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ECONOMIC ASSESSMENT OF THE IRON AND STEEL INDUSTRY IN SELECTED DEVELOPING COUNTRIES

Report

by

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39

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ECONOMIC ASSESSMENT OF THE IRON AND STEEL INDUSTRY IN SELECTED DEVELOPING COUNTRIES

INTRODUCTION

Industrialization is a mandatory requirement for the developing countries in order to create the necessary economic growth. The development of a steel industry is viewed as an important step in the industrialization of the developing countries, enabling them to satisfy certain of their basic needs. Industrial activities inevitably lead to an environmental impact on the environment. The steel industry is a prime example of a fundamental industry needed to develop an industrial base and at the same time to have an impact on environmental pollution through the enormous quantities of iron ore, scrap, coal and other raw materials used in the steel-making process.

The steel industry has undergone some major shifts in technology parameters and in production process during the last two decades. The latest challenges to the industry come from ecological and environment impact considerations. A few steel plants are already proceeding with the application of scientific innovations in environment protection technologies. Current technology cannot yet avoid the generation of dust, sulfuroxides, nitrogen oxides, polluted waste water, noise and various types of solid waste. Pollution prevention, however, must always be an important task in the steel industry.

Governments in Latin America and Asian Countries, having become aware of the negative environmental impact of their steel industry, plan to solve these environmental problems before the situation becomes uncontrollable. UNIDO has

been requested to conduct environmental fact-finding surveys in order to assist the Governments in the above regions to assess the environmental impact of their present steel works and to provide and recommend remedial measures.

In implementing such a programme, it is important ot have a well-balanced assessment of economic and environmental factors of the steel industry, bearing in mind the need of sustainable development. The present study is part of this programme and its main objective is to make an economic assessment of the iron and steel industry in selected Latin American (Argentina, Chile and Venezuela) and Asian Countries (Indonesia and Thailand). The purpose is to select and recommend two countries, one from each region, as candidates for receiving UNIDO's assistance in upgrading existing steel-making technologies for the purpose of promoting economic efficiency and pollution control in their steel industries.

The paper consists of five sections: Section I discusses briefly some recent economic developments in the iron and steel industry with more emphasis on developing countries. Section II deals with the technological aspects of steel manufacture in terms of raw materials and methods employed in steel production. Section III, analyses the economics of steel plants from the point of view of capital investment requirements and operating costs of steel-making, while section IV makes a comparative analysis of the statistical data related to the iron and steel industry of the five developing countries. Based on the above analysis, section V summarizes the main findings of the study and selects and recommends the two candidate countries to receive UNIDO's assistance.

I. THE WORLD IRON AND STEEL INDUSTRY

In the developed economies, the iron and steel industry is a basic indicator of economic health and its troubles in recent years have paralleled those of the international economy. In the developing countries the creation of a steel industry is often considered as an important step towards industrialization. In addition, the iron and steel industry is one of the key sectors of the economies of a number of developing countries. The developing countries accounted for 7.9 percent of world crude steel production in 1980 while their share increased to 12.5 percent in 1988. That is, crude steel production increased by 72.9 percent during the period 1980 - 1988 which amounted to an annual average rate of 8.1 percent. This is partly due to the relatively worse position of the developed countries' steel industries and to the investments in new steel-making capacity. Steel capacity of developing countries (including South Africa) reached some 132 million tonnes per year in 1984. But steel capacity is not evenly distributed among developing countries. Six countries (China, Brazil, India, Mexico, South Africa and Korea) account for 72 percent of capacity and five others (Argentina, Venezuela, Taiwan, Iran and Egypt) a further 11 percent.

Whereas crude steel output grew at the rate of 8.1 percent annually during the period 1980-1988, crude steel consumption (defined as production + imports - exports) grew at a lower annual rate of 1.1 percent. By contrast, consumption of steel increased continuously during the 1970's at an annual rate above 7 percent, because of strong economic growth and the increasing share of capital formation of GDP. Although steel production increased by a higher annual rate than consumption, there is clearly a gap between production and consumption of steel in developing countries. For example, in 1979 crude

steel consumption amounted to 96.6 million metric tons and production to 54.4 million metric tons (a difference of 42.2 million metric tons) while in 1988 this difference was reduced to only 10.9 million metric tons.

Developing countries own some 34 percent of the world's iron ore which is one of the most important raw material in steel production. Among developing countries, the major producers of iron ore are Brazil (11.9 percent), China (9.3 percent), India (5.1 percent), Liberia (2.5 percent), North Korea and Venezuela (1.2 percent each). Iron ore production world-wide grew at an annual rate of 1.4 percent in the 1970's and by a rate of 3.7 percent from 1980 to 1988. In developing countries, on the other hand, iron ore production increased by an annual rate of 1.9 percent for the period 1980-1988. The low growth in iron ore production is mainly the result of improving efficiency of iron ore usage. For every tonne of crude steel produced, 1.21 tonnes of iron ore are needed due to improved ore beneficiation and the use of electric furnaces which rely more on scrap than the traditional furnaces. It is clear, however, that there will be a continuing gap between production of iron ore and production of steel as well as between consumption and production of steel in developing countries (OECD, 1987).

The gap between consumption and production of steel in developing countries is bridged by international trade. At least half of world trade in steel products consists of trade between producer countries, because of product specialization, quality and cost differences. The other half results from countries with excess capacity to domestic consumption, exporting to countries with insufficient or no steel capacity. Trade in steel has been improved substantially in developing countries. Exports of semi-finished and finished steel products accounted for 6.7 percent of world total in 1980 and

increased to 15.9 percent in 1988. That is, exports of steel products of developing countries increased by 20.3 percent during the period 1980-1988. For the same period, imports of semi-finished and finished steel products declined by 15.4 percent from 31.1 percent share of world imports in 1980 to 22.2 percent share in 1988. Regardless of the improvement in trade of steel products, developing countries will need to import steel for some time in the future and as their capacity grows, there will be a market in other developing countries for whatever excess capacity may arise.

II. TECHNOLOGY OF STEEL MANUFACTURE

1. Raw Materials for Steel-making

The most important raw material used during the first stage of steel production is iron ore whose quality depends on the iron content and chemical composition. The most common type is the "hematite" which can approach a maximum 70 percent iron content. If the iron content is high enough, the iron ore is suitable for direct feed to the blast furnace of a steel plant after crushing and sizing to achieve a uniform range of particles. Fine ores are sintered by combustion with coke breeze, lime sand or crushed limestone, mill scale and flue dust. Sinter plants are located alongside steel mills, because the composition of the sinter can be best controlled to suit the plant. An important advantage of sintering is that most of the limestone required as a flux in iron making can be added at the sinter stage which improves fuel efficiency and productivity. On the other hand, very fine ores are pelletized by binding with bentonite clay and then roasting in a kiln or travelling grate fired by oil or natural gas. The increased cost of the petroleum-based fuels used to produce pellets, have made pelletizing less attractive in steel-making (OECD, 1987).

