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DEVELOPMENT PLANNING IN NIGERIA: A CASE STUDY OF THE PROPOSED INTEGRATED STEEL WORKS

by

Joshua Oluwole Oyebanji

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Geography)
in The University of Michigan
1975

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CHAPTER 1

INTRODUCTION

1. The Role of Steel in National Development Planning

In most parts of the world, developed or developing, nationalism is one of the major factors in the establishment of modern industrial plants, and more than any other manufacturing industry, the iron and steel seems to be "clothed with public interest."[1] The motives for political intervention in the steel industry are sometimes economic, sometimes sociological, and sometimes strategic. Underlying each of the above motives is desire for political and international prestige. As N. J. G. Pounds points out:

> The possession of a large, integrated iron and steel works not only gives economic strength to the country which has it but is thought also to confer political power and prestige. In underdeveloped countries the creation of such works, however small the national contribution to it may have been, focuses the attention of the people. It gives a sense of independence from, almost of equality with, other and more developed nations.[2]

N. J. G. Pounds' observation is not peculiar with underdeveloped nations, however. Both developed and underdeveloped nations seem to have been wrapped up in the iron and steel politics. In Western U.S.A., the Federal Government opened up plants at Fontana (California),

and Provo (Utah) for purely political strategic reasons during World War II. In South America, Brazil, Mexico, Argentina, Chile, Venezuela and Colombia had each established its own national steel plant even though they lack resources and good transportation and could not produce steel at a price cheaper than they pay on imported steel.[3] In Eastern Europe, steel plants have been opened in Romania, Bulgaria, Hungary, and in Yugoslavia despite the fact that in each of these countries, "reserves of both ore and of coking coal appear to be too small and by themselves, could not justify the erection of a large plant."[4] Even though Poland pays a high price for establishing a national plant, its people enjoy the psychological satisfaction they believe this industry gives them and they are proud to tell the world that "the whole nation builds Nova Huta."[5]

When we look elsewhere we see similar patterns as described above in steel establishments. Japan, which today produces steel at the cheapest possible rate in the world, had its first plant opened at Yawata about 1901 by its national government.[6] The geography of the Indian steel industry also "cannot be fully understood without some recognition of the desires of certain Indian States to have a steelworks, and the pressure they brought to bear on New Delhi in order to achieve their objectives."[7]

In Western Europe, nationalism has also been one of the major forces that led to the establishment of many

steel plants. Turkey has a steel plant despite the fact that its ore deposits are small and low in quality.[8] Italy did not only establish a plant in Taranto in rural Southern Italy; the whole nation also paid the price of deliberately protecting the industry at that "ecentric" location.[9] In Scandinavia, the Swedish and Norwegian governments have built small and uneconomic iron and steel plants in their northern territories at Lulea and Moirana, respectively, "which can only be interpreted as efforts to create employment in peripheral and underdeveloped, yet strategically important localities."[10] In Britain, the opening of the steel works at Ebbw Vale (1930) was mainly due to political intervention to reduce unemployment and poverty in that region. Commenting on European steel plants in general, Pounds points out that, "A further influence on the location of the European iron and steel industry during the present century has been the movement toward national self-sufficiency"[11] because "steel was of too vital an importance for any country to willingly depend wholly on others for its supply."[12]

Like many other nations, thus, Nigeria sees the development of a national steel works as an aspect of new nationalism. Even though money and other things seem hard to come by, one or more national integrated steel work- will be established in Niteria in the very near future.

2. Study Area

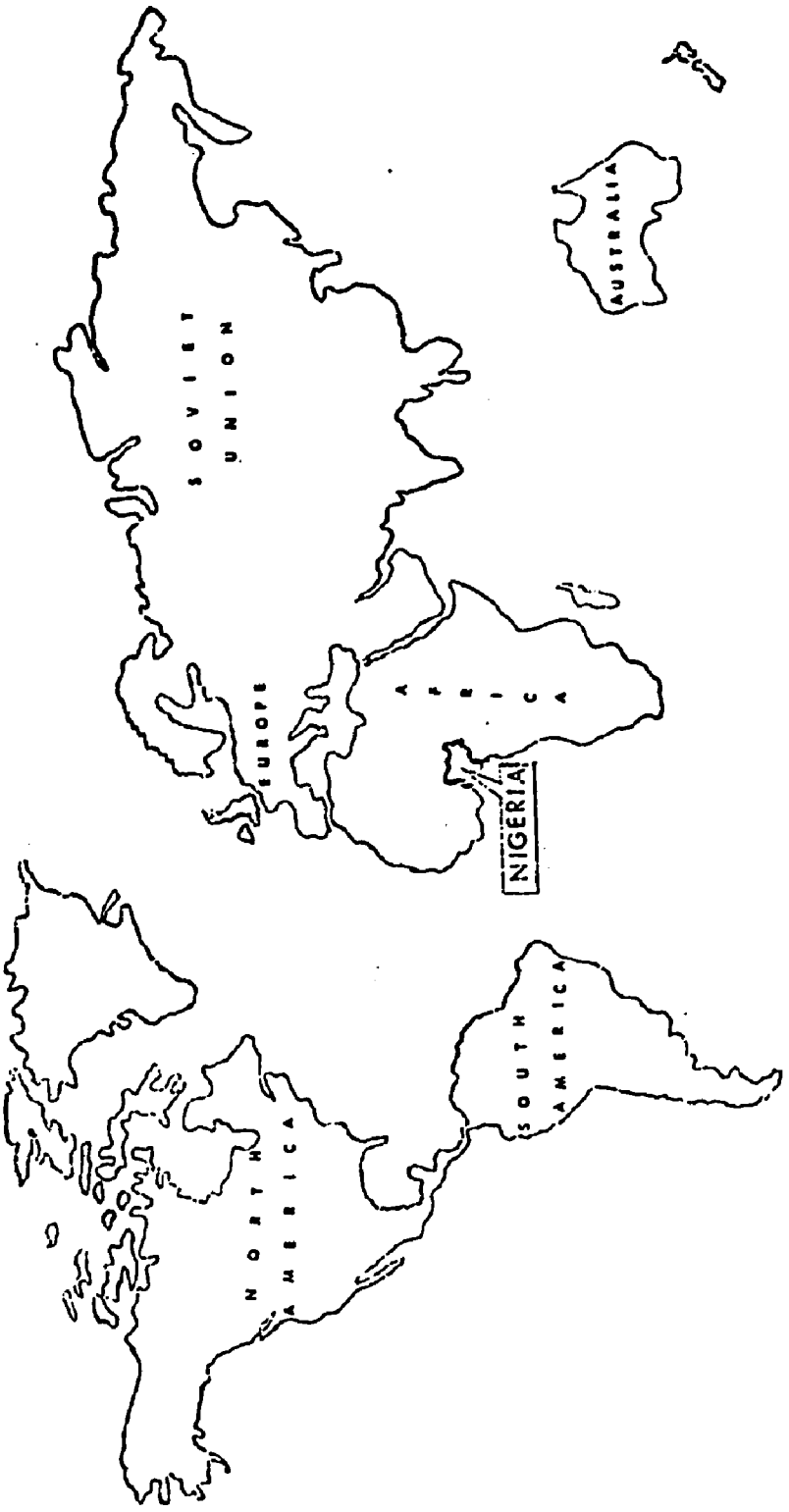
The study area focuses on Nigeria (Figure 1.1), a country with an average of about 357,000 square miles and a population of approximately 80 million people.[13] It is located in West Africa, Figure 1.2, and bounded in the west by Dahomey, in the east by the Cameroons, in the north by the Niger Republic and in the south by the Atlantic Ocean. Nigeria is the largest and the most populated country in black Africa. However, Nigeria, perhaps, is the most culturally diverse country in Africa, a factor which has led to many internal strifes.[14]

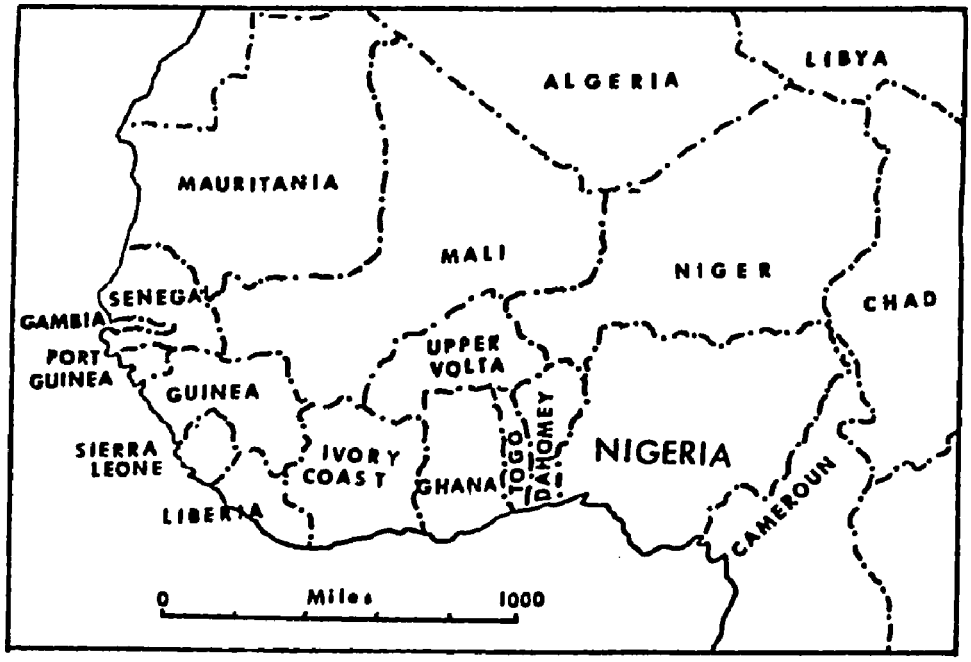
The peoples of northern Nigeria are mainly muslims while christianity predominates among the southerners. Religious differences among Nigerians are complicated by linguistic differences. Although Hausa is the most widely spoken language in the north, Yoruba in the west and Ibo in the east, a closer study has shown that Nigeria "comprises some 250 ethnic groups with a variety of customs, traditions, languages, and dialetc."[15]

The differences in language, religious and culture separate Nigerians from each other and breeds excessive regionalism which considerably "endangers national unity and weakens the power of the Federal Government."[16] This is largely reflected in the marked degree of political inter-regional competition on the location of public properties, as everyone in authority wants the interests of

FIGURE 1.1

LOCATION OF STUDY AREA (NIGERIA)





WEST AFRICA

FIGURE 1.2

his kin, friends and people to prevail over national interests.[17] The proposed iron and steel industry is an interesting example. In the present paper the influence of inter-regional political rivalry on steel location market demand and manufacturing costs are discussed. Thereafter the optimum solutions both economic and political are sought.

3. Study Objectives

The research objective is to establish the optimum location for an iron and steel mill in Nigeria under varying assumptions concerning economic, political, and social objectives in national industrial development planning. In particular, the factors affecting the optimum location such as size of plant, sources and costs of raw materials, and the impact of an industrial plant on local regional development will be considered. The results of the analysis will be the set of consequences expected under varying assumptions. The results should be useful to the Nigerian national planners who must eventually act on this topic, and in general, to identify pertinent variables and methods of analysis of the general problems associated with attempts to industrialize the poorer nations of the world.

The optimum location for the Nigerian iron and steel works will be the focus of the analysis. In resolving the location problem, two different solutions will be sought and the results compared under varying situations.

First, the purely economic solution will be sought in terms of only one integrated plant. Second, socio-political consideration will be discussed in terms of more than one plant, since the interstate rivalry on where the plant should be located is a major concern. Finally, comparison will be made between estimated average c.i.f. import price per ton of steel and estimated average factory price per ton of steel in domestic plants of different annual capacities.

4. Study Plan and Method of Analysis

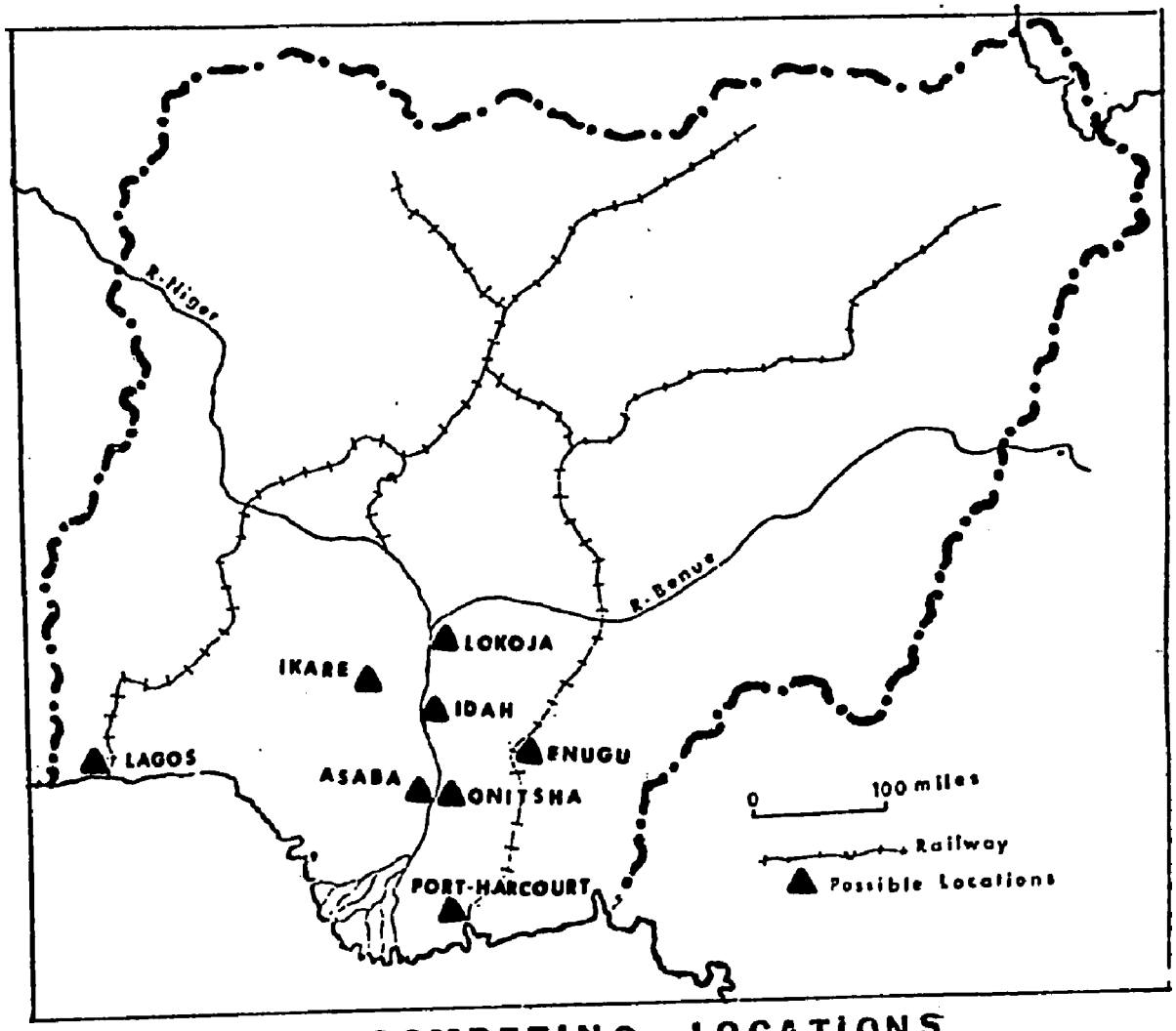
Chapter 1 discusses the role of steel in national development planning and delineates the study area (Nigeria) with which the present paper is concerned. The various efforts already made by Nigeria to establish an integrated iron and steel works,[18] steel manufacturing processes, and their uses and the optimum plant size for Nigeria are discussed in Chapter II. Chapter III examines the domestic distribution, quantity, quality and cost of each of the following: iron ore, coal, oil, scrap, limestone, labor, steel markets, transportation facilities, and other related matters.[19]

In Chapter IV, comparative investment and production costs by location and size of plant are made. Eight different locations are considered. The selection of the eight points is partly economic, and partly political. They include all the major material sites (especially coal, iron ore, limestone and water), as well as the major steel

markets. However, certain locations, which are neither material nor market sites of any significance have been included for the socio-political reason that at one time or the other, regional political leaders have put forward such sites as the "ideal" location for the plant (Aboyade, 1968).[20] Thus, the eight sites selected for this study are Lagos and Port Harcourt (essentially market sites), Onitsha, Enugu, Lokoja and Asaba (essentially material sites), and Ikare and Idah (neither market nor material sites). (See Figure 1.3.)

The optimal solution for one, two or three integrated plants are then carefully analyzed taking into consideration appropriate costs in plant, equipment, raw material, labor, transportation, and administrative costs.

In estimating investment and operating costs in plants of different sizes and locations, the importance of scale diseconomies which results from dividing the products of one large plant among many small plants are vividly brought out, using the Latin American examples. Studies from India and Latin America prove very useful in estimating items such as depreciation and interest costs.[21] Experience from the Kainji Dam in Nigeria provides precedence for estimating the required social overhead costs in the hypothesized steel works at different locations. Overseas training costs for Nigerian engineers are estimated using the average annual living and tuition fees at The University of Michigan, Ann Arbor.



THE COMPETING LOCATIONS

FIGURE 1.3

The implications of scale economies and diseconomies in steel manufacturing and steel prices are discussed in Chapter V. The conclusions of the study are finally presented in Chapter VI.

Footnotes

[1]Gerald Manners, The Changing World Market for Iron Ore, 1950-1980, An Economic Geography (Baltimore and London: The Johns Hopkins University Press, 1970), p. 83.

[2]N. J. G. Pounds, The Geography of Iron and Steel (London: Hutchinson University Library, 1971), p. 58.

[3]Ibid., p. 158.

[4]Ibid., pp. 128-36.

