan, the industrial activities involve the iron and steel, ocean-petrochemical, sea-salt chemical, and building-materials industries. These industries clustered around the port will accumulate such external economies as co-ordinated pollution control and economic reclamation of coastal level land, besides sharing public utilities of the likes of the generating station and the gas works. Under this circumstance, no strong linkage exists between the port and the iron and steel industry, but the port functions as the envelop within which industrial activities will agglomerate. When the port iron and steel complex in Wangtan is carried forward to the second stage, however, it will switch over to the property of standard MIDAs; that is, reliance on imported ore. As a whole, the planned MIDA in Wangtan displays how the iron and steel industry can share the port industrial infrastructure in the first phase and how the iron and steel industry can proceed to link itself backwardly and forwardly with the port in the second phase. These is no question that this port-iron and steel complex, counting on a combination of domestic and imported ores, offers an interesting variation on the pattern of contemporary MIDAs, a variation which some developing countries may do well to emulate.

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