The initial stage of steel-making, produces iron, either pig iron (BF) or direct reduced iron (DR). Pig iron production consists of removing the oxygen in the iron ore by combustion with carbon, which is supplied in the form of coke. Coke is made by heating crushed bituminous coal in airtight ovens. The quality of bituminous coal and the production of high grade coke is of great importance in a steel plant.

For the steel-making stage other important materials are needed. First oxygen is required to remove residual impurities. Second, manganese is added to control hardness, toughness and strength. Finally, steel scrap is an important ingredient at the steel-making stage. Scrap includes purchased scrap and circulated scrap, generated as a result of the steel mill's operations. The basic oxygen furnace (BOF) process uses from 10-30 percent scrap, while the electric arc furnace (EAF) process normally uses only scrap as feed but can use up to 100 percent direct reduced iron (ESCAP, 1988).

2. Steel-Making Alternatives

There are two major processes for the production of steel. Namely, the traditional blast furnace/basic oxygen steel (BF/BOS) process and the electric arc furnace (EAF) process when it mainly uses scrap metal as feed or alternatively the direct reduction/electric arc furnace (DR/EAF) when it uses direct reduced iron as a basic raw material. The choice between the above processes depends on the availability of raw material sources, energy cost and scale of operation. The production of steel consists of two distinct but fully integrated stages. The first stage produces iron, either pig iron (BF) or direct reduced iron (DR) while the second stage consists of steel-making.

the BF/BOS process consists of the production of liquid iron from iron ore on the blast furnace, followed by the production of steel in a converter in which the iron is purified by blowing in a stream of oxygen at the top. The minimum economic size of an integrated BF/BOS mill is 1.0 million tonnes per year and economies of scale can be realized up to about 5.0 million tonnes annual capacity. The BOS process is widely used and has replaced the open hearth process (OH). Total world crude steel production by BOS process amounted to 57.2 percent in 1988 and Luxembourg and Chile produced 100.0 and 95.7 percent respectively of crude steel by the above process.

An alternative route to BOS process is continuous casting which forms a continuous slab as liquid steel is fed from a ladle. The slab forms as the edge of the steel is cooled by moulds and the slab is cut to length and passed to secondary and finishing mills. Continuous casting is not suitable for production of alloy steels and stainless steels. The advantages of continuous casting are lower capital investments requirements per unit of capacity, lower

processing costs and higher yields. Casting activities are a major source of scrap which competes with direct reduced iron and traditional casting processes can produce up to 30 percent scrap while continuous casting may produce as low as 3 percent of scrap. The International Iron and Steel Institute (IISI) has estimated that the share of total world crude steel production by continuous casting rose from 22 percent in 1978 to 46.9 percent in 1984 and 59.0 percent in 1988.

The other major process of steel-making is the electric arc furnace (EAF) which manufactures regular carbon steels and special steels, such as stainless steel. The EAF can operate on 100 percent scrap as feed stock or direct reduced iron. The operation of the arc furnace consists of melting the feed by the creation of an electric arc between the feed and the carbon electrodes, through which the current is supplied. Alternating current is used and new developments include the use of ultra-high intensities, water cooling of the furnace walls, automation of material charging, better control of exhaust fumes, oxygen injection, preheating of scrap and the use of direct current (OECD, 1987). The share of EAF in total world crude steel production amounted to 26.4 percent in 1988, including 28.9 percent for the EEC countries, 31.5 percent for industrial countries and 15.3 percent for eastern european countries. Among developing countries, Venezuela produced 84.9 percent of its total crude steel by EAF process.

The EAF is an economic steel converter at low-scale provided that a rich iron feed can be used. The direct reduction process produces such a feed in the form of metallized agglomerate directly from iron ore and when combined

with the electric furnace can provide an economic steel mill at low scale. Electric furnaces capacity range from a few tonnes to 350 tonnes and for a country with resources of natural gas and relatively cheap electricity can build a steel industry (using the DR/EAF process) at a scale as low as 100,000 tonnes per year, with scale economies improving up to 3.00 million tonnes per year.

III. THE ECONOMICS OF THE IRON AND STEEL INDUSTRY

This section deals with the economics of a steel plant for various annual capacities employing either the BF/BOS or the DR/EAF process of steel-making. The analysis considers the economics of a steel plant in terms of capital investment requirements and in terms of cost of producing steel. The capital investment requirement figures are based on a study conducted by the Development Centre of OECD in 1987. These figures are expressed in 1984 dollar prices and have been escalated to 1989 costs by applying an annual inflation rate of 10 percent for the period up to 1989. Both estimates are presented in Table 1 below. On the basis of the figures of Table 1, it seems clear that in terms of capital investment, the DR/EAF plant offers substantial economies as against the BF/BOS plant. For example, for a plant of capacity of 3.0 million tonnes per year, the DR/EAF plant offers saving of capital investment of about 50 percent of the BF/BOS plant. Expansion of existing plants would imply much lower capital investment costs than those presented in Table 1.

Capital investment costs can vary according to economics of scale and location of the plant. Construction costs in different locations is affected by labour cost and the extent to which equipment can be locally produced, rather than imported. For Japan, South Korea, Taiwan and perhaps China and the ASEAN countries, construction costs might be 10 to 15 percent lower than in the United States or Europe, while in Latin America, the Middle East and Africa costs might be 10 to 20 percent higher (OECD, 1987).

Economies of scale occur in two areas: in the capital investment, and in operating costs. Capital investment rises at a rate slower than that of

TABLE 1

Capital Investment Requirements of a Steel Plant

BF/BOS Plant

	In 1984 Dollars					In 1989 Dollars				
Annual Capacity (million tonnes/year)	0.5	1.0	1.5	3.0	6.0	0.5	1.0	1.5	3.0	6.0
Capital Investment ($ per tonne)	2,676	2,028	1,724	1,400	1,137	4,311	3,267	2,777	2,255	1,832
Total Investment ($ billion)	1.3	2.0	2.6	4.2	6.8	2.1	3.2	4.2	6.8	11.0

DF/EAF Plant

	In 1984 Dollars					In 1989 Dollars				
Annual Capacity (million tonnes/year)	0.1	0.5	1.0	1.5	3.0	0.1	0.5	1.0	1.5	3.0
Capital Investment ($ per tonne)	991	718	625	600	600	1,596	1,157	1,007	967	967
Total Investment ($ billion)	99	329	625	900	1,800	159	578	1,007	1,450	2,900

Source: OECD, Aluminium, Copper and Steel in Developing Countries, Development Centre Studies, Paris, 1987

capacity. For example, in the case of BF/BOS process, a plant of capacity of 3.0 million tonnes per year would require a capital investment of twice that of a 1.0 million tonnes plant, while in the case of the DR/EAF plant, increases in scale are gained mainly through replication of equipment so that economies of scale can be realized up to 1.5 million tonnes per year; beyond this capacity no scale economies can be realized as it is shown in Table 1.