[5]Ibid., p. 58.

[6]R. C. Estall and R. O. Buchanan, Industrial Activity and Economic Geography (London: Hutchinson University Library, 1966), p. 164.

[7]Gerald Manners, op.cit., p. 92.

[8]N. J. G. Pounds, op.cit., p. 105.

[9]R. C. Estall and R. O. Buchanan, op.cit., p. 112.

[10]Gerald Manners, op.cit., p. 92.

[11]N. J. G. Pounds, op.cit., p. 92.

[12]Ibid., p. 95.

[13]United Nations, Africa Report: Magazine for New Africa, May-June 1974 (New York: United Nations Plaza, 1974), p. 24.

[14]John Hatch gives a very interesting and comprehensive history of Nigeria's political life in his book, Nigeria, A History (London: Secker and Warburg Press, 1971), pp. 197-264. Readers interested in a detail study of regionalism in Nigeria are advised to read Hatch's book. Hatch briefly summarized Nigeria's political life thus: "If Nigeria is regarded as single unity, it has been in a state of crisis throughout its history; for

its experience has always been one of contending ethnic communities" (p. 197).

[15]Ralph Uwechue, Reflections on the Nigerian Civil War, A Call for Realism (London: OITH International Publishers Ltd. 1969), p. 35.

[16]The Royal Institute of International Affairs, Nigeria, The Political and Economic Background (London: Oxford University Press, 1960), p. 3.

[17]William A. Hance, The Geography of Modern Africa (New York: Columbia University Press, 1968), p. 261.

[18]Reference sources include: Nigeria, National Development Plan 1962-68 (Lagos: Nigeria National Press, 1962); Nigeria, Government Gazette, 1971, pp. 75-82; Kwara State, Kwara State (Ilorin: Government Printers, 1968); Nigeria, Daily Times, Lagos, April 17, 1972, p. 23; United Nations, Industrial Growth in Africa, New York, 1963; United Nations, Economic and Social Council, 1965; Northern Nigeria, The Industrial Potentialities of Northern Nigeria (Kaduna: Government Printers, 1963).

[19]Among the most important references are: Nigeria, Guide to Nigerian Exports (Lagos: Nigerian National Press, 1966), p. 30; Kwara State, Kwara State (Ilorin: Government Printer, 1968), p. 24; United Nations, Yearbook of International Trade Statistics (New York, 1950 through 1972); Alan Sokolski, The Establishment of Manufacturing in Nigeria (New York: Praeger Press, 1965), p. 51; Nigeria, Wages and Salary Survey (Lagos: Nigerian National Press, 1965), p. 21; Nigeria, Population Census (Lagos: Nigerian National Press, 1963); Peter Kilby, Industrialization in an Open Economy: Nigeria 1945-1966 (London: Cambridge University Press, 1969), p. 256.

[20]O. Aboyade, "Industrial Location and Development Policy: The Nigerian Case," Nigerian Journal of Economic and Social Studies (Ibadan: University of Ibadan Press, 1968), pp. 275-301.

[21]Werner Baer, The Development of the Brazilian Steel Industry (Nashville, Tenn.: Vanderbilt University Press, 1969); Carl Liedholm, The Indian Iron and Steel Industry, An Analysis of Comparative Advantage (East Lansing: Michigan State University Press, 1972).

CHAPTER II

TOWARDS A NATIONAL STEEL SOLUTION

1. The Iron and Steel Politics

The last two decades have witnessed a change in Nigeria's strategy towards industrial undertakings. Prior to that time, the industry strategy adopted was one of exporting most of the country's raw materials to the more advanced and more industrialized countries of the world, particularly to the mother country, Britain. In the last two decades, however, the new industrial strategy has aimed at economic independence, whereby the indigenous raw materials are to be utilized in local industries to produce goods for home consumption, to provide employment for Nigerians, and help raise the wealth and the standard of living of the people. This goal was emphasized in the 1970 Nigerian Federal Government's statement which reads as follows:

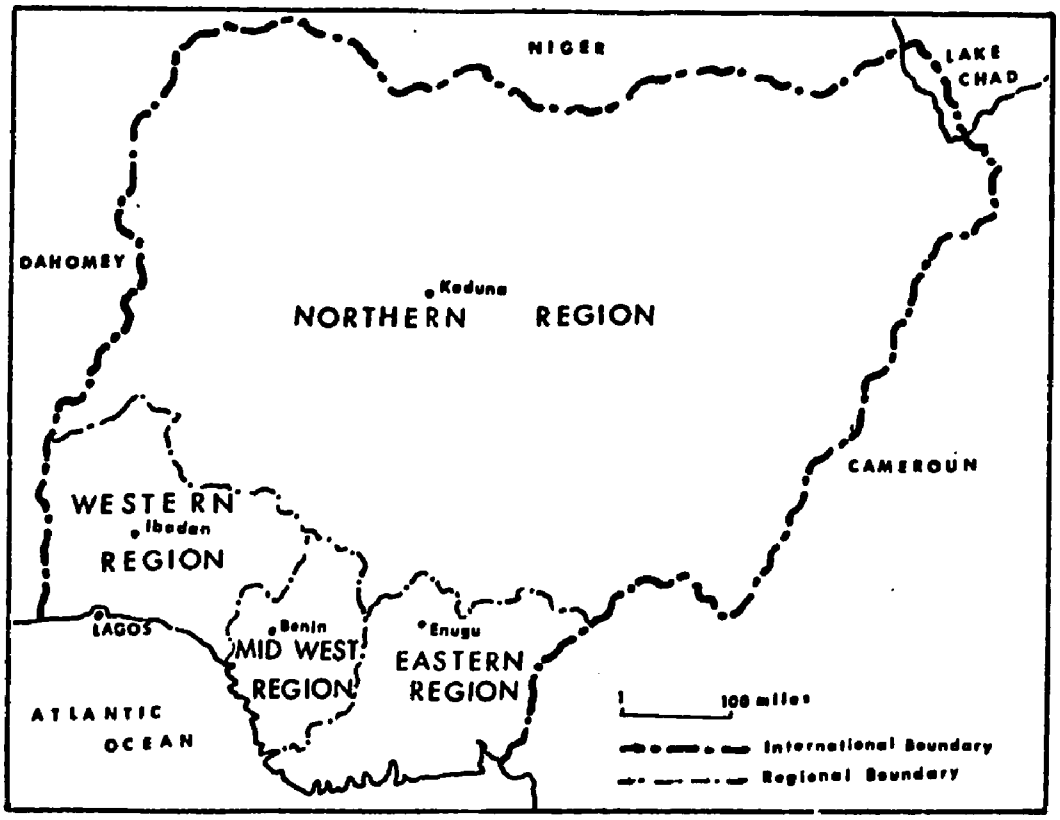
> Whereas during the World Wars the vigorous search for mineral resources in Nigeria was geared towards the Colonial War efforts, after the 1935-45 War and to date, the search has been aimed at locating economically significant raw materials for the establishment of local industries and for selling in the world market to earn foreign exchange which a developing country like Nigeria craves for so much in the drive for economic and social development.[1]

The objective towards economic independence by Nigeria is strongly based on its potential resources, especially minerals. Coal, oil, tin, limestone, iron ore, columbite, etc. are found in large quantities. Proven reserves of iron ore are close to 100 million tons and estimated potential reserves are about 300 million tons.[2] About 126 million tons of coal have been proven and estimated potential reserves reach nearly 300 million tons.[3] Limestone reserves have been proven to exceed 20 million tons.[4] Most important, Nigeria's current economic strength generated from oil revenues has assured Nigeria that shortage of capital, which typically burdens an underdeveloped country, is not currently a problem. Proven reserve of petroleum (oil) is about 15.0 billion barrels[5] and in these days of oil crisis, Nigeria's economy is booming; Nigeria's revenue from oil exports in 1974 alone was about $9.2 billion[6] and as a result of the rise in the oil prices and the oil boom, Nigeria's foreign exchange reserves was close to $4 billion. Thus, for the first time, Nigeria has almost more money than they know what to do with. The 1974 oil revenues could conceivably buy several steel mills. That the industry has not been built as of now is due to a combination of factors such as interstate political rivalry among the states in the country and lack of agreement on what kind of a steel mill is suitable for Nigeria for various technical and political

reasons. A brief review of the previous efforts to establish the plant is given below.

The first major attempt to open a plant in Nigeria occurred about 1958. Three alternative locations, Enugu and Onitsha (in the then Eastern Region) and Lokoja (in the then Northern Region) were suggested as possible sites.[7] The National Economic Council was appointed to determine the best of the three. At the same time, plant programs were requested from suppliers such as Demag, Westinghouse, Ferro-Stal-Mecco Consortium, International General Electric and Kaiser. Before this plan was submitted, the then Northern and Eastern Regional Governments began to lobby with units in the Federal Government. Norther Nigeria claimed that the largest and purest iron ore, coal and limestone occurred in its region (at Lokoja), and that the plant must be located there.[8] Northern Nigeria also pointed to the fact that Lokoja is a confluence town on the country's biggest rivers, the Niger and the Benue, and that this would offer cheap water for transportation and other uses in the plant. Eastern Nigeria on its own part claimed that the best location was either Enugu or Onitsha. Enugu, Eastern Nigeria claimed, has both coal and ore and is a railway town.[9] The East also reminded the Federal Government that Onitsha lies on the same river as does Lokoja, and that although Onitsha does not have ore, it has lignite.

Before the struggle between the East and the North was resolved, the then Western Nigeria quickly announced a "technical report" that claimed the discovery of the purest ore in the country at Ikare and consequently requested the Federal Government to locate the plant at Ikare.[10] Not to be undone, the only remaining region of the then Nigeria's four regions (see Figure 2.1), the Mid-West, came forward that no location was better than Asaba (in its region) with extensive limestone and lignite deposits. Driven to the wall by interstate rivalry, the Federal Government requested the assistance of a "neutral" mediator, the Economic Commission for Africa. But no sooner did ECA come in than it found itself entangled with Nigeria's politics. At first ECA suggested that the plant be opened at Port Harcourt, a port in the East. A short while later, in 1964, ECA came up with a different suggestion that "in the name of lasting national unity," three plants should be opened, one at Idah in the North, one at Onitsha in the East and the third at Ikare "or any other place in the West."[11] It was also suggested that once established, the plant was to use the strategic Udy or Elkem Process. The estimated investment of the "split" mill was about ₤50 million. Financial aid was already being sought through the United States Agency for International Development when foreign partners in the mill--a consortium of American, German and British steel interests (Koppers Int., Westinghouse, Demag, Didier-Werke,



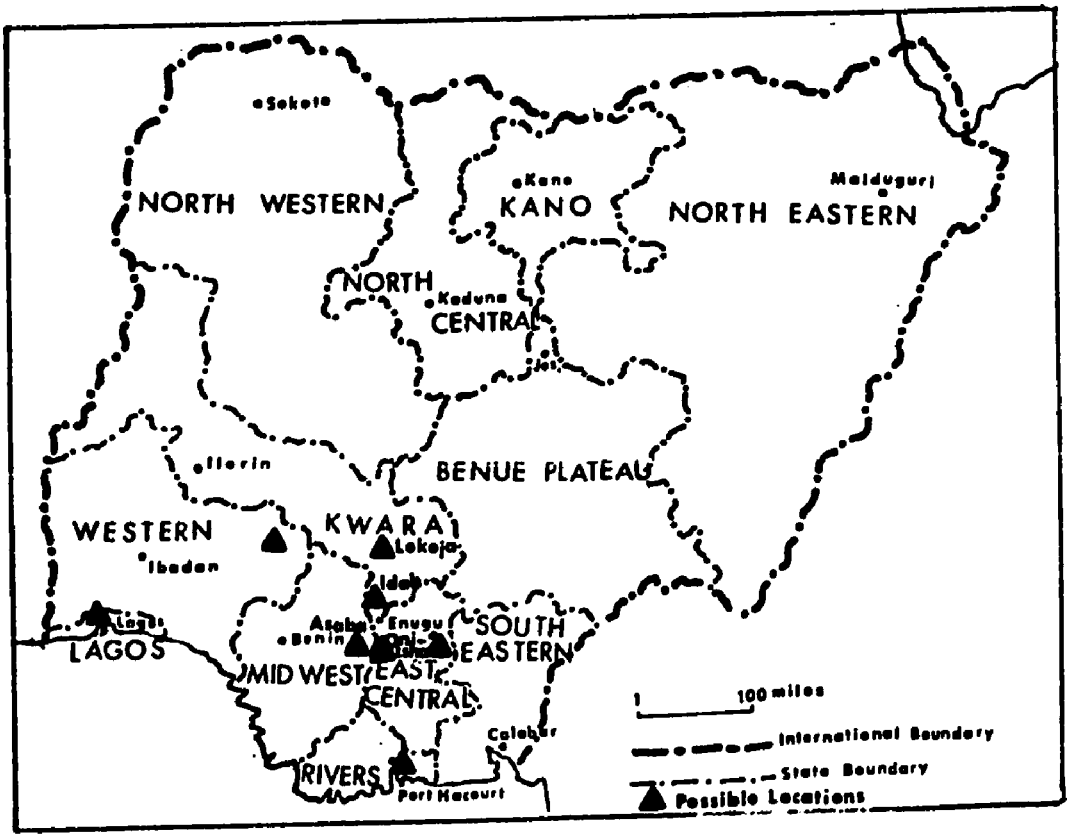
NIGERIA: THE REGIONS BEFORE MAY 1967

Figure 2.1

Ferrostahl and Hellman Amith Owens)--gave splitting a marginal plant between two or three distant locations a second thought; steadily, their involvement in the plant dwindled and the project was temporarily halted.

Further complication was added by ECA in the later part of 1964 when it suggested that rather for Nigeria to have a national mill, it should join hands in a feasible West African Integrated Steel Works. At first, Nigeria welcomed the idea thinking that the plant would be located in its domains. But the Commission recommended Gouina in Mali for a small electric reduction plant while the major integrated steel works with a capacity of 0.5 million tons of products be located at Liberia. No sooner was this suggestion on the location of a West African plant outside Nigeria made then Nigeria backed out of the plan to be followed at once by Gabon and Mauretania who, like Nigeria, thought that a West African plant should be located in their countries.[12]

The problem of where to locate a Nigeria national steel works dragged on until it was temporarily shelved with the onset of civil wars in 1967. With the end of the wars in 1970 and the creation of 12 states to replace the former Regions in 1969 (see Figure 2.2), political rivalry also shifted its directions; Kwara State in which Lokoja is located, and the East Central State where Onitsha and Enugu have located since made it an open confrontation. As soon as the Federal Government resumed



NIGERIA: THE STATES CREATED IN MAY '67

Figure 2.2

talks on the steel works, Kwara State reminded the Federal Government that:

> The largest and purest deposits of iron ore in Nigeria (estimted at over 260 million tons) are also found within the state on the Agbaja Plateau near the confluence of the Rivers Niger and Benue. There are deposits at Okene but they are yet to be proven. These deposits are expected to supply raw materials for the projected iron and steel complex in Nigeria.[13]

As though the above reminder was not enough, as soon as the Kainji Dam in Kwara State was completed by the Federal Government, Kwara State again stated that:

> Patti ridge is almost completely iron ore and with the Agbaja Plateau a few miles up-river from Lokoja, is one of the world's largest single deposits of iron ore. With the availability of cheap electricity from the ₦85 million (about $270 million) Kainji Dam, Lokoja would be the ideal site for a steel industry. In its commanding position on the confluence of the Niger and the Benue, there is every prospect for Lokoja becoming Nigeria's Pittsburgh.[14]

Whereas the interstate political campaign on the location of the mill prior to the Civil War was largely based on raw material "ownership," the campaign has had added impetus since about 1967. Today by and large, Kwara state's contention to see the steel industry located in its state stems from the fact that in the past it suffered badly from political prejudice which resulted in its being denied many socioeconomic opportunities.[15] Now that it has the bulk of the materials needed in the proposed national steel mills, it (Kwara State) thinks the time is appropriate for weakening the past political prejudices against it.

Although the East-Central State had no such case as past political prejudice to offer prior to 1966, the civil war seems to have given it something to complain of; hence in the struggle for the steel works, the East-Central State now believes that the steel industry would represent an appropriate compensation for the destruction which it suffered in the recent civil war, 1967-1970.[16]

It is clear from the above that any location decision by the Federal Government in favor of any one state will most likely antagonize the other and may worsen the already unhealthy atmosphere between them. It was to avoid this kind of conflict that the Federal Government apparently decided to start the process all over again. In April 1971, the Federal Government issued a decree to establish a commission entitled the "Nigerian Steel Development Authority."[17] Among other things, the Authority was to sit:

> To examine from the technical and economic point of view in all its aspects the feasibility of establishing in Nigeria a national iron and steel plant or national iron and steel plants on the basis of locally available raw materials, imported raw materials, or both, to consider suitable processes, possible sites, and other factors relating to the establishment of the said plant or plants and to make recommendations as to the viable economic conditions for the establishment thereof.[18]

Then, in light of its findings, the Authority is further empowered:

> To design, erect and construct in Nigeria a national iron and steel plant, or national iron

and steel plants and provide and carry out incidental services and works.[19]

True the said Steel Development Authority has been set up in Nigeria (Nigeria: Daily Times, April 17, 1972, p. 23). But the steel industry is yet unestablished. In realistic terms, one can only hope that an iron and steel complex based on Nigerian iron ore deposits would be in production in the 1980's.