The cost of producing steel consists of four main components: labour, energy, raw materials, and capital recovery charges. Wage rates, plant efficiency and raw material acquisition costs, makes for considerable difference between countries. Figures for total cost per tonne of steel produced for a BF/BOS and DR/EAF process in 1984 dollar prices, are presented in Table 2 based on the OECD Development Centre Study.

An important element of cost is the capital charge which consists of 5 percent annual depreciation rate for twenty years and a 20 percent return on capital before tax. Under these assumptions, the figures in Table 2 indicate an advantage in favour of DR/EAF process. Operating cost is greatly affected by prices of raw materials, energy and labour cost. Thus, a country with access to its own iron ore supplies will realize a lower operating cost. Energy cost is very crucial for the DR/EAF process particularly natural gas and electricity. A country endowed with gas in abundance and low cost of electricity will have an advantage in steel-making. Labour cost is also important element in operating cost and lower labour cost in Japan, for example, is one of the reasons why Japanese produce steel at lower cost than that of the United States and West Europe.

The clear conclusion which can be drawn from the above discussion is that the DR/EAF process is the most economical alternative for the production of steel and offers an opportunity for developing countries to engage in steel manufacture at comparatively modest initial scale. Countries with lower labour costs coupled with natural gas at good prices, they will be able to compete satisfactorily with world prices. For developing countries, the consumption of steel will continue to exceed production of steel for some time in the future and there would be opportunities for steel manufacture to satisfy domestic needs and also for export to other developing countries.

TABLE 2

Total Cost of Steel Production ($ per tonne)

	Capacity (million tonnes per year)			
	0.5	1.0	1.5	3.0
BF/BOS Process				
Operating Costs	240	240	240	240
Capital Charges (at 25 percent)	669	507	431	350
Total Cost	909	747	671	590
DR/EAF Process				
Operation Costs	200	200	200	200
Capital Charges (at 25 percent)	180	156	150	150
Total Cost	380	356	350	350

Source: OECD, Aluminium, Copper and Steel in Developing Countries, Development Centre Studies, Paris 1987

IV. THE IRON AND STEEL INDUSTRY IN SELECTED DEVELOPING COUNTRIES

The purpose of this section is to analyze the various aspects of the iron and steel industry in five developing countries. The five countries are Argentina, Chile and Venezuela from Latin America and Indonesia and Thailand from Asia. Based on the analysis and the data presented a choice of two countries, one from Latin America and one from Asia, will be made as candidates for the implementation of the steel project.

1. Latin American Countries

Some economic indicators describing the economic condition of the iron and steel industry in Argentina, Chile and Venezuela are presented in Tables 3,4 and 5 of Appendix A. Gross output of the iron and steel industry in Argentina amounted to 4.8 percent per year of the total manufacturing for the period 1980-1987, while for Chile and Venezuela the corresponding shares were 4.7 and 5.8 percent respectively. Employment in the iron and steel industry in Argentina declined during the period 1980-1987 and reached the lowest point in 1982. On the average, the share of employment amounted to 3.4 percent of the total manufacturing employment for the same period. Wages and salaries, on the other hand, increased substantially due mainly to high inflation. In Venezuela, employment in the iron and steel industry declined by 22.6 percent from 1980 to 1987 (from 37,457 employees in 1980 to 29,000 in 1987), while wages and salaries accounted on the average to 8.1 percent per annum of the total manufacturing. On the contrary, employment increased in Chile to 9,796 employees in 1987 from 8,060 in 1980 (an increase of 21.5 percent) and wages and salaries accounted for 5.5 percent per annum of the wages and salaries received by the manufacturing industry.

Figures for raw materials used in steel-making for the three Latin American countries are presented in Tables 6, 7 and 8. Among the three countries, Venezuela is the most important producer of iron ore, which is the most important raw material in the production of steel. Venezuela produces 1.2 percent of total world production of iron ore, 6.9 percent of total developing countries and 9.9 percent of total Latin America. From the total iron ore produced in 1988, only 32.6 percent was used for domestic production, while the other 67.4 percent was exported. Other raw materials produced in Venezuela are direct reduced iron, pellets, cinter and pig iron, which are all used as feed in the EAF or DR/EAF processes used mainly by Venezuela's iron and steel industry.

The most common process of steel production in Chile is the BF/BOS which employs large quantities of iron ore as feed. This is probably due to the fact that Chile produces large quantities of iron ore. Iron ore production in Chile amounted to 6.0 percent of total Latin American iron ore production in 1980 and to 4.0 percent in 1988. During the period 1980-1988, of the total iron ore production in Chile, on the average 81.3 percent per year was exported and the rest 18.7 percent was consumed by the Chilean iron and steel industry. Production of pellets and pig iron for domestic use increased by 26.2 and 20.2 percent respectively from 1980 to 1988. These two products are used as feed by the EAF process of steel-making which is used in very limited scale in Chile.

Argentina's consumption of iron ore grew by an average rate of 9.6 percent per annum for the entire period 1980-1988, while production and imports grew by a rate of 20.2 and 7.3 percent respectively. On the average

78.9 percent of total iron ore consumption is imported. However, a more intensive use of the EAF process of steel-making will result in a substantial decrease of iron ore imports. Argentina produces other raw materials, such as direct reduced iron, pellets, cinter and pig iron, which are used in the production of steel by the EAF or DR/EAF process, Argentina's most common method of steel production.

Tables 8, 9 and 10 show crude steel production by process for the three Latin American countries for the period 1980-1988. Argentina produces on the average 9.2 percent of total crude steel production in Latin America. Of the total crude steel produced in Argentina, 51.7 percent is manufactured by the EAF process, 30.9 percent by the BOF process and 16.1 percent by OH process. In addition, 56.7 percent of crude steel is produced by the continuous cast method. In Chile, on the other hand, the most common process used is the traditional basic oxygen furnace process which produces on the average 95.7 percent of the total annual crude steel, while the continuous cast method is not well developed in Chile. On the other hand, Venezuela produces on the average 8.3 percent of the total crude steel produced in Latin America. The major steel-making process are the electric arc furnace and the open hearth furnace which produce 79.7 and 20.3 percent of the total crude steel, respectively. Continuously cast steel has also increased in Venezuela from 40.5 percent in 1980 to 74.4 percent in 1988.

Data for consumption, exports and imports of steel products for the Latin American countries for the period 1980-1988 are presented in Tables 12, 13 and 14 in Appendix A. According to Table 12, Argentina's crude steel consumption amounted on the average to 10.0 percent of the total crude steel consumption of Latin America, while exports and imports of finished and

semi-finished steel products accounted for 9.3 and 17.4 percent of total exports and imports of Latin America respectively. Chile's crude steel consumption amounted to a low rate of 2.4 percent of total Latin America while its exports and imports accounted for 1.2 and 2.3 percent of the corresponding exports and imports of all Latin American countries. On the other hand, Venezuela consumes 8.7 percent per annum of the total crude steel consumption. Exports of finished and semi-finished steel products accounted for 10.3 percent of total exports of steel products and imports to 9.8 percent.