2. Previous Consumption Estimates

There have been previous steel consumption estimates for Nigeria. P. E. Management Group's report for the period 1955-1959 shows that the average annual increase in steel consumption in Nigeria was about 11 per cent. Over this time, imports of galvanized corrugated sheets and other sheets declined by about 1.5 per cent annually. For hoops and strips, the decline was about 12 per cent and for black plates and sheets it reached 19 per cent. However, imports of all other groups reportedly increased over this period.[20]

After the above study came the 1965 estimate and projection of steel consumption by the United Nations for every West African country. Their study, which put the average annual steel consumption growth in West Africa as 9 per cent was based on the early 1960's steel consumption. The 9 per cent figure was derived from fitting a regression line to the 1959/61 figures of steel

consumption per head and GDP per head for all the African countries. It was found out that with an increase of 1 per cent in GDP per head, steel consumption, at the then current rate of development, increased by 1.7 per cent. It was therefore found that corresponding to an increase of 6 per cent in GDP (which was assumed for most of West Africa) the increase in steel consumption would be about 9 per cent.[21] Consequent to the 9 per cent increase assumed by the United Nations, consumption of steel in Nigeria in 1970 and in 1975 was estimated to be about 350,000 tons and 526,000 tons respectively.[22]

The third and so far the last major estimate of steel consumption in Nigeria was in 1967 with UNIDO assistance. The study suggested that a steel plant producing about 750,000 tons annually be opened in Nigeria.[23] The breakdown of the product mix, however, is not available for this study.

3. Previous Plant Size Estimates

The plant size estimates for a Nigerian plant followed each of the major steel consumption estimates. Following the 1959-61 market survey by P. E. Management Group (1961), it was proposed that Nigeria's steel mill, which was hoped would be in operation by 1966 would have a capacity of between 125,000 and 250,000 tons, and that it would "concentrate on the manufacture of black and

corrugated sheets, rods and bars, angles and channels and other structural steel."[24] Specifically, the plant was to start first with about 40,000 tons of corrugated and galvanized steel sheets, 4,000 tons of black sheets, 3,000 tons of tin coated steel, and 28,000 tons of rolled steel rods and bars--up to 3 inch diameter. Other products which was hoped would eventually be produced within the "then" next ten years were "tight rolled steel sections, rolled steel hoops, and strips, railway sleepers, wire rod and wire products."[25]

The 1961 report indicated that "the" production of 125,000 tons of steel will require no less than 242,000 tons of iron ore, 75,200 tons of limestone, and 110,000 tons of coal (an estimate which fails to take account of the quality of Nigeria raw materials). The study also observed that direct employment would be provided for about 1500 people. Hence, "to ensure the minimum possible delay in commissioning the mill, the Federal Government set aside the full expected cost of £30 million ($90 million) for this purpose."[26] Unfortunately, interstate political rivalry prevented the location of the plant and by 1966, when the plant was planned to be in operation, there was no steel plant in Nigeria.

The second major estimate of plant size for Nigeria was carried out in 1967. Nigeria, with the help of the United Nations, estimated that a steel plant with a

capacity of about 750,000 tons per annum was feasible for Nigeria. The estimated cost of the plant, scheduled to begin operation in 1974, was about ₦120 million.[27] Once again, the year 1974 has passed by without a steel mill in Nigeria. While the size of the market is no doubt a very important problem, as indicated earlier, the main issues center on the interstate rivalry on plant location, and certain other technical and political issues. How to resolve the technical, plant size and product mix problems are discussed below.

4. The Process of Steel-making

Making steel involves three distinct stages; the manufacture of pig iron in the blast furnace, the making of steel by Bessemer, open hearth or electric furnace, and processing of the steel in the finishing mills. The major raw materials used in steel making are coal, iron ore, limestone and scrap. The process begins with the feeding of coke, iron ore, and limestone into the top of a blast furnace, usually a vertical steel cylinder lined with protective refractories.[28] As these materials burn in the blast furnace, hot air, natural gas, pulverized coal and fuel oil are ejected through the twyenes at the bottom. Iron oxides are eventually reduced to metallic ore and liqued slag which is produced by fluxing the ore and coke with addition of

limestone. The product of this stage, pig iron, is drawn from under the liquid slag.

In the steel-making process, such impurities as carbon, phosphorus, sulphur, silicon and manganese are ejected through oxidation. This can be done in one of three ways. In the Bessemer process, molten pig iron is the major input, but in the open-hearth process, cold scrap is also added. Although the latter process requires more fuel than the former, it does help to reduce the amount of blast furnace capacity required for efficient production, and consequently, the amount of capital required for steel-making. As steel scrap, limestone and iron ore are heated, the scrap melts, molten pig iron is added, and impurities such as carbon, phosphorus, sulphur, silicon and manganese are eventually ejected. If electric furnaces are used at the steel-making process, scrap and pig iron are melted by means of carbon electrodes at a temperature of about 3400°C and the impurities are removed.

The third and final stage in the making of steel, the processing in the finishing mill, involves heating the steel up to a temperature of some 1200°C, and the hammering, pressing and rolling of the steel into billets, small sections, bars, rods, and wire strips and sheets.

There is a good deal of literature on alternative steel production techniques for those countries with

poor qualities of coking coal, ore, scrap and labor. Since Nigeria falls within this category, the advantages and limitations of the various alternatives should be discussed. One of the most widely discussed alternatives to the blast furnace is the electric furnace which is useful for reducing coke consumption by about 50 per cent.[30] This method has successfully been used in Sweden and Italy which are rich in lower-cost hydroelectric resources. Also, the use of natural gas in the direct reduction process, as is done in Mexico, is capable of producing good steel even with low grade ores.[31] In the steel-making process, the L.D. basic oxygen converter is reportedly cheaper than the open-hearth furnace, especially where labor and management's skills are poor and where total steel output is small.[32] Finally, the continuous casting process as an alternative to the traditional primary rolling facilities at the finishing stage is believed can considerably lower both investment and operating costs, while at the same time, it improves the ingot, demands less rolling and saves a good deal of space in the iron and steel works.[33]

The quality of Nigeria's coal, iron ore, oil, and other inputs will determine what technology will be most appropriate for making steel in Nigeria. The location, quantity and quality of each of the major domestic resources will be discussed in a subsequent chapter.

5. Steel Manufacture by Type of Product

Manufactured steel products fall under two broad categories, flat products and nonflat products. The first products of the rolling mill are nonflat products or blooms, and flat products or slabs. Billets are made from blooms and of varying sizes. Rails, sections, beams and rounds are produced by heating billets in one stage without further reheating and are later straigtened and cooled down. The production of light sections, rails and bars, however, require more than one heating, hence, these billets are reheated and then rolled. To produce narrow strips and sheets require further reheating.[34] Pipe or tube, another end product of billet is produced in one of two ways. Seamless tubes are made by heating and rerolling round billets whereas welded tubes, usually larger pipes, are made by rolling a plate of steel.[35] Flat products such as plate sheets and strip steel are made from reheated slabs and then made into coils. If tin plates are required, they are made by frequently heating and cooling of steel strip to obtain the desired shapes.

In general, one can distinguish the consumers of flat products from those of nonflat products. Flat products are usually consumed by the automobile, naval, petroleum, canning and container industries, kitchen cabinets, office furniture and a host of fabricating

industries. Nonflat products, on the other hand, are usually consumed by the construction activities.[36]

It can be understood from the above that steel products such as blooms, billets, slabs, coils, rails, sections, bars, rod, plate and sheet are semi-finished products which require essentially the establishment of re-rolling mills.[37] On the other hand, steel products such as tin plates, galvanized sheet, tubes, wires, or tinning lines are finished steel and they require still bigger machinery and more capital and labor to produce them. Since most of the steel consumed in developing countries where the level of industrialization is also low, are generally semi-finished products, the need to concentrate on the production of semis and import any finished products needed as a means of reducing their costs has often been emphasized.

Something also has to be said about the production and consumption of tubes, pipes and fittings. They are essentially consumed by industrial activities. Their main use is in the conveyance and control of fluids such as steam, compressed air and water, sewage systems, gas and oil.[38] They are also often used in industries such as power plants, oil refineries, chemical plants, food processing plants, and those that operate cross-country pipelines.[39] In the construction industry, welded pipes are used to support heavy load.[40] What all this

means is that pipes, tubes and fittings are not essentially the products that steel industries in developing countries with low level of industrialization is advised to concentrate upon, especially if the main markets for such mills are the domestic markets. As the level of industrialization progresses in these countries, however, great emphasis could be placed on the production and consumption of tubes, pipes and fittings, and on flat products.

6. Plant Size Estimate for Nigeria

The estimated plant size for a Nigerian steel plant was based mainly on the projected consumption of steel in Nigeria by 1980, the year which hopefully the proposed steel works would be in production. First data were collected on steel imports by product type for the 1963/70 period.[41] Steel consumption by product type in Nigeria can broadly be classified with three, viz; bars, rods and sections; universals, plates and sheets; and tubes, pipes and fittings (Table 2.1). Since Nigeria does not currently have a steel plant, steel imports are a good surrogate for steel consumption. Second, data were gathered on manufacturing employment for the same period, 1963/70.[42] The selection of 1963 as the base year was based partly on the fact that it marked the beginning of Nigeria's political independence

TABLE 2.1

NIGERIA: IMPORTS OF IRON AND STEEL AND GROSS DOMESTIC PRODUCT, 1963 - 1970

Year	Iron and Steel Bars, Rods, Etc. (Thou. Tons)	Universals, Plates and Sheets of Iron and Steel (Thou. Tons)	Rails and Railway Track Materials of Iron and Steel (Thou. Tons)	Tubes, Pipes, Fittings of Iron and Steel (Thou. Tons)	Manufacturing Employment Index=1963=100
1963	50.6	50.6	10.5	44.7	100.0
1964	96.2	74.5	24.3	89.6	135.1
1965	87.5	58.4	--	107.7	137.1
1966	96.9	65.1	1.1	108.7	135.0
1967	54.1	81.3	--	81.9	166.9
1968	61.8	68.8	0.2	91.7	176.7
1969	78.0	100.9	--	135.3	208.5
1970	174.7	225.6	--	181.8	264.5

Source: For steel imports, see: United Nations, Yearbook of International Trade Statistics (New York: United Nations, 1964), p. 561; (1968), p. 631; (1974), p. 637. For Manufacturing Employment, see: United Nations, Yearbook of Labor Statistics, 1973 (Geneva: International Labor Office, 1973), p. 344.

after which Nigeria had more direct control over its economic planning objectives, and partly because reliable data on steel consumption by product type for pre-1963 are not available to the author. The year 1970 was selected as the ceiling year in the present study because post-1970 data on steel consumption by product type are also not available to the author at this time.

As a first step, manufacturing employment by 1980 was estimated by running the regression of manufacturing employment as the dependent variable on time as the independent variable. The resulting R^2 was 0.88553 and the regression equation was $Y = -0.38912 + 19.871X_1$ where Y represented manufacturing employment in 1980 and X_1 represented the year 1980. The above regression equation gave Y in 1980 to be about 432.58.

Second, a regression of steel consumption by each group of product types as the dependent variable was run on manufacturing employment as the independent variable. The results showed that manufacturing employment explained about 50 per cent in the consumption of bars, rods, and sections ($R^2 = 0.4960$), about 80.15 per cent of the variation in the consumption of universals, plates and sheets ($R^2 = 0.80145$), and about 78.44 per cent of the variations in the consumption of tubes, pipes and fittings ($R^2 = 0.78441$). The resulting regression equation of bars, rods and sections, on manufacturing

employment was

$$Y_1 = -2.661 + 0.53716X_1 \quad ,$$

where Y_1 represented the consumption of bars, rods and sections in 1980 and X_1 represented manufacturing employment by 1980. Thus, Y_1 in 1980 equals 229.65.

The resulting regression equation of universals, plates and sheets on manufacturing employment was

$$Y_2 = -71.501 + 0.97991X_2 \quad ,$$

where Y_2 represented the consumption of universals, plates and sheets in 1980 and X_2, manufacturing employment by 1980. Thus, Y_2 in 1980 equals 352.39.

The resulting regression equation of tubes, pipes and fittings on manufacturing employment was

$$Y_3 = -9.2711 + 0.69162X_3 \quad ,$$

where Y_3 represented consumption of tubes, pipes and fittings in 1980 and X_3 represented manufacturing employment by 1980. Thus, Y_3 in 1980 equals 289.91.

From the above, total consumption of all types of steel by 1980 would be about 872,000 tons. Of course, in the iron and steel, the bigger the plant, the greater the gains in scale economies. A Nigerian plant based on domestic consumption by 1980 means that only about 800,000 metric tons of steel would be produced. Considerable economies can be gained, however, by increasing the capacity of the plant. By how much the plant should be

expanded requires a careful consideration. First, production above the domestic demand means that the excess must be exported. But it is doubtful if Nigeria would be able to compete with cheaper producers in the overseas market without subsidizing foreign consumers and this will weigh heavily on Nigeria's tax payers who will have to pay for running an expensive national plant at home, and also for buying expensive domestic steel should the government impose, as is likely, a protective tariff on its mills to keep away cheaper and better refined foreign steel. It is therefore the opinion of the present writer that at the initial stage, any excess for export should be avoided. More in defense of this policy will be found in Chapter V of the present paper.

Footnotes

[1]Nigeria: Focus in Nigeria, Trade and Industry, New Commonwealth No. 8 (Lagos: Nigerian National Press, 1970), p. 19.

[2]Gerald Manners, The Changing World Market for Iron Ore, 1950-1980, An Economic Geography (Baltimore and London: Johns Hopkins Press, 1971), p. 241; International Bank for Reconstruction and Development, The Economic Development of Nigeria (Baltimore: Johns Hopkins Press, 1955), p. 419.

[3]Federal Republic of Nigeria, Guide to Nigerian Exports (Lagos: Nigerian National Press, 1966), p. 30.

[4]Alan Sokolski, The Establishment of Manufacturing in Nigeria (New York: Praeger Press, 1965), p. 51.

[5]"Fiscal and Oil" in Time Magazine (New York: Garden City, January 6, 1975), p. 11.

[6]Ibid., p. 26.

[7]O. Aboyade, "Industrial Location and Development Policy: The Nigerian Case," in Nigerian Journal of Economic and Social Studies (Ibadan: University of Ibadan Press, 1968), pp. 201-202.

[8]Northern Nigeria, The Industrial Potentialities of Northern Nigeria (Kaduna: Government Printer, 1963), p. 165.

[9]Alan Sokolski, The Establishment of Manufacturing in Nigeria (New York: Praeger Press, 1969), pp. 273-77.

[10]Nigeria, Journal of Economic and Social Studies, op.cit., p. 201.

[11]Ibid., p. 202.

[12]Gerald Manners, The Changing World Market..., op.cit., pp. 89-90.

[13]Information Division, Office of Secretary to the Military Government of Kwara State, Kwara State (Ilorin: Government Printer, 1968), p. 24.

[14]Ibid., pp. 19-20.

[15]J. C. Pugh and K. M. Buchanan, Land and Peoples of Nigeria (London: Oxford University Press, 1955), pp. 60-61, 71, 111.

[16]The Nigerian Civil War (1967-70) started following the attempted secession of the former Eastern Region from the rest of the country under a new name "Biafra." This part of the country however has again been incorporated within Nigeria under the names East Central State, Rivers State, and South Eastern State. These three together with nine others created at the same time to end hostilities, now comprise the same former Nigeria. See also Sir Rex Niven, The War of Nigerian Unity (New Jersey: Littlefield Press, 1970).

[17]See "The Nigerian Steel Development Authority Decree 1971" in Nigeria, Federal Republic of Nigeria Official Gazette, Vol. 58, Decree No. 19 (Lagos: Nigerian National Press, 14th April 1971), pp. 75-82.

[18]Ibid., pp. 75-76.

[19]Ibid., p. 76.

[20]United Nations, Industrial Growth in Africa (New York: United Nations, 1963), p. 35.

[21]United Nations, Economic and Social Council (New York: United Nations, 1965), p. 4.

[22]Ibid., p. 36.

[23]Kwara State, First Development Plan, 1970-1974 (Ilorin: Government Printer, 1970), p. 36.

[24]Nigeria, First National Development Plan, 1962-1968 (Lagos: Nigerian National Press, 1962), p. 61.

[25]Northern Nigeria, The Industrial Potentialities of Northern Nigeria, op.cit., p. 164.

[26]Nigeria, First National Development Plan, 1962-1968, op.cit., p. 61.

[27]Kwara State, First Development Plan, 1970-1974 (Ilorin: Government Printer, 1970), pp. 36-37.

[28]Gerald Manners, The Changing World Market...., op.cit., p. 27.

[29]Ibid., p. 31.

[30]Ibid., p. 44.

[31]Ibid., p. 45.

[32]Ibid., p. 33.

[33]Ibid., pp. 53-54.

[34]J. D. O. Bradts, The Manufacture of Iron and Steel (London: English University Press, 1953), p. 209.

[35]Werner Baer, The Development of the Brazilian Steel Industry (Nashville, Tenn.: Vanderbilt University Press, 1969), p. 14.

[36]Ibid., pp. 15, 96-97.

[37]Meeting of the West African Interim Expert Committee on Iron and Steel, "Proposed Agreement Establishing a West African Iron and Steel Commission," Unpublished mimeograph (Freetown: 15-22 April, 1966), p. 4; Meeting of the West African Interim Expert Committee on Iron and Steel, "Problems Involved in Establishing and Managing Iron and Steel Plants in West African Countries," Unpublished mimeograph (Abidjan, 15-22 October, 1965), p. 2.

[38]Edward Mellor, Pipes and Valves (New York: Brooklyn, 1941), pp. 3, 5.

[39]Hoolasar Rampaul, Pipe Welding Procedures (New York: Industrial Press, 1973), p. 6.

[40]Ibid., p. 6.

[41]United Nations, Yearbook of International Trade Statistics (New York: United Nations, 1964), p. 561; (1968), p. 631; (1974), p. 637.

[42]United Nations, Yearbook of Labor Statistics, 1973 (Geneva: International Labor Office, 1973), p. 344.