Finally, Table 15 summarizes the relationship between exports of steel products to total production and imports to total consumption for each of the three Latin American countries. On the basis of this Table, Argentina exports on the average 27.6 percent per annum of its total produced steel products, while it imports 25.1 percent of its total consumption. Chile exports 13.8 percent of its total production and import only 13.1 percent of its total consumption of steel products. Lastly Venezuela imports only 18.8 percent per year of its total consumption and it exports 25.1 percent per annum of its total production of steel products. The general conclusion can be drawn from Table 16 is that all three countries in question export more steel products than they import.

2. Asian Countries

This section deals with an analysis of the iron and steel industry of two Asian developing countries based on the data presented in Appendix B. Tables 16 and 17 present some economic indicators of the iron and steel industry in Indonesia and Thailand. Gross output produced by the iron and steel industry of Indonesia constantly increased from 1980 (3.5 percent) to 1986 (5.5 percent) and on the average accounted for 4.6 percent of total manufacturing gross output (Table 16). On the contrary, in Thailand gross output declined from 3.9 percent in 1980 to a low 2.2 percent in 1988. The share of gross output of the iron and steel industry accounted on the average only to 2.6 percent of total manufacturing. The declining importance of the iron and steel industry in Thailand is reflected in the employment figures shown in Table 17. Employment in the iron and steel industry declined by 40.0 percent from 22,552 employees in 1980 to 13,429 in 1986, which represents a 5.8 percent decline per annum. Employment in the iron and steel industry in Indonesia, on the other hand, grew by an average rate of 13.1 percent, to 16,900 in 1986 from 8,800 in 1980 (a total increase of 92.1 percent).

Data of raw materials used in the iron and steel industry in Indonesia and Thailand are not really available as it is shown in Tables 18 and 19. Very small quantities are produced domestically and the two countries are mainly dependent on imported raw materials. In addition, according to the ESCAP study, Thailand produces its total crude steel by EAF or DR/EAF processes while Indonesia employs those methods for 90 percent of its crude steel production.

Tables 20 and 21 of Appendix B present data of production, consumption, exports and imports of steel products for Indonesia and Thailand. Indonesia produces only 3.5 percent per annum of the total crude steel production in Asia while it consumes 5.3 percent of total Asian consumption. On the other hand, exports and imports of finished and semi-finished steel products amounted to 2.0 and 6.7 percent respectively of the corresponding total exports and imports of the Asian developing countries. Corresponding figures for Thailand are shown in Table 21. Thailand produces 1.2 percent of the total Asian crude steel production, while it consumes 5.4 percent per annum of the total Asian crude steel consumption. Similarly, Thailand's exports of steel products on the average accounted for 1.2 percent of total Asian exports for the period 1980-1988 and imports to 10.2 percent of the total Asian imports of steel products.

However, there is a substantial gap between consumption and production which is bridged by high level of imports by both countries. This gap is shown in Table 22. According to this Table, Indonesia exports on the average 11.1 percent per year of its total production while 43.2 percent of its total annual consumption consists of imported steel products. Thailand is in worst situation since it relies more heavily on imported steel products. That is, 75.2 percent of its annual consumption is satisfied through imports, while in 1983 total imports amounted to 79.5 percent of its total consumption. Thailand's exports on the other hand, accounted for an average rate of 24.0 percent of its annual production of steel products. Exports of steel products to total steel production reached a low level of 13.1 percent in 1982, the lowest for the period 1980-1988.

V. CONCLUSION

This section summarizes the main findings of the study and recommends Argentina and Thailand as the two candidate countries for implementing UNIDO's programme for strengthening the technological capabilities in environmental control and risk management activities in the steel industry of the developing countries. The main conclusions are the followng:

At present, there are two major processes of steel-making, the blast oxygen steel (BF/BOS) process which uses iron ore as the basic feed and the electric arc furnace process which can operate by using scrap as feedstock (EAF) or alternatively by using direct reduced iron (DR/EAF). The choice of a steel-making process depends on three major factors: scale of operations, availability of raw materials particularly iron ore and energy costs. The minimum economic scale for a BF/BOS plant is 1.0 million tonnes per year with important economies of scale up to 5.0 million tonnes per year. These scales are large for developing countries and capital investment for BF/BOS process is unlikely to be competitive in developing countries. Scale of operations is less constraining for the alternative DR/EAF process and more appropriate for developing countries, particularly for those with small domestic market, since a country can start its won steel industry with minimum economic scale of 100,000 tonnes per year or even less. In India, for example, two steel plant's (SIIL Company and the Ipitata Iron Ltd.) started operating in 1984 and 1986 with capacity of 30,000 and 90,000 tonnes per year respectively, while in Burma two government owned plants started with capacity of only 20,000 tonnes per year. In general, the BF/BOS process requires large-scale production and large capital investment (ESCAP, 1989).

The iron and steel industry is one of the major consumers of fuel and power in the national economies of both developed and developing countries. The share of the iron and steel industry in the total consumption of energy significantly varies mainly due to the size of the industry and to the processes employed. Direct energy costs account for between 20 and 60 percent of production costs at separate stages of iron and steel production. The scrap based EAF process is the less energy intensive process, while gas-based DR/EAF processes are the most important and account for more than 90 percent of total DR capacity due to higher energy efficiency and the availability of cheap natural gas in a number of developed and developing countries.

Another very important factor which determines the selection of steel-making process is the availability of raw material and especially iron ore. For the traditional BF/BOS process, 1.21 tonnes of iron ore are required per tonne of steel produced (OECD, 1987). However, countries endowed with abundant sources of iron ore should employ the iron ore intensive BF/BOS process. In the five countries selected for this study, this relationship holds in most of the cases. For example, Indonesia and Thailand with no iron ore sources, produce 90 percent and 100 percent of steel respectively by the EAF or DR(EAF) processes, while Chile with large iron ore deposits, more than 95 percent of its steel output is produced by the BF/BOS process. Venezuela, on the contrary, produces about 80 percent of its steel output by the EAF method although it produces 1.2 percent of total world production of iron ore. This is a contradiction which may be explained by the fact that most of Venezuela's steel plants are relatively new and of small capacity. Finally, Argentina which is endowed with small deposits of iron ore, produces about 50 percent of its steel output by the EAF or DR/EAF process and the other 50 percent by the BF/BOS and open hearth furnaces (OH) processes. This is

probably due to the fact that many of Argentina's steel plants are old. For example, three of Argentina's steel plants, Acindar Rosario, Acindar Villa and Somisa San Nicolas, were build in the 1940's (Maxwell, 1982).

Finally, Thailand and Argentina are the two countries recommended for the implementation of UNIDO's programme for the following reasons. Thailand's steel industry is declining and its employment has reached a low level of 13,429 employees in 1986 from 22,552 employees in 1980. Total steel output is produced by the EAF or DR/EAF processes which means that a lot of improvements can be made with relatively low capital investment. Most important, there is a big gap between consumption and production of steel products in Thailand. Its imports amounted to 75.9 percent of its consumption needs. However, restructuring and upgrading the industry can increase its productivity, the quality and quantity of steel products and reduce foreign exchange needs of Thailand.

The iron and steel industry of Argentina is a vital industry in many respects. First, its gross output remains constant while its employment share to total manufacturing increases. Second, Argentina is endowed with relatively small deposit of iron ore and imports small quantities for the operation of steel plants employing the BF/BOS or OH process, while it produces almost entirely the raw materials necessary for the EAF or DR/EAF processes. Finally, Argentina is self-sufficient in steel needs and modernization of the industry will increase production and exports to other developed and developing countries.

In summary, based on the above discussion and the data presented in this paper, Argentina and Thailand are recommended as the candidate countries for

implementing UNIDO's programme for strengthening the steel industry of the developing countries in terms of risk management and environmental control activities.

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APPENDIX A

STATISTICAL DATA OF LATIN AMERICAN COUNTRIES

TABLE 3

Economic Profile of the Iron and Steel Industry in Argentina, 1980-1987 (in shares of total manufacturing except otherwise indicated)

Economic Indicators	1980	1981	1982	1983	1984	1985	1986	1987
Gross Output	3.9	4.1	5.0	5.0	5.0	5.2	5.0	5.0
Employment (Number of Employees)	43,987	38,205	35,787	37,662	40,750	41,379	38,547	37,957
Employment	3.3	3.3	3.2	3.3	3.5	3.7	3.6	3.5
Wages and Salaries ('000 of national currency)	94	146	349	2213	21306	140151	240499	559136
Wages and Salaries	3.3	3.2	3.4	3.6	3.8	4.2	3.7	4.1
Index of Industrial Production (1980 = 100)	100	90	102	107	101	98	109	125

Source International Iron and Steel Institute, Steel Statistical Yearbook, 1989, Committee on Statistics, Brussels, 1989.

TABLE 4

Economic Profile of the Iron and Steel Industry in Chile, 1980-1987 (in shares of total manufacturing except otherwise indicated)

Economic Indicators	1980	1981	1982	1983	1984	1985	1986	1987
Gross Output	4.7	4.2	4.8	4.9	4.6	4.8	4.8	4.7
Employment (Number of Employees)	8,060	6,590	6,400	5,970	6,200	7,580	8,220	9,378
Employment	3.9	3.4	4.2	3.9	3.7	4.1	3.9	3.9
Wages and Salaries ('000 of national currency)	1,935	2,888	3,285	3,689	4,550	6,078	8,266	9,796
Wages and Salaries	4.2	4.7	5.9	5.8	5.7	5.8	5.7	5.8
Index of Industrial Production (1980 = 100)	100	90	60	76	91	90	92	96

Source International Iron and Steel Institute, Steel Statistical Yearbook, 1989, Committee on Statistics, Brussels, 1989.

TABLE 5

Economic Profile of the Iron and Steel Industry in Venezuela, 1980-1987 (in shares of total manufacturing except otherwise indicated)

Economic Indicators	1980	1981	1982	1983	1984	1985	1986	1987
Gross Output	4.9	4.7	5.7	5.4	5.4	5.9	6.9	7.1
Employment (Number of Employees)	37,457	26,000	24,100	28,500	24,300	25,200	26,000	29,000
Employment	7.9	6.1	5.5	6.7	5.8	5.9	5.9	6.5
Wages and Salaries ('000 of national currency)	1,341	1,427	1,810	2,100	1,756	2,258	2,432	3,257
Wages and Salaries	8.3	6.9	8.1	8.9	7.4	8.4	8.2	8.2
Index of Industrial Production (1980 = 100)	100	112	132	107	124	119	173	272

Source International Iron and Steel Institute, Steel Statistical Yearbook, 1989, Committee on Statistics, Brussels, 1989.

TABLE 6

Production, Consumption, Exports and Imports of Raw Materials in Argentina, 1980-1988 ('000 metric tons)

	1980	1981	1982	1983	1984	1985	1986	1987	1988
Direct Reduced Iron Production	757	805	879	950	898	989	935	1,034	1,067
Production of Pellets	312	374	616	546	465	495	646	465	595
Cinter Production	666	809	833	815	820	876	854	905	813
Pig Iron Production	1,027	912	1,015	909	893	1,310	1,625	1,752	1,610
Pig Iron Imports	153	10	122	205	177	32	0	0	91
Pig Iron Exports	0	0	0	0	0	0	0	0	0
Pig Iron Consumption *	1,180	922	1,137	1,114	1,070	1,342	1,625	1,752	1,701
Iron Ore Production	412	382	583	590	572	578	788	844	1,162
Iron Ore Imports	1,893	2,013	1,913	1,691	2,199	2,459	3,182	3,342	3,131
Iron Ore Exports	0	0	0	0	0	0	0	0	0
Iron Ore Consumption *	2,305	2,395	2,496	2,281	2,771	3,037	3,970	4,186	4,293

Source International Iron and Steel Institute, Steel Statistical Yearbook, 1989, Committee on Statistics, Brussels, 1989.

* Consumption is equal to (production + imports) - exports.

TABLE 7

Production, Consumption, Exports and Imports of Raw Materials in Chile, 1980–1988 ('000 metric tons)

	1980	1981	1982	1983	1984	1985	1986	1987	1988
Direct Reduced Iron Production	0	0	0	0	0	0	0	0	0
Production of Pellets	3,178	3,266	3,376	3,072	3,371	3,607	3,317	3,694	4,073
Cinter Production	0	0	0	0	0	0	0	0	0
Pig Iron Production	647	592	453	539	594	575	592	617	778
Pig Iron Imports	0	0	0	0	0	0	0	0	0
Pig Iron Exports	0	0	0	0	0	0	0	0	0
Pig Iron Consumption *	647	592	453	539	594	575	592	617	778
Iron Ore Production	8,960	7,650	6,356	5,809	6,685	6,534	6,981	6,637	7,280
Iron Ore Imports	0	0	0	0	0	0	0	0	0
Iron Ore Exports	7,591	6,830	5,502	4,719	5,232	4,816	4,846	5,329	6,397
Iron Ore Consumption *	1,369	820	854	1,090	1,453	1,718	2,135	1,308	883

Source International Iron and Steel Institute, Steel Statistical Yearbook, 1989, Committee on Statistics, Brussels, 1989.

* Consumption is equal to (production + imports) - exports.