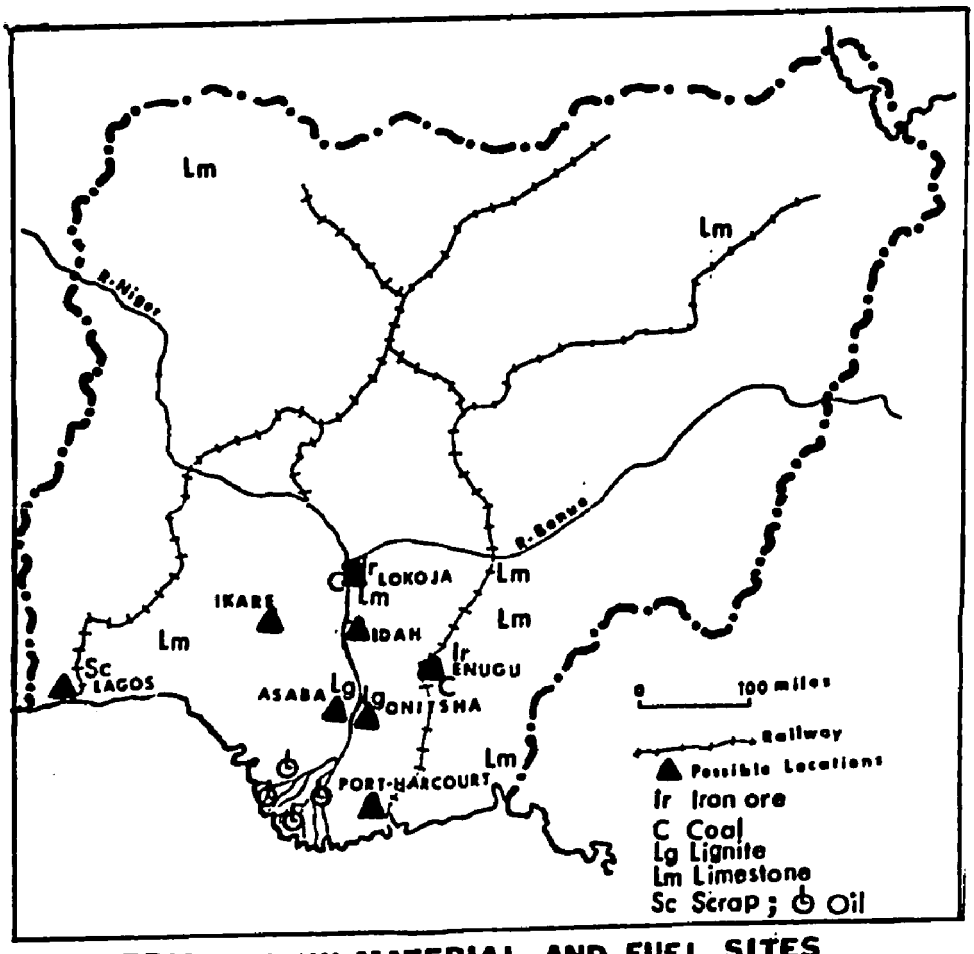
CHAPTER III

LOCATION FACTORS IN THE NIGERIAN STEELWORKS

The location of any integrated steel complex is subject to a number of economic and noneconomic factors. The more important among these influences are: raw materials, fuel, labor, wage levels, unionization, consumer demand, capital, space (land), climate, water, taxes, transportation, government, and foreign trade.[7] Most if not all of these factors are involved in the problem of deriving an optimal location for the proposed all-Nigerian integrated iron and steel industry. In this paper, however, emphasis will be placed on only those factors which are regarded as being most relevant to the Nigerian situation.

1. Location and Quantity of Raw Materials

The traditional input materials in the iron and steel industry are coal, iron ore, scrap, and limestone. In this section, emphasis will be placed on the locations, qualities, and quantities of such raw materials in Nigeria (see Figure 3.1).



NIGERIA: RAW MATERIAL AND FUEL SITES

Figure 3.1

a. Iron Ore

Nigeria has large reserves of iron ore to meet the demand of an integrated steel industry (Table 3.1). Over 300 million tons of ore have already been discovered. In 1952-53, 260 million tons of ore deposits were discovered near Lokoja in Kwara State. According to reports by the Geological Survey, which carried out a program of diamond drilling over selected portions of the deposits, these ore reserves averaged 45-50 percent Fe in quality. In thickness, the deposits average 23-25 feet and occur:

> ...on the top of the Agbaja Plateau, a steep-sided, flat-topped, table-land of some forty square miles. It is accessible by road, about 26 miles from the town of Lokoja, and the Niger (River) flows past it within about one-half mile--and some 700 feet below it in elevation--at the nearest point.[2]

About the same time that the iron ore reserves at Lokoja were discovered, another Geological Survey discovered approximately 49 million tons of iron ore near Enugu. These deposits average about 2-28 feet in thickness, and:

> ...occur near Nsude Village, on a plateau about six (6) miles to the west of Enugu.... The ore is lateritic in character and contains a high percentage of sand; the investigation indicates that it will average some 33% Fe, but that the sands could be screened off to raise this to about 40% Fe.[3]

b. Coal

Another important raw material in the steel industry is coal. Nearly 259 million tons of sub-bituminous

TABLE 3.1

IRON ORE RESERVES

Locality	Province and State	Reserves Indicated by Drilling	Percentage Fe Contained
Ensude near Enugu	Onitsha, East-Central State	49 million	30% Fe
Agbaja near Lokoja	Kabba, Kwara State	260 million	50% Fe

Source: The Economic Development of Nigeria, Report of a mission organized by the International Bank for Reconstruction and Development at the request of the Government of Nigeria and the United Kingdom, John Hopkins Press, Baltimore, 1955, 3rd printing, 1961, p. 419.

See also Kwara State published by the Information Division of Office of Secretary to the Military Government, Kwara State, Ilorin, Nigeria, 1968, p. 24.

coal have been discovered in Nigeria. Of these, about 170 million tons are located near Loloja, and nearly another 70 million tons exist near Enugu.[4]

Thus, similar conclusions to those drawn in the case of iron ore reserves can be drawn for coal. The first is that there are enough coal reserves to maintain an integrated steel complex in Nigeria, and the second is that more than half of the total coal reserves in Nigeria are located around Lokoja in Kwara State (Table 3.2).

c. Scrap

The potential sources of scrap for the proposed all-Nigerian integrated steel complex are the other manufacturing industries in the country, as well as the wreckages of various motor vehicles such as trucks, lorries, tractors, railway cars, etc. It is evident that the major potential supplier of scrap is Lagos, which has three times as much industry as any other town in Nigeria. Again, for any one year, more vehicles are licensed and/or relicensed in Lagos than in the entire of Western and Mid-Western States; as many vehicles are licensed and/or relicensed in Lagos as in all of the towns of Eastern Nigeria at any given point in time. The young stage of industrialization in Nigeria, the relatively small number of heavy industries and transportation vehicles, all indicate that scrap supplies are as yet minimal,[5] as shown in Table 3.3.

TABLE 3.2

COAL AND LIGNITE RESERVES

Locality	Geological Formation	Province and State	Reserves Indicated by Drilling (tons)
Coal			
Enugu	Lower Coal Measures	Onitsha, East-Central State	33,000,000
Ezimo	Lower Coal Measures	Onitsha, East-Central State	25,000,000
Orukpa	Lower Coal Measures	Benue, Plateau-Benue State	40,000,000
Okaba	Lower Coal Measures	Kabba, Kwara State	60,000,000
Ogboyoga (including Odokpono)	Lower Coal Measures	Kabba, Kwara State	70,000,000
Inyi	Upper Coal Measures	Onitsha, East-Central State	9,000,000
TOTAL			242,000,000
Lignite			
Obomkpa	Lignite Formation	Benin, Mid-Western State	10,000,000
Ogwashi-Asaba	Lignite Formation	Benin, Mid-Western State	60,000,000
TOTAL			70,000,000

Source: Federal Republic of Nigeria, Guide to Nigerian Exports, compiled and published for the Federal Ministry of Trade and Industry by the Federal Ministry of Information, Nigerian National Press, Apapa, Lagos, 1966, p. 30.

TABLE 3.3

NIGERIA: EXPORT OF IRON AND STEEL SCRAP

Year	'000 Tons	₦'000
1964	10.9	123
1965	6.2	64
1966	9.7	103
1967	6.8	62
1968	7.5	67
1969	20.5	113

Source: United Nations, Yearbook of International Trade Statistics, New York, 1967, p. 631; 1969, p. 633.

d. Limestone

Limestone, which is usually used as a flux in the iron and steel industry, is very abundant in Nigeria. It is also fairly well distributed all over the country. The total quantity of limestone reserves is not yet known. But there are reports that about 20 million tons of crystallized limestone or marble have been found at Jakura Valley, about 25 miles northwest of the iron deposits at Lokoja. Large reserves of limestone have also been discovered at Itobe, which is 20 miles south of Lokoja. To the northwest of Enugu, about 32 miles away, large quantities of limestone have also been found around Nkalagu. The Nkalagu reserves stretch as far as Igumale in the Benne-Plateau State. The reserves at Igumale alone have been estimated at over 10 million tons. In Kwara State, apart from Lokoja, extensive

limestone deposits have also been found at Elebu in northern Ilorin province. In the western state, there are some deposits of limestone at Abeokuta near Lagos, and at Igbetti. North-Central State has limestone reserves at Burum, and North-Eastern State has similar reserves at Ashaku, near Bauchi, and at Gombe, near Maiduguri. North-Western State's deposits are located at Sokoto, and in the South-Eastern State, Calabar also has some reserves of limestone[6] (see Figure 3.1).

2. Quality of Raw Materials and Effect of Impurities

Of much great importance to the iron and steel industry is the quality rather than the quantity of each of the available raw materials. The poorer the material or the larger the impurities in them, the larger the quantities required per ton of finished steel.

The quality of any iron ore deposit depends on the iron content of the ore. Although reportedly Nigeria has large ore reserves, the quality of the ore is only about average. The proven reserves of ore in Lokoja contain between 48-50 per cent ore (Fe), 0.5-0.8 per cent phosphorous, 0.54 titanium dioxide and 6.68-7.0 per cent silica.[7] The known reserves at Enugu contain between 40-43 per cent ore, 0.2 per cent phosphorous, 20 per cent silica and 0.8 per cent titanium.[8] Each of the above mentioned impurities has its adverse effect

on the production of steel. For example, phosphorous cannot be eliminated in the blast furnace. It has to be removed in the open-hearth furnace by the addition of extra flux and coke[9] or by the use of the Bessemer process.[10] Also, too much phosphorus and silica causes steel to become brittle when cold. Although the impact of titanium on the blast furnace is yet not clearly understood, it is thought that too much of it may prevent the fusing of slag in the blast furnace.[11]

The quality of Nigeria's coal and limestone also needs careful examination. Although reportedly Nigeria has coal reserves estimated at nearly 300 million tons, including 126 million tons of proven reserves, the coal is sub-bituminous and non-coking.[12] Although a method for using this type of coal in the steel industry has been developed, it is not going to be without some difficulties. Reportedly, the coal in Nigeria contains about 40 to 60 per cent fixed carbon, 3.9 to 10.0 ash, 40 to 55 per cent volatile matter, and 8.3 to 16.0 moisture. The sulphur content in the Nigerian coal varies between 0.45 and 1.0 per cent.[13] Sulphur is an impurity that is very difficult to remove in the blast furnace, and "even in small quantities it seriously impairs the metallurgical qualities of the metal."[14] An increase of 0.1 per cent sulphur in the coke will increase the coke rate consumption by about 0.1 per cent with a proportionate decrease blast furnace efficiency and an

increase in limestone consumption of about 1.5 to 2.0 per cent. A United Nations report states that in general, although slag may be used to absorb sulphur in blast furnace operations, the "slag can only absorb some 2.7 to 3.0 per cent of its weight of sulphur," and that a sulphur content of above 2.0 per cent causes brittleness in the slag and limits its effectiveness.[15] Thus, if there is sulphur in ore, careful sintering may be necessary before it is usable.

The calorific value of Nigeria's coal varies between 13,000 B.T.U./lb and 15,000 B.T.U./lb.[16] This is the normal range for bituminous coal. Ash in Nigerian coal was estimated to be about 10 per cent.[17] Ash acts as an inert material in the burden of the blast furnace, thus reducing operation efficiency. Liedholm points out that in India, "with each additional 1.0 per cent of ash in the coaking coal, there is an increase in coke consumption by 4 to 5 per cent, an increase in limestone consumption by 5 per cent, and a decrease in the production of pig iron by 3 to 6 per cent."[18] For these reasons, lignite deposits are usually not considered useful for steel production because lignite is low in B.T.U., high in water and ash content. To reduce the ash content in coal requires sorting and washing stages, the cost of which must be balanced against gains in efficiency. Therefore, there is an incentive for using the high grade, lowest sulphur content coal.

Nigeria's limestone contains large proportions of calcium carbonate, the minimum reportedly being about 98.5 per cent[19] in the 20 million Jakura reserves. This indicates of course that Nigeria's limestone is of high quality.

Very little can be said about the quality of domestic scrap. The total supply as indicated earlier is very small.

3. Fuel

Among the more important fuel sources of Nigeria's proposed steel complex are coal, oil, gas and hydro-electricity. The location, quantity, and quality of Nigeria's coal reserves have been dealt with earlier in this paper. Coal is without doubt the major fuel in the iron and steel industry. Hydro-electricity is less often used because it is more costly than coal in steel and in other heavy industries.

Water is also important as a source of electric power. Nigeria has recently completed the ₦68 million (about $210 million) Kainji Dam on the Niger, with a power capacity of about 700 mw. This is the largest plant in the country so far. By 1980, two other dams on the Niger are expected to increase the total power capacity on the Niger to over 960 mw.[20] The recently completed Kainji Dam is located in Kwara State and will

supply energy to a large number of cities in Niger. Lagos currently receives power from her 86,000 kw power house at Ijora,[21] while Asaba, Onitsha, and Enugu's major supply of energy comes from the gas-fired station on the Oji River, midway between Onitsha and Enugu.

Ikare gets its power from Akoko about 50 miles away. Idah has no power at all at present, but it is not far from the Kainji Dam.

Also, the Delta areas of Nigeria are rich suppliers of oil and natural gas. It was pointed out earlier that reserves of oil in Nigeria reach nearly 15.0 billion barrels and that production is about 2-3 million barrels per day. Reserves of gas was estimated at 1161 thousand million cubic metres in 1972 and production in that year was only 159 million cubic metres.[22] As much of the gas from the oil field is currently flaring off, the gas can be used as a possible alternative to coal in the steel industry. The economics of using Nigeria's gas in the steel industry as an alternative to coal should therefore be investigated.

4. Management and Labor

Among the people needed to work in the steel industry are managerial and senior technicians, administrative and clerical employees, skilled, semi-skilled and unskilled workers. While Nigerians can be found to fill the administrative, clerical, semi-skilled and unskilled

positions in the proposed steel works, to fill all the management, senior technicians, and skill positions with Nigerians will be very hard. In 1970/71 the total number of economically active engineers, scientists and technicians was only 35,126 (composed of 19,885 scientists and engineers and 15,241 technicians).[23] The obvious solution is that Nigeria should embark on massive overseas training of domestic engineers and technicians from this time on, that the people so concerned should work for some experience overseas and then return to Nigeria to participate in the construction and running of the plant.

5. Domestic Steel Markets

The concentration or otherwise of the Nigerian steel market will greatly influence what site is optimal for the proposed mill, for as Walter Isard points out, where there is a single market, large enough to absorb the products of an integrated steel works, the optimal location would be that market, other things being equal.[24] An attempt to analyze the sizes of Nigerian steel markets, however, faces some problems. As far as the present writer knows, no adequate analysis of the regional destination of the imported iron and steel products have been made more than in very broad regional terms such as "in 1959...only 10 per cent of the sales were made in

the North, while 33 per cent were made to the Eastern Region, and the remainder to Lagos plus the Western Region."[25]

In order to resolve the above problem, I have chosen to analyze the distribution of steel markets in Nigeria using employment in manufacturing industry in each province.[26] This is shown in column 2 of Table 3.4. I have added up all the provincial estimates and then further expressed per cent engaged in industry for any province as per cent of total for all provinces. My result is contained in column 3. Nearly 97 per cent of the steel is consumed by 12 provinces alone. The provincial headquarters are taken as the provincial market points. Thus while Lagos consumes about 47 per cent of Nigeria's steel, Kano consumes less than 1 per cent, etc. The last column of Table 3.4 and Figure 3.2 show the hypothetical regional distribution of the output of the proposed steel (estimated at about 800,000 tons) per year.