TABLE 8

Production, Consumption, Exports and Imports of Raw Materials in Venezuela, 1980-1988 ('000 metric tons)

	1980	1981	1982	1983	1984	1985	1986	1987	1988
Direct Reduced Iron Production	1,635	1,797	2,153	2,380	2,486	2,635	2,938	3,111	3,096
Production of Pellets	1,772	2,078	3,109	3,567	3,184	3,652	3,293	4,350	4,400
Cinter Production	0	0	0	0	0	0	0	0	0
Pig Iron Production	497	420	202	169	325	440	491	473	503
Pig Iron Imports	0	0	0	0	0	0	0	0	0
Pig Iron Exports	0	0	0	0	0	0	0	0	0
Pig Iron Consumption *	497	420	202	169	325	325	440	491	503
Iron Ore Production	13,681	13,179	11,424	9,138	12,723	14,710	16,207	17,197	18,220
Iron Ore Imports	0	0	0	0	0	0	0	0	0
Iron Ore Exports	11,723	12,405	6,616	6,245	8,456	9,032	10,027	11,905	12,289
Iron Ore Consumption *	1,958	774	4,808	2,893	4,267	5,678	6,180	5,292	5,931

Source: International Iron and Steel Institute, Steel Statistical Yearbook, 1989, Committee on Statistics, Brussels, 1989.

* Consumption is equal to (production + imports) - exports.

TABLE 9

Crude Steel Production in Argentina, 1980-1988
('000 metric tons)

	Crude Steel Production			Crude Steel Production by Process							
				Quantity *			% to Total Crude Steel Production *				
	Total Latin America	Argentina	% to total Latin America	BOF	EAF	OH	BOF	EAF	OH	Continuously Cast Steel Production	Continuously Cast as % of Crude Steel Prodn
1980	28,861	2,687	9.3	700	1,441	444	26.1	53.7	16.6	1,431	53.3
1981	27,047	2,526	9.3	699	1,426	327	27.7	56.5	13.0	1,244	49.2
1982	26,691	2,913	10.9	668	1,553	635	23.0	53.4	21.8	1,510	51.8
1983	28,708	2,942	10.2	594	1,624	670	20.2	55.2	22.8	1,429	48.6
1984	33,154	2,647	8.0	567	1,440	591	21.4	54.4	22.3	1,254	47.4
1985	35,629	2,946	8.3	981	1,552	438	33.3	51.7	14.9	1,839	62.4
1986	37,351	3,235	8.7	1,425	1,469	341	44.0	45.4	10.5	2,100	64.9
1987	39,627	3,610	9.1	1,534	1,696	380	42.5	47.0	10.5	2,372	65.7
1988	42,444	3,631	8.6	1,444	1,754	424	39.9	48.4	11.7	2,427	66.8

Source: International Iron and Steel Institute, Steel Statistical Yearbook, 1989, Committee on Statistics, Brussels, 1989.

* The addition of the figures for the three methods is not always equal to total production. The difference is produced by other methods which are not presented in this table.

TABLE 10

Crude Steel Production in Chile, 1980-1988
('000 metric tons)

	Crude Steel Production			Crude Steel Production by Process							
				Quantity			% to Total Crude Steel Production				
	Total Latin America	Chile	% to total Latin America	BOF	EAF	OH	BOF	EAF	OH	Continuously Cast Steel Production	Continuously Cast as % of Crude Steel Prodn
1980	28,861	704	2.4	736	10	0	98.7	1.3	0.0	15	2.1
1981	27,047	644	2.4	625	32	0	95.1	4.9	0.0	9	1.4
1982	26,691	492	1.8	475	8	0	98.3	1.7	0.0	4	.8
1983	28,708	618	2.2	593	18	0	96.0	2.9	0.0	8	1.3
1984	33,154	692	2.1	663	27	0	96.1	3.9	0.0	11	1.6
1985	35,629	689	1.9	648	36	0	94.7	5.3	0.0	13	1.9
1986	37,351	706	1.9	674	32	34	91.1	4.3	4.6	19	2.7
1987	39,627	719	1.8	685	0	34	95.3	0.0	4.7	12	1.7
1988	42,444	899	2.1	860	39	0	95.7	4.3	0.0	18	2.0

Source International Iron and Steel Institute, Steel Statistical Yearbook, 1989, Committee on Statistics, Brussels, 1989.

TABLE 11

Crude Steel Production in Venezuela, 1980-1988
('000 metric tons)

	Crude Steel Production			Crude Steel Production by Process							
				Quantity			Percentage to Total Crude Steel Production			Continuously Cast Steel Production	Continuously Cast as % of Crude Steel Production
	Total Latin America	Venezuela	% to total Latin America	BOF	EAF	OH	BOF	EAF	OH		
1980	28,861	1,975	6.8	0	1,185	635	0.0	65.1	34.9	800	40.5
1981	27,047	2,030	7.5	0	1,462	567	0.0	72.1	27.9	1,262	62.3
1982	26,691	2,226	8.3	0	1,801	414	0.0	81.3	18.7	1,558	68.4
1983	28,708	2,367	8.2	0	1,929	391	0.0	83.1	16.9	1,817	78.3
1984	33,154	2,770	8.4	0	2,218	552	0.0	80.1	19.9	2,000	72.2
1985	35,629	3,060	8.6	0	2,587	473	0.0	84.5	15.5	2,250	73.5
1986	37,351	3,402	9.1	0	2,798	604	0.0	82.2	17.8	2,425	71.3
1987	39,627	3,722	9.4	0	3,159	563	0.0	84.9	15.1	2,850	76.6
1988	42,444	3,654	8.6	0	3,082	572	0.0	84.4	15.6	2,720	74.4

Source International Iron and Steel Institute, Steel Statistical Yearbook, 1989, Committee on Statistics, Brussels, 1989.

TABLE 12

Consumption, Exports and Imports of Steel Products in Argentina, 1980-1988
('000 metric tons)

	Crude Steel Consumption			Consumption of Finished Steel			Exports of Finished and Semi-finished Steel Products			Imports of Finished and Semi-finished Steel Products		
	Total Latin America	Argentina	% to total Latin America	Total latin America	Argentina	% to total latin America	Total Latin America	Argentina	% to total Latin America	Total Latin America	Argentina	% to total Latin America
1980	34,832	3,578	10.3	28,511	3,009	10.6	2,188	286	13.1	7,075	1,035	14.6
1981	32,422	2,601	8.0	26,316	2,174	8.3	2,923	590	20.2	7,338	653	8.9
1982	27,873	2,743	9.8	23,265	2,232	9.6	4,020	752	18.7	5,060	609	12.0
1983	22,448	2,912	13.0	19,110	2,218	11.6	7,985	673	8.4	2,792	648	23.2
1984	26,780	3,074	11.5	22,542	2,226	9.9	8,941	542	6.1	3,711	898	24.2
1985	27,437	2,184	8.0	23,085	1,569	6.8	10,147	1,111	10.9	3,362	461	13.7
1986	30,166	2,510	8.3	25,886	2,126	8.2	9,618	1,175	12.2	3,641	554	15.2
1987	32,156	3,260	10.1	27,264	2,556	9.4	10,152	1,064	10.5	3,944	764	19.2
1988	29,285	2,956	10.1	25,617	2,365	9.2	14,810	1,570	10.6	3,825	990	25.9