6. Transport Facilities

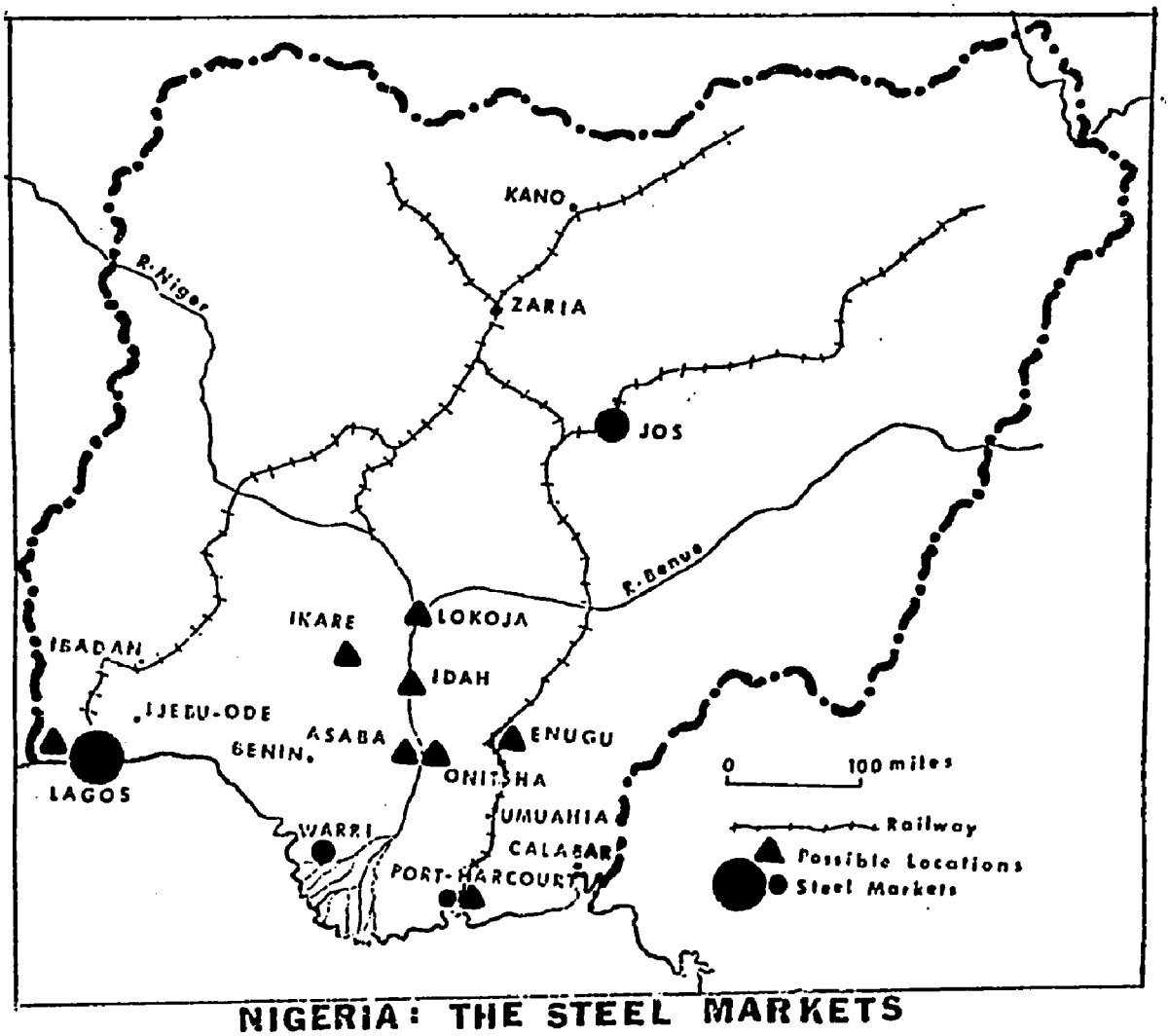
Figure 3.3 shows the main rail and waterways in Nigeria. The total number of route miles for the railway is about 2,178. Although the number sounds small, a special report prepared by The Netherlands Engineering Consultants (NEDECO) for the government in 1971 stated that "the existing network would carry a far greater

TABLE 3.4

ESTIMATED ANNUAL STEEL DEMAND FROM THE PROPOSED 800,000-TON PLANT IN NIGERIA

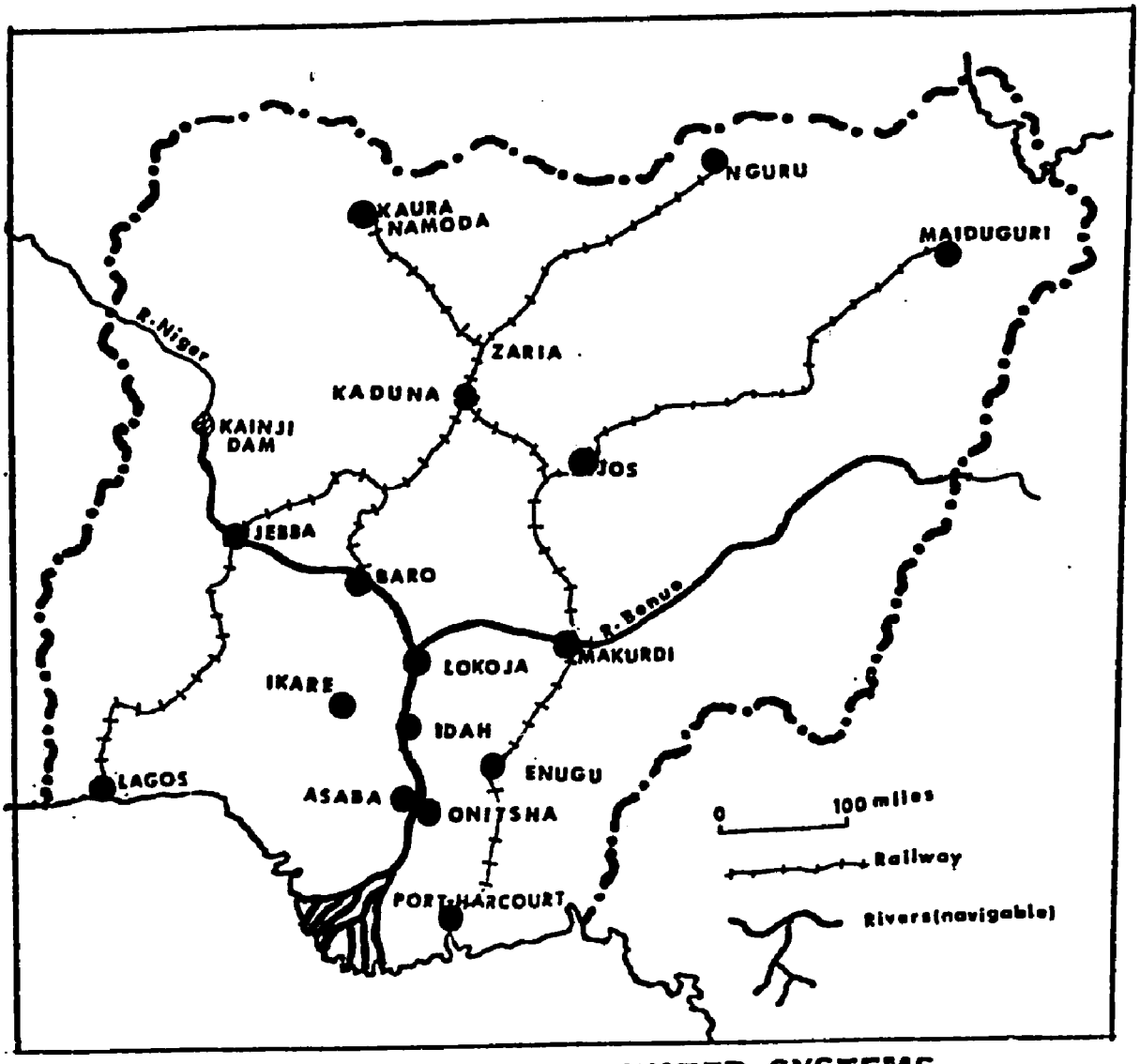
Port Harcourt	Estimated Total Employed in Manufacturing Industry ('000)	Provincial Share of National Total (%)	Estimated Steel Consumed; % Total Demand	Estimated Annual Total Steel Demand
Kano	1.10	0.73	0.73	6,051
Plateau (Jos)	36.39	24.26	24.26	201,078
Zaria	4.23	2.82	2.82	23,373
Ibadan	1.47	0.98	0.98	8,123
Ijebu-Ode	2.04	1.36	1.36	11,272
Ikeja (Lagos)	70.05	46.70	46.70	387,070
Benin	1.98	1.32	1.32	10,941
Delta	13.25	8.83	8.83	73,187
Calabar	1.47	0.98	0.98	8,123
Enugu	3.84	2.56	2.56	21,218
Port Harcourt	6.92	4.61	4.61	38,209
Umuahia	2.06	1.37	1.37	11,355
TOTAL	44.78	96.52	96.52	800,000

N.B. Twelve out of the thirty-three provinces in Nigeria have as much as 96.52 per cent of the nation's total employment in manufacturing industry. Since the twenty-one others contribute only 3.46 per cent, the markets for steel are consequently divided among the "big twelve" provinces in this study.



NIGERIA: THE STEEL MARKETS

FIGURE 3.2



NIGERIA: RAIL & WATER SYSTEMS

FIGURE 3.3

transport volume than will be required in the next twenty years."[27] In other words, what is necessary is to make full use of the present lines and not necessarily to add new lines. The network is operated by the Nigerian Railway Corporation (NRC) which by 1964 owned 5,490 wagons with an average loading capacity of 25.8 tons each and a total capacity of 141,000 tons (as 5,248 wagons were actually in service).[28] NEDECO also reported that plans are to run linear trains of 25 wagons (axle load 16 tons, empty weight 19 tons, load 45 tons) with a loading capacity of more than 1,000 tons per train.[29] The costs per ton mile of linear trains will be much lower than cost per ton mile of normal rail services.[30] High volume involved in the steel industry transport needs will justify linear train use.

The principal navigable waterways in Nigeria are the Niger and its main tributary, the Benue, the Delta creeks and the lagoons bordering the coast. The general navigability of the system is very poor due to winding courses and rock outcrops. Navigability was restricted to the wet season until the completion of the Kainji Dam. With the completion of the Kainji Dam, a constant supply of water from the reservoir is now possible throughout the dry season and today, navigability is maintained throughout the year. The three major transport companies

are the Niger River Transport (NRT), Holt's Transport (HT), and the Niger Benue Transport Company (NBTC). According to NEDECO, the total carrying capacity of the present barge fleets in one direction is about 220,000 tons.[31]

Road network is much larger than either rail or waterways. In 1964, there were about 46,000 miles of classified and maintained roads, 6,900 of which was paved.[32] The size of the trucks on the roads vary between 3-5 tons.

For the proposed steel works, major considerations should be given to the means of transporting the raw materials and the finished steel to the markets. One can rule out road as a possible means of carrying these items because of high per ton-mile cost of truck transport and inability of the road system to handle heavy traffic that would be needed. Major considerations should be given to both rail and barges as their capacity for heavy shipment is higher and cost per ton-mile lower than roads.

The fact that the porposed steel works should use only rail and water as its means of transportation, is reinforced in another way. The Stanford Research Institute (SRI) report on the Economic Coordination of Transport Development in Nigeria stated that the term "cost of transport" should be more concerned with "the

real cost," which "would include both the expense borne by the carrier in furnishing the service and the expense incurred by government in providing the service."[33] In other words, the cost of transport should rather be looked at in terms of "the real cost to the economy in terms of all resources required to provide a service," and not only as the cost to the shipper or traveller for services purchased or the cost to the transporter of furnishing a service. The SRI report states that, in Nigeria, the railways average cost figures of 2.2 pence per ton-mile and unlike road transport does "reflect the full economic cost to the economy."[34] Therefore "the railway will remain for Nigeria as it has for other industrializing countries, the most economical carrier in areas not served by water transport for the heavy-commodity transport requirement of both agriculture and industry."[35] Concerning water transport, the report found the real economic cost of waterways was found to be 1.7 pence per ton-mile.[36] The SRI report found that on the other hand, road users are not paying the full public costs of roads, including maintenance and a reasonable return on the capital costs;[37] the average cost per ton-mile of road transport is 6.0 pence[38] and SRI concluded that road transport is costly to the national economy and therefore suggested a substantial reduction in investment in road vehicles and

highway development.[39] Like NEDECO in 1971, SRI in 1961 discovered that not only do rail and water offer the lowest cost to the national economy, but that the current routes have excess capacity that could yet be utilized without a substantial additional investment; the rail line, it was found, can handle at least twice the present volume of traffic, and the waterways can carry almost unlimited traffic with little additional investment in capital works.[40] This may be interpreted to mean that delivering finished steel to various Nigerian markets would not require large investment in transportation facilities. Roads, on the other hand, have virtually no excess capacity and would require heavy investment in vehicles and highway development.[41] The SRI report further declared that whereas full capacity roads average rate per ton-mile is 6.0 pence, had waterways been operating at capacity, its average cost would have been only 1.3 pence per ton-mile.[42]

The above does help to emphasize that in the interest of national economy, rail and/or water should be used to move the material inputs and finished products of the proposed steel works in Nigeria. The proposed steel works demands on transportation are for specialized wagons and barges which would represent a sizeable capital investment but would not require investment in new rail line development except for certain options such as

location at Ikare would require a new 300-mile rail line to connect it with the nearest coal and ore center (Lokoja).

a. Rail Line Cost Estimate

It is suggested that the new line pass through Ikare to the nearest steel market on the existing rail line to the west. The nearest such market is Ibadan; thus the new rail will connect Lokoja with Ibadan, a distance of about 300 miles.

The first task is estimating the construction cost of the new rail (at the expense of Ikare). This of course will vary with the character of the terrain and with soil conditions. For lack of engineering knowledge, however, the author wishes to base his cost estimate on precedence. On August 10, 1970, the Federal Commissioner for Transport informed NEDECO that "the Federal Government had taken a firm decision to construct new railway lines from Baro via Benin to Warri and from Makurdi via Ogoja to Calabar"[43] and the Commissioner requested NEDECO to investigate the effects that these lines would have on future post development and their total construction costs. According to NEDECO, the Baro-Wirri line would be about 370 miles.[44] Its total construction cost was estimated at about ₦34 million.[45] The Makurdi-Calabar line, whose line would vary between 262.5 miles and

305.5 miles,[46] was estimated to cost between £26.6 million and £30.8 million.[47] Assuming, for lack of engineering knowledge, that the character of the terrain and soil conditions on a Lokoja-Ibadan line are comparable with those on a Makurdi-Calabar line, one can assume that the suggested Lokoja-Ikare-Ibadan rail line would incur a cost of about £30 million in total construction cost.

The optimum plant size for Nigeria has been suggested as 800,000 tons. As Chapter IV would explain, to produce these would require about 1,600,000 tons of coal (2 tons of coal per ton of steel) and 3,200,000-4,800,000 tons of ore, and 480,000 tons of limestone. The task is to estimate the number of wagons and barges which would be required to carry about 5,300,000-6,500,000 tons of coal, ore, and limestone and 800,000 tons of steel.

b. Steel Carrying Facilities

For the proposed steel works specialized wagons and barges would be required for moving steel from the mill to the markets. Estimating the total number of wagons and barges for the purpose of moving finished steel to the domestic markets for any given plant location can be done in three steps. First, the distance in miles by water and/or rail, between a given plant site and every domestic market must be known; this information is

contained in Table 4.12 of the present paper. Second, market demand by location must be known; information regarding this is contained in Table 3.5 of the present study. Third, total ton-miles of transport by water and/or rail for any given plant location must be known; this can be obtained by first multiplying quantity demanded by a given market by the rail and/or water distance involved and then by summing up for each plant location the ton-miles of transport between itself and all domestic steel markets. The result of such analyses for Nigeria shows that the total ton-miles of transport for Enugu composes 184.5 million ton-miles by rail and 147.5 million ton-miles by water; Lokoja, 54.7 million ton-miles by rail and 273.7 million ton-miles by water; Onitsha and Asaba respectively, 52.4 million ton-miles by rail and 248.7 million ton-miles by water; Lagos, 171.3 million ton-miles by rail and 46.7 million ton-miles by water; Idah, 52.3 million ton-miles by rail and 252.4 million ton-miles by water; Ikare, 325.2 million ton-miles by rail and 22.8 million ton-miles by water; and Port Harcourt, 128.9 million ton-miles by rail and 131.8 million ton-miles by water.

Next, it is necessary to estimate how many ton-miles of services a wagon and a barge can provide per year in order to know how many of these would be required by plant location. Given the fact that the average train speed is about 25 mph (40 mph maximum speed and 15 mph

minimum speed),[48] and assuming effective running time per day to be about 8-10 hours (assuming 4 hours lost in transit, 16 hours running half time empty) a train would be able to travel only about 250 miles per day; thus, every 45 ton-capacity wagon would have an effective 11,250 ton-mile/day. Assuming the wagons are down for repairs and maintenance 20 per cent of the possible effective 350 operating days, every wagon would operate roughly 3.2 million ton-mile/year. On this assumption, Enugu would need about 62 wagons, Lokoja 17 wagons, Onitsha and Asaba 16 wagons respectively, Lagos 57 wagons, Idah 16 wagons, Ikare 108 wagons and Port-Harcourt 43 wagons. Cost wise, given the fact investment in wagons at the 1970 prices was ₤2.250 per 45-ton wagon,[49] Enugu would incur about ₤139,500 on wagons, Lokoja ₤38,250, Onitsha and Asaba respectively ₤36,000, Lagos ₤128,250, Ida ₤36,000, Ikare ₤243,000, and Port-Harcourt ₤96,750.

Also, given the fact that the average speed of the barge is only about 9 mph[50] (i.e., about one-third that of the rail) barge would be able to travel only 90 miles per day. The size of the barge that can operate on Nigeria's water reportedly varies between 100' x 26' and 130' x 33'. The former has a maximum capacity of about 325 tons and the latter 670 tons. Assuming that only the 130' x 33' barges are bought for moving steel, each barge would have an effective 60,300-ton-mile/day. Again assuming that 20 per cent of the possible effective

250 operating days are lost to maintenance and repairs, every barge would have an average of 16.9 million ton-mile/year. Following this assumption, Enugu would need 9 barges, Lokoja 16 barges, Onitsha and Asaba respectively 15 barges, Lagos 3 barges, Idah 15 barges, Ikare 2 barges, and Port Harcourt 8 barges. Since the landed cost of each 130' x 33' barge in Nigeria is about ₦39,000,[51] investment costs on barges for Enugu would be ₦351,000, Lokoja ₦117,000, Idah ₦585,000, Ikare ₦7,800 and Port Harcourt ₦312,000.

The above method of estimating steel carriers and their costs by plant location does not take into account customer services and delivery time at the market but rather bulk delivery to market-oriented steel warehouses. The Lagos warehouse would be right at the plant and costs of local delivery in this case, as in all others, are not included in the estimate but would presumably entail using a fleet of smaller trucks and/or rail wagons where convenient. The alternative would be to assume that customers accept transport costs from steel warehouses.

c. Raw Material Movement

The number of barges and wagons required to carry raw materials would vary by plant location since some locations are close to raw materials and others are far away. For example, while Lokoja and Enugu can procure coal, ore and limestone within a 30-mile radius, Lagos would have to procure these from Lokoja, which is about 520 miles away by water transport.

It is assumed in the present study that any given plant location would procure raw materials from their cheapest sources. Thus, Lokoja, Idah, Onitsha, Asaba, Lagos and Port Harcourt would procure coal, ore and limestone from Lokoja, while Enugu would procure these materials from itself. As it will be pointed out in Chapter IV, about four tons of Lokoja ore and six tons of Enugu ore would be required to produce one ton of steel. Also, as it will be demonstrated in Chapter IV, irrespective of location, of materials and plant, about 2 tons of coal and 0.5 ton of limestone are required per ton of finished steel. Thus, the task is to estimate how many wagons or barges are needed by location to move about 5,300,000 tons of raw materials from Lokoja or 6,500,000 tons of raw materials from Enugu.

Both Lokoja and Enugu can procure raw materials within a 30-mile radius. Round trip to get these materials to the plant would be approximately 60 miles.

Given the rail average speed of 25 miles per hour, mine-plant round trip journey could be made in about 3 hours. Loading at the mines and unloading at the plants is assumed to take the rest of the working hours of the day (about 8-10 hours). Thus, the 60 mile mine-plant-mine trip is assumed to be a day's journey. Therefore, as in the case of steel, a linear train of 25 wagons, each wagon carrying 45 tons of either ore, coal or limestone would be carrying about 1,000 tons at a time. Since daily running of such a train (during 350 days of the year) with an average load of 1,000 tons would transport 350,000 tons a year, Lokoja would need about 378 wagons for raw material movements and Enugu would need about 464 such wagons.

Onitsha and Asaba are both about 150 miles from Lokoja and are on the same river as Lokoja. Investment in transportation involves first barges to serve between them and Lakoja, and second, wagons to bring the raw materials from the mines to the Lokoja port. NEDECO's study shows that a round-trip journey between the Delta port and Onitsha or Asaba (190 miles one way) takes 7 days (42 sailing hours and 36 port hours)[52] and that a round-trip journey between the Delta port and Lokoja (320 miles one way) takes roughly 10 days (71 sailing hours and 36 port hours).[53] Thus, realistically, the round-trip journey between Onitsha/Asaba and Lokoja

would take 3 days, i.e., 117 round-trips could be made per barge in 350 working days of the year. Thus, each barge could carry about 78,390 tons per year. To carry 5,300,000 tons of raw material from Lokoja to Onitsha or Asaba therefore would need about 34 barges.

Port Harcourt is about 360 miles from Lokoja, about the same distance as the above mentioned Delta-Lokoja distance, i.e., 320 miles involving about 10 days in round-trip journey, which is about 35 round trips per year. To move 5,300,000 tons of raw materials per year to Port Harcourt from Lokoja would thus require about 226 barges.

Lagos is about 518 miles from Lokoja. NEDECO reports that a 520 mile round-trip journey between the Delta ports and Jebba involved 120 sailing hours and 36 port hours, i.e., 13 total days[54] or 25 round trips per year. Thus, per year a barge carrying raw materials from Lokoja to Lagos would transport about 8,710 tons. Moving 5,300,000 of raw materials from Lokoja therefore would need 609 barges.

Ikare would not need barges to procure raw materials from Lokoja, as these would be done by rail over a distance of about 120 miles (round trip would be about 240 miles, i.e., about 6 hours journey, 3 hours one way). It is assumed that loading and unloading at both ends takes one and one-half working days and that the total round trip journey takes two working days. Thus, per

year, a linear train with 25 wagons, each wagon carrying about 45 tons, would carry about 175,000 tons per year. To carry 5,300,000 tons of raw materials from Lokoja to Ikare, therefore, would require about 757 wagons.

As in the case of steel-carrying wagons and steel, however, it is necessary to increase the estimated number of wagons and barges by location by 20 per cent to account for additional carriers to be kept in stock for emergency purposes such as maintenance and repair time on those that might break down. Thus, for a 800,000-ton plant, Lokoja would actually need to purchase 378 wagons costing ₤850,000; Enugu 464 wagons costing ₤1,044,000; Onitsha and Asaba respectively would require 378 wagons and 82 barges, costing ₤4,048,500; Idah 378 wagons and 41 barges, costing ₤2,449,500; Port Harcourt also 378 wagons and 271 barges, costing ₤10,569,000; Lagos 378 wagons and 731 barges, costing ₤29,359,500; and Ikare 1287 wagons, costing ₤2,895,750. On the other hand, for each location, a 400,000-ton plant would incur half the above estimated cost and a 267,000-ton plant would incur a third of the respective locational costs.

d. Total Investment Costs on Rail Line Wagons and Barges

These costs include the cost on the suggested rail line, and the wagons and barges required to carry both

raw materials and finished steel. Cost variations by location and size of plant are shown below (Table 3.5).

TABLE 3.5

ESTIMATED TOTAL INVESTMENT COSTS
IN TRANSPORTATION FACILITIES
(₤ million)

Location	800,000-ton Plant	400,000-ton Plant	267,000-ton Plant
Lokoja	1.52	0.76	0.51
Enugu	1.53	9.77	0.51
Onitsha	11.67	2.34	1.56
Asaba	4.67	2.34	1.56
Idah	3.07	1.54	1.02
Ikare	33.15	31.55	31.05
Port Harcourt	10.98	5.49	3.66
Lagos	29.60	14.68	9.79

7. Summary

The present chapter has concentrated on the analysis of the major location factors in the proposed steel works in Nigeria. The comparative costs and benefits of alternative locations are discussed in the next chapter.

Footnotes

[1]H. H. Yeates and B. J. Garner, The North American City (New York: Harper & Row, 1971), p. 139.

[2]International Bank for Reconstruction and Development, The Economic Development of Nigeria (Baltimore: Johns Hopkins Press, 1955), p. 419.

[3]Ibid., pp. 419-20.

[4]Federal Republic of Nigeria, Guide to Current Exports (Lagos: Nigerian National Press, 1966), p. 30.

[5]Exports of scrap began in any reasonable measure only about 1964. Since then, annual exports are about 10,000 tons. Assuming that twice as much scrap is consumed locally as is exported, the fact still remains that total local scrap supply is small indeed. See United Nations, Yearbook of International Trade Statistics (New York: United Nations, 1967), p. 631; 1969, p. 633.

[6]Allan Sokolski, The Establishment of Manufacturing in Nigeria (New York: Praeger Press, 1965), p. 51. See also, W. A. Perkins and J. H. Stembridge, Nigeria: A Descriptive Geography (London: Oxford University Press, 1966), p. 108.

[7]United Nations, Economic Aspects of Iron Ore Preparation (Geneva, 1966), p. 93.

[8]Ibid., p. 93.

[9]Carl Liedholm, op.cit., p. 51.

[10]United Nations, Economic Aspects of Iron Ore Preparation, p. 9.

[11]Ibid., p. 10.

[12]United Nations, World Trade in Steel and Steel Demand in Developing Countries (New York: United Nations, 1968), p. 160.

[13]Nigeria, Geological Survey of Nigeria: The Nigerian Coalfields, Bulletin No. 24 (Lagos: Nigerian National Press, 1954), pp. 70-74.

[14]Carl Liedholm, The Indian Iron and Steel Industry, An Analysis of Comparative Advantage (East Lansing: Michigan State University, 1972), p. 51.

[15]United Nations, Economic Aspects of Iron Ore Preparation, op.cit., p. 9.

[16]Nigeria, Geological Survey of Nigeria: The Nigerian Coalfields, op.cit., pp. 66-79.

[17]Ibid., pp. 70-74.

[18]Carl Liedholm, op.cit., p. 51.

[19]Allan Sokolski, op.cit., p. 51.

[20]Ibid., p. 114.

[21]Northern Nigeria, Ministry of Trade and Industry, The Industrial Potentialities of Northern Nigeria (Kaduna: Government Printer, 1963), p. 203.

[22]United Nations, Statistical Yearbook, 1973 (New York: United Nations, 1974), p. 172.

[23]UNESCO, Statistical Yearbook, 1972 (Belgium: Impimerie Centerick, 1973), p. 590.

[24]Smith and Taaffee et al., p. 174.

[25]P. E. Management Groups, op.cit., Part I, p. 5.

[26]Nigeria, Federal Ministry of Industries, 5th Edition (Lagos: Nigerian National Press, 1970), pp. 3-59. [First, total labor force in manufacturing industries is calculated for each province. The provincial totals are added together to obtain national total. Each provincial total is then expressed as percentage of national total. The twelve provinces which constribute more than 90 per cent of national manufacturing and industrial labor force are shown in Table 3.5 as the major steel markets.]

[27]Federal Government of Nigeria's Ministry of Transport and Kingdom of Netherlands' Ministry of Foreign Affairs, Development of the Port of Nigeria 1970-1990: A Study of Port Development and Related Subjects (Lagos: Nigerian National Press, 1971), Annex IV-6.

[28]Ibid., Annex IV-13.

[29]Ibid., Annex IV-6.

[30]Ibid., Annex IV-11.

[31]Ibid., Annex V-15.

[32]Ibid., Annex VI-1.

[33]Stanford Research Institute, The Economic Coordination of Transport Development in Nigeria (California: Menlo Park, 1971), p. 7.

[34]Ibid., p. 8.

[35]Ibid., p. 34.

[36]Ibid., p. 7.

[37]Ibid., p. 13.

[38]Ibid., p. 7.

[39]Ibid., pp. 5-6.

[40]Ibid., p. 20.

[41]Ibid., p. 20.

[42]Ibid., p. 87.

[43]Federal Government of Nigeria's Ministry of Transport and Kingom of Netherlands' Ministry of Foreign Affairs, Development of the Port of Nigeria..., op.cit., Annex IV-15.

[44]Ibid., Annex IV-17.

[45]Ibid., Annex IV-18.

[46]Ibid., Annex IV-18.

[47]Ibid., Annex IV-18.

[48]Ibid., Annex IV-1.

[49]Ibid., Annex IV-21.

[50]Ibid., Annex IV-26.

[51]Ibid., Annex V-24.

[52]Ibid., Annex IV-27.

[53]Ibid., Annex IV-27.

[54]Ibid., Annex IV-27.

CHAPTER IV

COMPARATIVE COSTS OF ALTERNATIVE SOLUTIONS

To derive an optimum solution for one, two, or three plants requires analysis of the costs of plant and power, working capital, raw materials, labor, depreciation, interest on working capital, transportation investments and transport costs per ton of particular goods, and steel town community. The present chapter addresses itself to this question.

1. Plant, Power, Pre-Plant Costs and Working Capital

Plant and power include the following items: blast furnace, steel mill, rolling mill, slag-based building materials, power, auxiliary plants, works administration and other miscellaneous. Pre-plant costs include "the initial cost for the first five years subsequent to starting of production for non-African experts and processing costs for nonutilizations of capacity during the start of operations." Working capital includes the product inventory, parts and raw materials accumulated prior to opening of the plant.

For want of better information than the recent "Memorandum on the Establishment of an Iron and Steel Plant in Liberia,"[1] West Africa, this present study draws much from that study. About 1965, the United Nations was invited to carry out a feasibility study of an iron and steel works in Liberia. The Commission recommended a plant producing about 700,000 tons of steel per annum for Liberia (hoping that this would serve the whole of West African needs). Their estimates, excluding the cost of training, are as in Table 4.1

TABLE 4.1

1965 ESTIMATE OF INVESTMENT COSTS IN A 700,000-TON PLANT FOR LIBERIA

Item	Cost (in U.S. $)
Plant and Equipment	
Blast furnace	13,000,000
Steel mill	24,000,000
Rolling mill	16,000,000
Slag-based building material	3,000,000
Power plant	17,500,000
Auxiliary plants	15,000,000
Works administration	1,000,000
Miscellaneous	4,000,000
TOTAL	$94,500,000
Initial Cost (for first five years subsequent to starting production, etc.)	28,000,000
Working Capital	13,000,000
GRAND TOTAL	$135,500,000

Given the above and assuming costs in Nigeria to be at least roughly comparable to Liberian costs, one can estimate that an 800,000-ton plant in Nigeria in 1965 would have cost about $155,000,000. Since about 1964, however, rising costs have averaged about 5 per cent per annum.[2] Thus, assuming continued inflation, a Nigerian plant intended to be in production by 1980 having construction commence in 1976, the total cost of plant, power, initial costs and working capital would come to nearly $265,000,000.

The $265,000,000 (£87,200,000) estimate above relates to the cost of one integrated 800,000-ton plant. But it was also stated earlier in this paper that due to political reasons, Nigeria could have two 400,000-ton plants or three 267,000-ton plants. What will be the investment costs in each of these plants?

Studies in Latin America in 1966 have shown that diseconomies of scale results from dividing the output of a big plant among smaller plants. It was found that in Latin America investment per ton costs $330.04 for an 800,000-ton plant; cost rise to about $484.51 per ton in a 400,000-ton plant; and to about $560.00 per ton in a 270,000-ton plant.[3] Thus, whereas total investment in an 800,000-ton plant was about $264,000,000, it was about $194,000,000 (£64,000,000) in a 400,000-ton plant and about $150,000,000 (£50,000,000) in a 276,000-ton plant. Thus, two 400,000-ton plants would incur about

$388,000,000 and three 267,000-ton plants would incur about $450,000,000. These cost increased, based on the Latin American studies, amount to a 47 per cent increase for two 400,000-ton plants, and a 70 per cent increase for three 267,000-ton plants.[4] Compared to our original estimate of an investment of $265,000,000 for one 800,000-ton plant, costs would rise to about $390,000,000 (£128,000,000) on two 400,000-ton plants and to about $451,000,000 (£149,000,000) on three 267,000-ton plants.

2. Investment in Rail Line, Wagons and Barges by Size of Plant and Location

See Chapter III for the estimated investment costs in rail line, wagons and barges by size of plant and location.

3. Pit-head Cost of Raw Materials

The major raw materials in the iron and steel industry are coking coal, iron ore, limestone and scrap. Gerald Manners points out that due to major advances, especially the use of scrap in modern steel technology, one ton of finished steel requires about 1.5 tons of iron ore,[6] 1.0 ton of coal, 0.6 ton of scrap and 0.3–0.4 ton of limestone.[7] But Nigeria does not have scrap in any reasonable amount, nor coal, and iron ore of the

required qualities. Therefore, material combinations in Nigeria will differ from those steel industries in the West.

The Nigerian iron and steel works should avoid using scrap at least initially, as it would have to be imported. Imports achieving the proportions suggested alone would require 480,000 tons of scrap to produce 800,000 tons of steel and would cause an average annual foreign exchange loss of about $20.6 million.[8] Even in the advanced countries such as the United States, which is richer in scrap than Nigeria is, the proportion of purchased scrap used in steel making has been declining in recent years partly because of its increasing scarcity which tends to make steel making relatively more expensive, and partly because it has metallurgical disadvantages. It contains stray alloys and contaminats which cause difficulties in the making of steel which meets rigid specifications. In the fully integrated steel mills in the United States in the early 1950's, about 1.94 tons of Mesabi ore (51.5% Fe) and 1.20 tons of coal plus only a small amount of scrap were used per ton of finished steel.[9] Luxembourg also provides an example: in 1956, about 1.71 tons of coal, 4.04 tons of iron ore, and 0.009 ton of scrap were used per ton of finished steel.[10]

Thus, ignoring scrap, about 4.0 tons of Lokoja ore (50% Fe) or 6.0 tons of Enugu ore (30% Fe) would be needed

per ton of steel in a Nigerian plant. Since coal energy is derived from its carbon and volatile materials, and since Nigerian coal is about 85 per cent (45 per cent carbon and 40 per cent volatile), about 2 tons of coal would be required per ton of steel. Other estimated inputs include 0.5 ton of limestone.

The tonnage of each raw material per ton of finished steel is shown in Table 4.2.

TABLE 4.2

WEIGHTED TONNAGE OF RAW MATERIAL PER TON OF FINISHED STEEL

Raw Material	Tons/Ton of Finished Steel	Tons per Plant (800,000 tons of steel)
Coal	2.0	1,600,000
Ore	4.0 or 6.0	3,200,000 or 4,800,000
Limestone	0.5	400,000

The pit-head cost per ton of raw material is the f.o.b. price at the mines. The average pit-head costs of limestone and coal in Nigeria are 40 shillings and 50 shillings respectively.[11] Ore mining is yet to begin in Nigeria for the purpose of the present study, it is assumed that when ore mining commences in Nigeria, the pit-head cost per ton would be about the same as in Sierra Leone and Liberia. Thus, since the average f.o.b. price of ore in Sierra Leone and Liberia varies

between $8.00 and $9.00 per ton,[12] the present study assumes an $8.50 (56.0 shillings) per ton for a possible Nigeria ore mining activity. For plants of different sizes, pit-head costs therefore would be as shown in Table 4.3.

4. Labor and Training Costs

a. Direct Labor

Labor cost estimates begin with an estimate of direct employment in the proposed steel works in Nigeria. The estimate of the direct employment derives from looking at plant and employment sizes in existing steel industries in the world. Since the hypothesized Nigerian plant is small (less than 1 million tons), the population sample on which the employment estimate will be based will come from countries producing only about 25 million tons of steel per annum. The sample countries, and their plant and employment sizes are shown in Table 4.4.[13] Although all the countries in Table 4.4 are much more advanced than Nigeria, they comprise the countries producing small quantities of steel produced per year. The sample ranges from such advanced countries as Sweden, to the less developed ones as Spain and India. A regression analysis run on these countries correlating plant capacity as the independent variable and labor size as the dependent variable will help the employment estimate

TABLE 4.3

RAW MATERIAL PIT-HEAD COST BY SIZE OF PLANT

Pit-head Cost per Ton	Input Coefficient	Plant Size (million shillings) 800,000-ton Plant	400,000-ton Plant	267,000-ton Plant
Coal (50 shillings)	2 tons	80.0	40.0	26.7
Ore (56 shillings)	4 or 6 tons	179.2/268.2	89.6/134.4	59.7/89.6
Limestone	0.5 tons	16.0	8.0	5.3
		275.2/364.8	137.6/182.4	91.7/121.6

in a Nigerian plant, especially after weighing the estimate by certain correction factors.