Source: International Iron and Steel Institute, Steel Statistical Yearbook, 1989, Committee on Statistics, Brussels, 1989

TABLE 13

Consumption, Exports and Imports of Steel Products in Chile, 1980-1988
('000 metric tons)

	Crude Steel Consumption			Consumption of Finished Steel			Exports of Finished and Semi-finished Steel Products			Imports of Finished and Semi-finished Steel Products		
	Total Latin America	Chile	% to total Latin America	Total Latin America	Chile	% to total Latin America	Total Latin America	Chile	% to total Latin America	Total Latin America	Chile	% to total Latin America
1980	34,832	811	2.3	28,511	627	2.2	2,188	9	.4	7,075	92	1.3
1981	32,422	724	2.2	26,316	559	2.1	2,923	5	.2	7,338	67	.9
1982	27,873	334	1.2	23,265	258	1.1	4,020	163	4.1	5,060	41	.8
1983	22,448	461	2.1	19,110	356	1.9	7,985	146	1.8	2,792	25	.9
1984	26,780	655	2.4	22,542	505	2.2	8,941	99	1.1	3,711	71	1.9
1985	27,437	660	2.4	23,886	509	2.2	10,147	100	1.0	3,362	77	2.3
1986	30,166	756	2.5	25,085	584	2.3	9,618	127	1.3	3,641	166	4.6
1987	32,156	823	2.6	27,264	635	2.3	10,152	94	.9	3,944	174	4.4
1988	29,285	1,027	3.5	25,617	793	3.1	14,810	46	.3	3,825	145	3.8

Source: International Iron and Steel Institute, Steel Statistical Yearbook, 1989, Committee on Statistics, Brussels, 1989

TABLE 14

Consumption, Exports and Imports of Steel Products in Venezuela, 1980-1988

('000 metric tons)

	Crude Steel Consumption			Consumption of Finished Steel			Exports of Finished and Semi-finished Steel Products			Imports of Finished and Semi-finished Steel Products		
	Total Latin America	Venezuela	% to total Latin America	Total Latin America	Venezuela	% to total Latin America	Total Latin America	Venezuela	% to total Latin America	Total Latin America	Venezuela	% to total Latin America
1980	34,832	2,798	8.0	28,511	2,305	8.1	2,188	241	11.0	7,075	919	13.0
1981	32,422	2,578	8.0	26,316	2,198	8.4	2,923	388	13.3	7,338	855	11.6
1982	27,873	2,968	10.6	23,265	2,557	11.0	4,020	293	7.3	5,060	932	18.4
1983	22,448	1,698	7.5	19,110	1,476	7.7	7,985	852	10.7	2,792	258	9.2
1984	26,780	2,088	7.8	22,542	1,809	8.0	8,941	801	9.0	3,711	210	5.7
1985	27,437	1,776	6.5	23,085	1,542	6.7	10,147	1,266	12.5	3,362	151	4.5
1986	30,166	2,622	8.7	25,886	2,268	8.8	9,618	913	9.5	3,641	238	6.5
1987	32,156	3,274	10.2	27,264	2,856	10.5	10,152	918	9.0	3,944	527	13.3
1988	29,285	3,126	10.7	25,617	2,718	10.6	14,810	848	5.7	3,825	389	10.2

Source: International Iron and Steel Institute, Steel Statistical Yearbook, 1989, Committee on Statistics, Brussels, 1989

TABLE 15

Relationship of Exports to Production and Imports to Consumption of Steel Products, 1980-1988

Year	Ratio of Exports to Crude Steel Production			Ratio of Imports tp Crude Steel Consumption		
	Argentina	Chile	Venezuela	Argentina	Chile	Venezuela
1980	10.6	1.3	12.2	28.9	11.3	32.8
1981	23.4	.8	19.1	25.1	9.3	33.2
1982	25.8	33.1	23.2	22.2	12.3	31.4
1983	22.9	23.6	36.0	22.3	5.4	15.3
1984	20.5	14.3	28.9	29.2	10.8	10.1
1985	37.7	14.5	41.4	21.1	11.7	8.5
1986	36.3	18.0	26.8	22.1	22.0	9.1
1987	29.5	13.1	24.7	23.4	21.1	16.1
1988	43.2	5.1	23.2	33.5	14.2	12.4
Ave-rage	27.6	13.8	25.1	25.3	13.1	18.8

Source: Tables 9, 10, 11, 12, 13 and 14

APPENDIX B

STATISTICAL DATA OF ASIAN COUNTRIES

TABLE 16

Economic Profile of the Iron and Steel Industry in Indonesia, 1980-1986 (in shares of total manufacturing except otherwise indicated)

Economic Indicators	1980	1981	1982	1983	1984	1985	1986
Gross Output	3.5	3.0	2.9	5.3	6.7	5.0	5.5
Employment (Number of Employees)	8,800	9,500	10,100	12,900	14,000	15,600	16,900
Employment	.9	.9	1.0	1.2	1.2	.9	1.0
Wages and Salaries ('000 of national currency)	8,932	9,191	11,000	20,000	27,000	29,000	49,000
Wages and Salaries	2.0	1.6	1.5	2.2	2.5	1.7	2.6
Index of Industrial Production (1980 = 100)	100	121	94	111	113	112	131

Source: International Iron and Steel Institute, Steel Statistical Yearbook, 1989, Committee on Statistics, Brussels, 1989.

TABLE 17

Economic Profile of the Iron and Steel Industry in Thailand, 1980-1987 (in shares of total manufacturing except otherwise indicated)

Economic Indicators	1980	1981	1982	1983	1984	1985	1986	1987
Gross Output	3.9	2.9	2.5	2.3	2.1	2.5	2.0	2.2
Employment (Number of Employees)	22,552	18,256	14,422	13,058	11,853	13,076	13,429	-
Employment	1.5	1.2	1.1	1.0	.9	1.0	1.0	-
Wages and Salaries ('000 of national currency)	1,249	1,108	959	951	946	1,221	1,029	1,324
Wages and Salaries	2.8	2.1	1.8	1.6	1.5	1.8	1.4	1.5
Index of Industrial Production (1980 = 100)	100	96	85	82	105	96	120	-

Source International Iron and Steel Institute, Steel Statistical Yearbook, 1989, Committee on Statistics, Brussels, 1989.