Table 4.4 shows plant size in million tons and employment size in thousand people for a sample comprised of 13 countries. The resulting regression equation of labor size (L) on steel plant size (S) for the year 1970 is:

$$L = 9.1 + 3.2\ S \text{ (number in thousands)}$$

with R^2 of 0.60. Since the estimated plant size (S) in Nigeria is about 800,000 tons, then labor required in that plant is:

$$\begin{aligned} L &= 9.1 + 3.2 \times 0.8 \text{ (thousands)} \\ &= 9.1 + 2.56 \text{ (thousands)} \\ &= 11.7 \text{ (thousands)} \quad . \end{aligned}$$

Thus employment estimates for Nigeria based on the world model is about 11,700 people. For two reasons, the present writer has decided to increase this figure by about 20 per cent. First, all countries in the sample study, even Spain, Portugal and India, are considerably more advanced than Nigeria in steel making processes (Figure 4.1). They are all on the high side of the estimate of employment per ton of steel and Nigeria will also very likely have a high ratio compared to the more advanced nations. Problems of learning and installation will increase labor per ton of steel but on the other hand compared to the older steel-producing

TABLE 4.4

STEEL PRODUCTION IN MILLION TONS AND NUMBER OF PEOPLE EMPLOYED IN THOUSANDS IN SELECTED WORLD STEEL-PRODUCING COUNTRIES, 1970

Country	Tons of Steel (million)	Number Employed ('000)
Belgium	24.1	57.4
Italy	25.7	74.4
Luxembourg	10.3	22.0
Netherlands	8.6	21.4
Austria	7.7	52.7
Denmark	0.7	3.0
Spain	11.6	77.2
Norway	1.5	7.3
Portugal	0.7	4.3
Sweden	8.1	41.0
Turkey	2.7	14.9
India	18.9	120.2

Source: Organization for Economic Cooperation and Development (OECD), The Iron and Steel Industry in 1970 and Trends in 1971, Paris, 1971, p. 67; Hindustan Steel Ltd., Statistics for Iron and Steel Industry in India — 1970, Ranchi, India, 1970, pp. 4, 142.

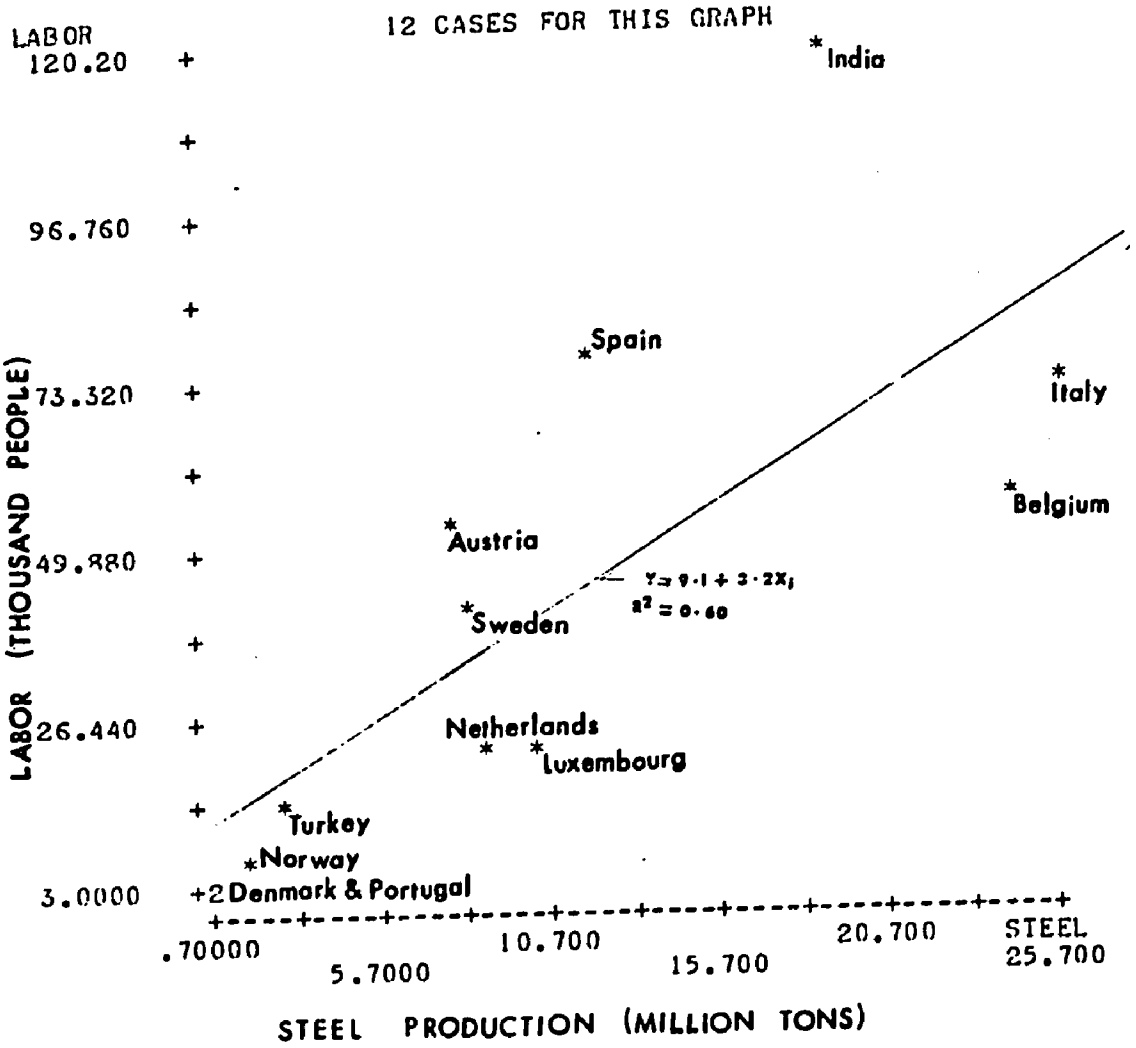


Figure 4.1--The Regression of Labor (Employment) on Steel Production for Selected World Countries (1970).

centers, the Nigerian mill will take advantage of the latest technology which would suggest less labor per ton of steel. Second, processes that require more employment and less capital will prove more economical in a nation where capital costs are higher relative to wage costs. Nigeria is more likely to compare in labor productivity with places like India, Portugal and Spain than with places like Belgium and Netherlands. Hence, increasing the 11,700 figure obtained from the above regression equation by a rather arbitrary 20 per cent as a balance between the opposing factors gives employment size of about 14,000 in an 800,000-ton steel plant in Nigeria.

Labor requirements in a 400,000-ton plant and a 267,000-ton plant also have to be estimated. It was already emphasized how diseconomies of scale can result from breaking down the products of an integrated steel works among smaller plants as certain sectors, such as managerial and administrative, clerical and sales will require duplication of workers. Specifically, the present study has shown that when in Latin America two 400,000-ton plants were established in place of one 800,000-ton plant, scale diseconomies reached about 70 per cent.[2] Although these percentage values were derived from overall investment by plant, the present study assumed that the ratio of labor diseconomies alone will be comparable to total plant diseconomies. Assuming the

Latin American experiences were realistic for Nigeria, a 400,000-ton plant would employ at least 10,000 workers and the figure will rise to nearly 8,000 in every 267,000-ton plant.

Thus, from the point of view of development strategy, two small plants instead of one would provide jobs for about 6,000 more people and three small plants in place of one would offer employment opportunity for an additional 10,000 people.

b. Labor Mix

Having hypothesized basic (direct) workers in Nigerian plants of different sizes and combinations, the next step is to estimate the breakdown of employment by job category. In other words, how many people will be employed as (1) process workers, (2) apprentices, (3) workers in auxiliary departments and services, and (4) technical, administrative and clerical workers? Again, ideally we should look at experiences in steel works in other parts of the world; preferably using data from the same countries on which gross employment size estimate has been based[14] (except insofar as data are available).

Table 4.5 shows the breakdown of employment in steel works by major category in 1970, for approximately the same set of countries in Table 4.4. The total number of process workers is 161,266; apprentices, 2,461;

TABLE 4.5

NUMBER EMPLOYED IN STEEL WORKS: BREAKDOWN BY PROCESS, 1970

Country	Process Workers	Apprentices	Workers in Auxiliary Department and Services	Technical, Administrative and Clerical Workers
Belgium	28,630	--	19,402	9,382
Italy	39,500	70	22,000	12,800
Luxembourg	10,044	295	8,625	2,988
Netherlands	6,647	324	6,915	7,468
Denmark	1,950	--	535	515
Spain	31,016	1,480	26,770	17,970
Ireland	373	20	290	141
Portugal	2,266	104	1,455	498
Turkey	38,187	--	8,265	1,795
Finland	2,653	168	2,230	1,375
TOTAL	161,266	2,461	96,487	54,932
PRECENT GRAND TOTAL	51.17	0.78	30.62	17.43

Source: OECD, Paris, 1971, pp. 66-67.

auxiliary department and services workers, 96,487; and technical, administrative and clerical workers, 54,931. As a percentage of workers, process workers has 51.17; apprentices, 0.78; auxiliary department and services 30.62; and technical, administrative and clerical workers, 17.43 (Table 4.5). Looking at a relatively less advanced nation like Spain, however, reveals that there are more auxiliary workers (34.7%) and technical, administrative and clerical workers (23.3%) and less process workers (40.16%) than average. Nigeria will probably look more like Spain and thus, Spain's percentage values are better recommended for Nigeria.

c. Labor Costs

The acute shortage of indigenous skilled workers, especially engineers and technicans, for the proposed steel works in Nigeria was already emphasized. At the initial stage, therefore, Nigeria must have to rely on the service of foreign technicians and engineers. At the same time, Nigeria should embark on massive training of Nigerians in overseas technical and engineering schools. In the United States, for example, the norm is a ratio of one engineer for every 50 workers, and in the Brazilian Volta Redonda steel works in the mid-sixties, the ratio was one engineer for every 63 workers.[15] If the Brazilian case is assumed reasonable for

Nigeria because both countries are underdeveloped, then about 230 out of the estimated total 14,000 labor force for an 800,000 ton plant would be engineers. Also, each 400,000-ton plant would employ about 115 engineers and each 267,000-ton plant about 77 engineers. In each case, as in Volta Redonda,[16] half of the engineers should consist of metallurgical engineers; the rest should be in the fields of mechanical, civil and electrical engineering. The training of 230 engineers, including tuition and living expenses in a place like The University of Michigan would cost Nigeria about $1.4 million per year ($6,000 per head), and assuming a four-year college education, about $16.8 million (₤5.6 million). The people so trained should seek internship in overseas steel works and return home to participate in the construction and running of the plant or plants.

It is the suggestion of the present writer that when the plant commences, wages should be comparable with current wages in the Nigerian petroleum and coal industries. Wages to workers in the petroleum and coal industries are much higher than wages to workers elsewhere.[17] The average annual wage or salary per worker in the petroleum and coal works in 1971 was about ₦2,500 or ₤1,250. The average annual wage or salary per worker in the porposed steel works, therefore, should be about ₤1,250. Total annual wages or salaries would

therefore be about ₤17.50 million in an 800,000-ton plant, ₤12.50 million in every 400,000-ton plant, and ₤10.0 million in every 267,000-ton plant. Such good wages and salaries presumably would help to reduce labor turnover, absenteeism, and adherence to normal work rules.

5. Social Overhead Investment

It is the further suggestion of the present writer that in order to entice and encourage people to work and remain with the steel works, they should be given very decent infrastructure. For the operating staff of the project should be provided living quarters, public services such as roads, water supply, sewage and power distributions, schools, hospitals and banks. The supply of such items as suggested for major construction staff in Nigeria is not a novelty. During the construction of the Kainji Dam (1963-1969), about 15,000 people were employed[18] (this was the peak-employment figure). Kainji township was built exclusively for the operating staff at a cost of nearly ₤3,000,000. Such services as are suggested were provided. Another ₤4,000,000 was spent building roads for the efficient running of the project.[19] All in all, investment per head was about ₤500 ($1,500).

Estimating investment per head in a new steel community can be quite a problem. A new steel community in an underdeveloped region like Lokoja would require heavy overhead investment. But so also will a new community in a developed but overcrowded region like Lagos. Thus assuming that new investment per head would be higher in an undeveloped region than in a developed region can be quite misleading. It is therefore the suggestion of the present writer that investment per head in the new steel community should be comparable to that at Kainji, that is, ₦500 per head, irrespective of location. This will serve three purposes; it will help to maintain the workers in a relatively better developed community, it will serve as a model for future planning, and third, it will help to maintain a new community of middle-class people and, hopefully, serve as a means of income redistribution in favor of the less fortunate, which is one of Nigeria's national goals. Thus, irrespective of location, a sum of ₦7.0 million would be spent on the 14,000 workers in an 800,000-ton plant, ₦5.0 million on the 10,000 workers in every 400,000-ton plant, and ₦4.0 million on the 8,000 workers in every 267,000-ton plant.

6. Depreciation

The "wear and tear" that is going to take place in the plants must be replaced if the plants are to operate efficiently. In estimating the annual depreciation rate in plants of different sizes, the Indian experience has been employed. Liedholm points out that the annual depreciation rate per ton of steel in Bhilai mill in India "at the initial level" was "5 percent Bhilai's actual capital costs per ton of its steel output."[20] Capital cost is defined as the fixed assets of the works[21] for Nigeria, this includes the costs of plant and equipment, railway, wagons, barges, and steel town community structures. In the present study, machines, i.e., plant and equipment, will assume a 5 per cent annual rate of depreciation. Wagons, barges, railway and steel town community, however, will assume a 10 per cent annual rate of depreciation as the average life of these is generally believed to be about 10 years.[22]

Basing estimates of plant and equipment on the Liberian study referred to earlier, and allowing for rising costs since 1965 (i.e., 5 per cent inflation rate), plant and equipment alone would cost nearly $185,000,000 (₤61,000,000) by 1976 for an 800,000-ton plant. For a 400,000-ton plant, plant and equipment etc. would reach about $136,000 (₤45,700,000). On the

other hand, in a 267,000-ton plant, plant and equipment would reach about $104,000,000 (£34,000,000. The results of a 5 per cent annual depreciation cost on plant and equipment and a 10 per cent annual depreciation cost on railway, wagons, barges, and steel town community structures by location and size of plant are respectively shown in Table 4.6.

7. Interest on Working Capital

Again, for the Bhilai mill quoted above, Liedholm points out that the interest on working capital in the mill was "7-1/2 percent of Bhilai's works costs (materials and labor) for six months;" this amounts to about 15 percent per year.[23] Consequently, a 15 per cent value will be used to estimate interest on working capital in plants of varying sizes at different locations in Nigeria. These estimates of interest on working capital by location and size of plant are also shown in Table 4.6.

8. Selling Cost, Head Office Cost and Margin for Contingencies

Liedholm points out that in the Bhilai mills in India, selling cost, head office cost and margin for contingencies total about 5 per cent of total works costs.[24] Again, this Indian experience has been used to estimate

TABLE 4.6

ESTIMATED ANNUAL VALUE ADDED (V_i) BY LOCATION AND SIZE OF PLANT

(₦ Million)

	Lagos	Lokoja	Enugu	Port Harcourt	Onitsha	Idah	Ikare	Asaba
The 800,000-ton Plant								
Works costs*	31.24	31.26	35.74	31.26	31.26	31.26	31.26	31.26
Interest on working capital	4.60	4.60	5.36	4.60	4.60	4.60	4.60	4.60
Depreciation on plants & equipment	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05
Depreciation on transportation facilities and steel-town community structures	3.66	0.85	0.85	1.90	1.27	1.11	4.02	1.27
Selling, office costs, contingencies	1.50	1.50	1.79	1.50	1.50	1.50	1.50	1.50
Total Value Added (V_i)	44.07	41.26	46.26	42.31	41.68	41.52	44.43	41.68
The 400,000-ton Plant								
Works costs*	19.38	19.38	21.62	19.38	19.38	19.38	19.38	19.38
Interest on working capital	2.91	2.91	3.24	3.24	3.24	3.24	3.24	3.24
Depreciation on plants & equipment	2.29	2.29	2.29	2.29	2.29	2.29	2.29	2.29
Depreciation on transportation facilities and steel-town community structures	1.97	0.58	0.58	1.05	0.73	0.65	3.66	0.73
Selling, office costs, contingencies	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Total Value Added (V_i)	27.52	26.13	28.81	26.93	26.61	26.53	29.54	26.61
The 267,000-ton Plant								
Works costs*	14.59	14.59	16.08	14.59	14.59	14.59	14.59	14.59
Interest on working capital	2.19	2.19	2.41	2.19	2.19	2.19	2.19	2.19
Depreciation on plants & equipment	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70
Depreciation on transportation facilities and steel-town community structures	1.38	0.45	0.45	0.77	0.56	0.50	3.51	0.56
Selling, office costs, contingencies	0.73	0.73	0.80	0.73	0.73	0.73	0.73	0.73
Total Value Added (V_i)	20.59	19.66	21.44	19.98	19.77	19.71	20.72	19.77

*Material and labor costs less transport costs on raw materials.

these costs for Nigerian plants of varying sizes at varying locations. Again, these estimates are shown by location and size of plant in Table 4.6.