TABLE 18

Production, Consumption, Exports and Imports of Raw Materials in Indonesia, 1980-1988 ('000 metric tons)

	1980	1981	1982	1983	1984	1985	1986	1987	1988
Direct Reduced Iron Production	370	400	436	514	740	1,060	1,320	1,030	980
Production of Pellets	0	0	0	0	0	0	0	0	0
Cinter Production	0	0	0	0	0	0	0	0	0
Pig Iron Production	0	0	0	0	0	0	0	0	0
Pig Iron Imports	36	75	84	88	96	81	101	80	80
Pig Iron Exports	93	82	117	62	70	87	96	90	90
Pig Iron Consumption *	0	0	0	0	0	0	0	0	0
Iron Ore Production	100	100	140	120	100	130	130	130	130
Iron Ore Imports	300	701	121	128	198	1,700	2,100	1,400	1,400
Iron Ore Exports	0	0	0	0	0	0	0	0	0
Iron Ore Consumption *	400	801	261	248	298	1,830	2,230	1,530	1,530

Source: International Iron and Steel Institute, Steel Statistical Yearbook,1989, Committee on Statistics, Brussels, 1989.

* Consumption is equal to (production + imports) - exports.

TABLE 19

Production, Consumption, Exports and Imports of Raw Materials in Thailand, 1980–1988 ('000 metric tons)

	1980	1981	1982	1983	1984	1985	1986	1987	1988
Direct Reduced Iron Production	0	0	0	0	0	0	0	0	0
Production of Pellets	0	0	0	0	0	0	0	0	0
Cinter Production	0	0	0	0	0	0	0	0	0
Pig Iron Production	17	10	6	10	10	10	10	10	10
Pig Iron Imports	5	27	15	13	15	16	15	15	15
Pig Iron Exports	0	0	0	0	0	0	0	0	0
Pig Iron Consumption *	22	37	21	23	25	26	25	25	25
Iron Ore Production	84	60	30	70	70	100	40	100	100
Iron Ore Imports	0	0	0	0	0	0	0	0	0
Iron Ore Exports	0	0	0	0	0	0	0	0	0
Iron Ore Consumption *	84	60	30	70	70	100	40	100	100

Source: International Iron and Steel Institute, Steel Statistical Yearbook,1989, Committee on Statistics, Brussels, 1989.

* Consumption is equal to (production + imports) - exports.

TABLE 20

Production, Consumption, Exports and Imports of Steel Products in Indonesia, 1980-1988

('000 metric tons)

	Production of Crude Steel			Consumption of Crude Steel			Consumption of Finished Steel Products			Exports of Finished & Semi-finished Steel Products			Imports of Finished & Semi-finished Steel Products		
	Total Asia	Indonesia	% to total Asia	Total Asia	Indonesia	% to total Asia	Total Asia	Indonesia	% to total Asia	Total Asia	Indonesia	% to total Asia	Total Asia	Indonesia	% to total Asia
1980	23,653	543	2.3	38,163	3,104	7.9	31,588	2,477	7.8	6,139	24	.4	17,034	2,055	12.1
1981	26,723	621	2.3	41,558	3,126	7.5	34,723	2,589	7.5	6,508	16	.2	18,040	2,091	11.6
1982	29,099	695	2.4	43,529	3,028	7.0	36,626	2,551	7.0	8,009	2	0	18,478	1,969	10.7
1983	29,612	983	3.3	44,145	2,850	6.5	37,693	2,421	6.4	8,447	0	0	18,718	1,586	8.5
1984	31,896	1,171	3.7	43,306	1,966	4.5	36,669	1,680	4.6	9,194	50	.5	16,926	726	4.3
1985	34,647	1,374	4.0	46,928	2,328	5.0	40,052	2,001	5.0	9,147	111	1.2	17,290	931	5.4
1986	36,712	1,729	4.7	48,611	1,851	3.8	41,625	1,604	3.9	8,875	225	2.5	17,226	331	1.9
1987	40,983	2,059	5.0	54,468	1,715	3.2	47,877	1,493	3.1	9,293	607	6.5	19,663	307	1.6
1988	46,885	1,850	3.9	59,570	1,393	2.3	52,374	1,220	2.3	11,120	700	6.3	22,454	300	1.3

Source: International Iron and Steel Institute, Steel Statistical Yearbook, 1989, Committee on Statistics, Brussels, 1989

TABLE 21

Production, Consumption, Exports and Imports of Steel Products in Thailand, 1980-1988

('000 metric tons)

	Production of Crude Steel			Consumption of Crude Steel			Consumption of Finished Steel Products			Exports of Finished & Semi-finished Steel Products			Imports of Finished & Semi-finished Steel Products		
	Total Asia	Thailand	% to total Asia	Total Asia	Thailand	% to total Asia	Total Asia	Thailand	% to total Asia	Total Asia	Thailand	% to total Asia	Total Asia	Thailand	% to total Asia
1980	23,653	450	1.9	38,163	1,990	5.2	31,588	1,636	5.2	6,139	78	1.3	17,034	1,344	7.9
1981	26,723	300	1.1	41,558	1,854	4.5	34,723	1,536	4.4	6,508	82	1.3	18,040	1,369	7.6
1982	29,099	312	1.1	43,529	2,456	5.6	36,626	2,069	5.6	8,009	41	.5	18,478	1,847	10.0
1983	29,612	244	.8	44,145	3,092	7.0	37,693	2,626	7.0	8,447	38	.4	18,718	2,457	13.1
1984	31,896	381	1.2	43,306	2,328	5.4	36,669	1,990	5.4	9,194	69	.8	16,926	1,733	10.2
1985	34,647	425	1.2	46,928	2,748	5.9	40,052	2,362	5.9	9,147	148	1.6	17,290	2,145	12.4
1986	36,712	450	1.2	48,625	2,319	4.8	41,611	2,009	4.8	8,875	150	1.7	17,226	1,769	10.3
1987	40,983	534	1.3	54,468	2,438	4.5	47,877	2,123	4.5	9,293	150	1.6	19,663	1,808	9.2
1988	46,885	535	1.1	59,570	3,176	5.3	52,374	2,780	5.3	11,120	150	1.3	22,454	2,462	11.0

Source: International Iron and Steel Institute, Steel Statistical Yearbook, 1989, Committee on Statistics, Brussels, 1989

TABLE 22

Ratios of Exports to Production and Imports to Consumption of Steel Products, 1980–1988

Year	Ratio of Exports to Crude Steel Production		Ratio of Imports to Crude Steel Consumption	
	Indonesia	Thailand	Indonesia	Thailand
1980	4.4	17.3	68.2	67.5
1981	2.6	27.3	66.9	73.8
1982	.3	13.1	65.0	75.3
1983	0	15.6	55.6	79.5
1984	4.3	18.1	36.9	74.4
1985	8.1	34.8	40.0	78.1
1986	13.0	33.3	17.0	76.3
1987	29.5	28.1	17.9	74.2
1988	37.8	21.5	21.5	77.5
Average	11.1	24.0	43.2	75.2

Source: Tables 20 and 21