9. Estimated Transport Costs on Raw Materials and Finished Steel by Plant Size, Location and Strategy

Estimated transport costs require analysis of the following elements:

a. Raw material required per ton of finished steel by location;

b. Transport costs on raw materials by rail, water and road, including capital costs;

c. Market demand for steel at different locations; and

d. Plant size at different locations.

As previously estimated, about two tons of coal from either Enugu or Lokoja, and about four tons of ore from Lokoja or six tons of ore from Enugu would be required to produce one ton of steel. Investments in transportation by location was estimated; this does not, of course, include transportation charged by any means of transport.

Nigeria Railway Corporation, Railway Passengers and Goods Services, Tariff No. 7 (Lagos: Nigerian National Press, 1970, pp. 109-70), provides rail freight rates for different classes of goods (see Table 4.7 for freight rates for coal and coke, iron ore, scrap, and steel

products). But there are no "definite or universally applied rating systems or rate structures in effect" for road. (See Transportation, A Guide to Current Costs in Nigeria (Lagos: Nigerian National Press, 1969), p. 8.) There are also "no overall rate regulations in force" for water. (See Transportation, A Guide..., p. 22). However, the average per ton mile cost for road, rail and water are known to be 6d.; 2.2d.; and 1.3d. respectively as discussed earlier. The per ton mile rates for various classes of goods, including coal, iron ore, steel, etc. are provided in the above mentioned Tariff No. 7 and shown in Figure 4.2. For example, ore and limestone are moved under class D goods, coal under class B and steel under class E. As water and road transport costs by different zones are not available, we assume them to be proportional to the ratio of the average rail to water costs and rail to road costs. Thus, for the ten-mile zone in which rail costs are 26 shillings the water rate is calculated to be 15 shillings by solving the following expression of the proportion:

$$\frac{\text{2.2d (average rail)}}{\text{1.3d (average water)}} = \frac{\text{26 shillings}}{x} \quad \begin{matrix}\text{(total rail cost for 10 mi.} \\ \text{(total water cost for 10 mi.}\end{matrix}$$

Similar estimates are made to derive equivalent costs for other distances by water and the analysis is repeated to derive road transport costs per ton using the

TABLE 4.7

WATER, RAIL AND ROAD FREIGHT RATES* PER TON MILE
ON IRON AND STEEL GOODS, COAL AND COKE,
IRON ORE AND SCRAP

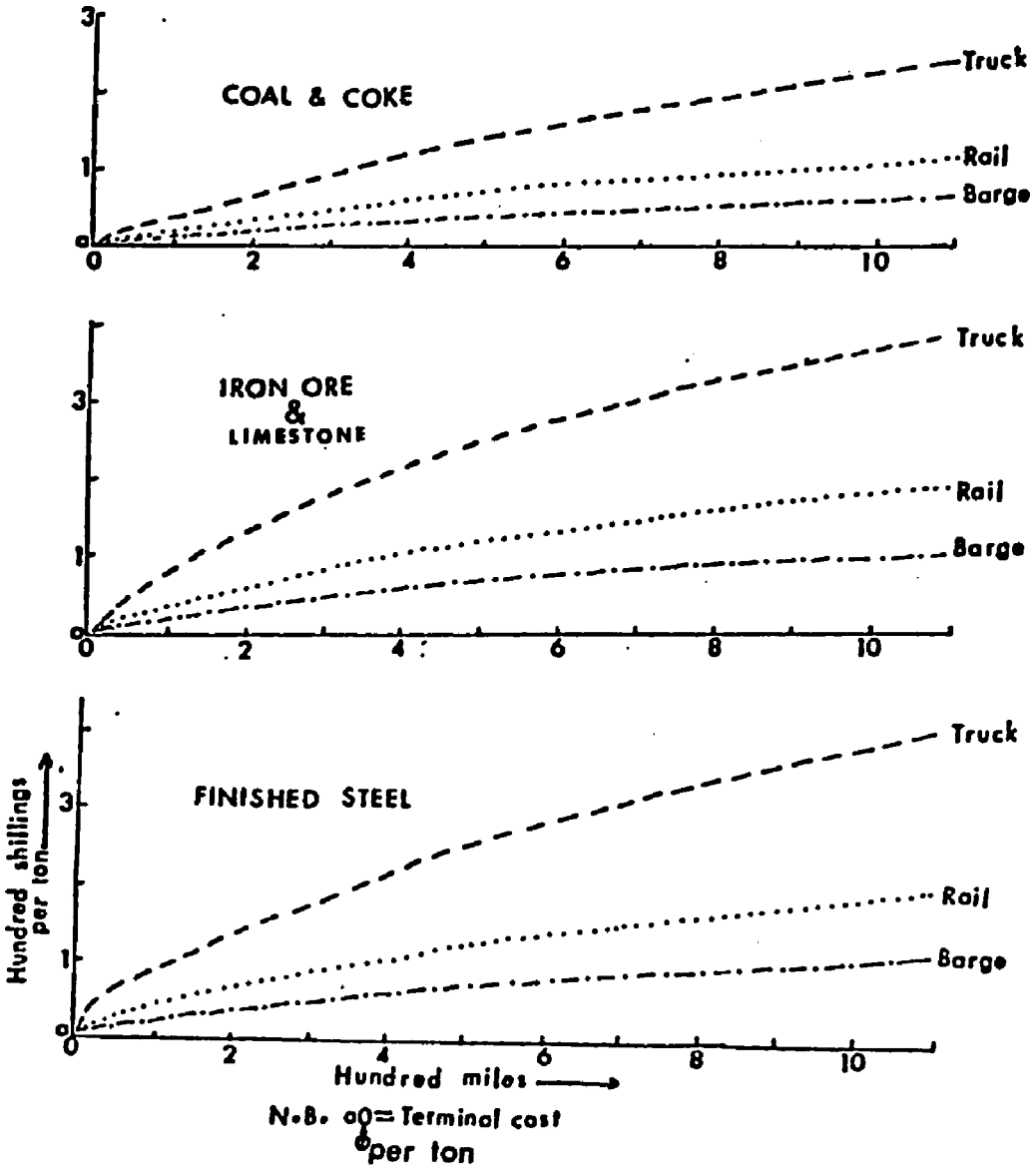
	Iron and Steel Per Ton Cost By:			Coal and Coke Per Ton Cost By:			Iron Ore and Limestone Per Ton Cost By:		
Miles	Water	Rail	Road	Water	Rail	Road	Water	Rail	Road
10	15	26	71	7	12	33	11	18	49
50	19	32	87	8	13	35	14	24	65
100	26	44	120	11	18	49	22	38	104
150	34	58	158	13	22	60	31	52	142
200	40	68	185	19	32	87	37	62	169
250	48	81	220	23	39	106	45	76	207
300	52	88	240	27	46	125	50	84	229
350	59	100	273	31	52	142	58	98	267
400	64	108	295	34	58	158	63	106	289
450	70	118	322	38	64	175	69	116	316
500	73	124	338	40	68	185	71	120	327
550	78	132	360	43	73	199	76	128	349
600	82	138	376	46	78	213	79	134	365
650	87	147	401	49	83	226	83	141	385
700	90	152	415	52	88	240	86	146	398
750	95	160	436	54	92	251	90	154	420
800	97	164	447	56	96	262	93	158	431
850	100	170	464	59	100	273	96	163	445
900	104	176	480	61	104	284	99	168	458
950	108	183	499	63	107	292	102	173	472
1000	111	188	513	66	112	305	105	178	485
1050	115	195	532	69	116	316	108	183	499
1100	118	200	545	71	120	327	111	188	512

*Rates in shillings.

N.B. Twelve pence (12d.) = One shilling (1s.). Twelve shillings (20s.) = One pound (£1). One pound (£1) = Three dollars ($3).

FIGURE 4.2

RATES & INCREASING AT DECREASING RATE WITH DISTANCE



N.B. a0 = Terminal cost & per ton

rail to road ratio (i.e., 2.2d to 6.0d). This methodology can be justified insofar as the bases of measurement, i.e., 2.2d per ton mile by rail and 1.3d per ton mile by water respectively represents the real cost of transportation to the economy and insofar as both raw materials and finished steel are moved mainly by rail and water. As goods are moved from one place to the other or transferred from one shipper to the other, the appropriate terminal and handling charges should be added. The Nigerian Railway Corporation's Passenger and Goods Services, Tariff No. 7 stated that irrespective of the carries and the good in transit, the official terminal and handling charges have been put at five shillings per ton.[26] Thus all terminal and handling charges in the present study assume five shillings per ton.

a. Assumptions

In estimating the cost of moving raw materials and of moving finished steel, the following assumptions were made:

a. Because limestone is very ubiquitous in Nigeria, it is regarded invariant with location.
b. Because the potential sources of scrap available is so small, it has been disregarded.
c. Water is ubiquitous and invariant with location.

d. Because coal and ore deposits are yet undeveloped and will each require the same investment to achieve production, the pit-head price per unit of coal and ore can be assumed to be the same for all locations. What varies is the cost of transporting coal and ore from the mines to the steel plant.

e. That each hypothesized steel location procures coal and ore from their cheapest source relative to itself and sells steel to every market.

f. Total national steel demand should be fulfilled.

g. The demand by each market as already estimated in this study cannot be exceeded.

h. Each market buys steel from its cheapest source.

i. Where all the demand of a particular market cannot be fulfilled by the cheapest plant because that plant has sold all its products to other cheaper locations, the market so concerned buys the remaining it needs from the next cheapest plant.

j. Where two or three plants are to be located, they are of equal size with identical product mix.

b. Raw Material Movement

For any given location, the cost of moving raw material can be represented as:

$$TC_i = \sum_{j=1}^{n} Q_j(U_{ij} + T_{ij})$$

where

TC_i = total procurement cost at plant location i (i=1,2,...,m)

U_j = mining cost of one unit of input j (j=1,2,...,n) at pit-head j

T_{ij} = unit cost of transportation from pit-head j, to plant location i

Q_j = required quantity (input coefficient) of input j for given output.

The costs of hauling coal and ore from place to place are shown in Table 4.8 (using Table 4.7). Estimated total costs of hauling coal and ore by plant size and location are shown in Table 4..11.

c. Movement of Finished Steel

For a given location, the cost of moving steel can be represented as:

$$A_i = \sum_{k=1}^{n} Q_k(T_{ik})$$

where

A_i = the aggregate travel cost involved in serving k markets from location i, which may be measured in terms of distance or cost depending on the data applied to T

Q_k = quantity of the product sold at market k (k=1,2,...,n)

TABLE 4.8

ESTIMATED TRANSPORT COST PER TON OF COAL AND IRON ORE

Locations	ENUGU Miles	Cost/ Ton	LOKOJA Miles	Cost/ Ton	ONITSHA Miles	Cost/ Ton	LAGOS Miles	Cost/ Ton
COAL								
Lokoja	150 (water, Lokoja to Makurdi)	13	30 (rail, Lokoja) Terminal & handling	12 10	128 (water, Lokoja to Onitsha)	12	518 (water, Lokoja to Lagos)	41
	137 (rail, Makurdi to Enugu)	21			Terminal & handling	10	Terminal & handling	10
	Terminal & handling	15						
Enugu	30 (rail, Enugu) Terminal & handling	12 10	137 (rail, Enugu to Makurdi)	21	70 (road, Enugu to Onitsha)	31	151 (rail, Enugu to Port Harcourt)	22
			150 (water, Makurdi to Lokoja)	13	Terminal & handling	10	315 (water, P.H. to Lagos)	28
			Terminal & handling	15			Terminal & handling	15
IRON ORE & LIMESTONE								
Lokoja	150 (water, Lokoja to Makurdi)	31	30 (rail, Lokoja) Terminal & handling	21 10	128 (water, Lokoja to Onitsha)	26	518 (water, Lokoja to Lagos)	72
	137 (rail, Makurdi to Enugu)	45			Terminal & handling	10	Terminal & handling	10
	Terminal & handling	10						
Enugu	30 (rail, Enugu) Terminal & handling	21 10	137 (rail, Enugu to Makurdi)	45	70 (road, Enugu to Onitsha)	58	151 (rail, Enugu to Port Harcourt)	52
			150 (water, Makurdi to Lokoja)	31	Terminal & handling	10	318 (water, P.H. to Lagos)	52
			Terminal & handling	15			Terminal & handling	15

Table 4.8 (Continued)

Locations	IDAH Miles	IDAH Cost/ Ton	IKARE Miles	IKARE Cost/ Ton	ASABA Miles	ASABA Cost/ Ton	PORT HARCOURT Miles	PORT HARCOURT Cost/ Ton
COAL								
Lokoja	70 (water, Lokoja to Idah)	9	100 (rail, Lokoja to Ikare)	18	150 (water, Lokoja to Asaba)	13	360 (water, Lokoja to P.H.)	31
	Terminal & handling	10	Terminal & handling	10	Terminal & handling	10	Terminal & handling	10
Enugu	60 (road, Enugu to Idah)	40	160 (road, Enugu to Ikare)	64	70 (road, Enugu to Asaba)	41	151 (rail, Enugu to P.H.)	22
	Terminal & handling	10	Terminal & handling	10	Terminal & handling	10	Terminal & handling	10
IRON ORE & LIMESTONE								
Lokoja	70 (water, Lokoja to Idah)	17	70 (rail, Lokoja to Ikare)	30	150 (water, Lokoja to Asaba)	31	360 (water, Lokoja to P.H.)	59
	Terminal & handling	10	Terminal & handling	10	Terminal & handling	10	Terminal & handling	10
Enugu	60 (road, Enugu to Idah)	73	160 (road, Enugu to Ikare)	143	70 (road, Enugu to Asaba)	81	151 (rail, Enugu to P.H.)	52
	Terminal & handling	10	Terminal & handling	10	Terminal & handling	10	Terminal & handling	10

TABLE 4.9

ESTIMATED TRANSPORT COSTS ON RAW MATERIAL PER TON OF FINISHED STEEL
(costs per shillings

Tons of Raw Material per Ton of Finished Steel	Lagos	Lokoja	Enugu	Port Harcourt	Onitsha	Idah	Ikare	Asaba
Coal (2 tons)	102	34	34	64	44	38	54	46
Limestone (0.5 ton)	41.0	13	13	35	18	13	20	21
Iron Ore (4 tons or 6 tons)*	328	104	156	276	144	108	160	164
Total Procurement Costs	471	151	203	375	206	159	234	231

*4 tons at Lokoja; 6 tons at Enugu

TABLE 4.10

ESTIMATED TRANSPORT COSTS ON RAW MATERIAL IN THE PRODUCTION OF
800,000 TONS OF STEEL PER YEAR
(costs in million shillings)

	Lagos	Lokoja	Enugu	Port Harcourt	Onitsha	Idah	Ikare	Asaba
Coal and Iron Ore	376.8	120.8	162.4	300	164.8	127.2	168.0	184.8

N.B. The numbers in this table are derived by multiplying each number in the last row of Table 5.3 by 800,000.

TABLE 4.11

ESTIMATED TRANSPORT COSTS ON RAW MATERIAL BY LOCATION AND SIZE OF PLANT

(Costs in £ Million)*

	800,000-ton Plant	400,000-ton Plant	267,000 ton Plant
Lagos	18.84	9.42	6.14
Lokoja	6.00	3.20	2.00
Enugu	8.12	4.60	2.71
Port Harcourt	15.00	7.5	5.0
Onitsha	8.24	4.12	2.75
Idah	6.36	3.18	2.12
Ikare	9.36	4.68	3.12
Asaba	9.24	4.62	3.08

*20 shillings = 1 pound.

T_{ik} = unit cost of transportation between i and k.

The cost of hauling steel from place to place are shown in Table 4.12 and hauling cost per plant size and plant combinations are shown in Table 4.15.

d. Estimated Annual Overall Costs by Plant Location and Planning Strategy

The objective of the present study is to derive the optimum locations for one 800,000-ton plant, two 400,000-ton plants, and three 267,000-ton plants. This can now be done by summing up annual costs as estimated by plant size, location, or combinations of locations as shown in Tables 4.6, 4.11, and 4.13. The results are discussed below. Formally, $TC_i+V_i+A_i=T_i$ where V_i = value added

1. One Integrated 800,000-Ton Steel Works

Table 4.16, which has been compiled using Tables 4.6, 4.11, and 4.15, shows the total costs of producing 800,000 tons of steel at different locations, taking into consideration the costs of transportation, investment and value added by production at various locations. The table shows Lokoja, an essentially material site, as the optimum location for an integrated 800,000-ton plant in Nigeria. The total annual cost here is about ₦45.07 million ($135 million). The next best alternative location, Idah, is about ₦6.37 million (14%) more expensive

TABLE 4.12

ESTIMATED TRANSPORT COSTS ON A TON OF FINISHED STEEL

(Cost in shillings)

	DESTINATION							
	LAGOS		PORT HARCOURT		IBADAN		KANO	
ORIGIN	Miles	Cost/ Ton	Miles	Cost/ Ton	Miles	Cost/ Ton	Miles	Cost/ Ton
ENUGU	151 (rail to P.H.)	58	151 (rail to P.H.)	58	859 (rail to Ibadan)	172	557 (rail to Kano)	133
	315 (water, P.H. to Lagos)	54	Terminal & handling	10	Terminal & handling	10	Terminal & handling	
	Terminal & handling	15						
LOKOJA	518 (water to Lagos)	75	360 (water to P.H.)	60	128 (water to Jebba)	30	74 (water to Baro)	22
	Terminal & handling	10	Terminal & handling	10	183 (rail, Jebba to Ibadan)	64	349 (rail, Bar. to Kano)	100
					Terminal & handling	15	Terminal & handling	15
ONITSHA OR ASABA	390 (water to Lagos)	62	232 (water to P.H.)	45	321 (road to Ibadan)	190	270 (water to Makurdi)	50
	Terminal & handling	10	Terminal & handling	15	Terminal & handling	15	420 (rail, Makurdi to Kano)	112
							Terminal & handling	15
LAGOS	12 (rail to Lagos)	26	315 (water to P.H.)	54	120 (rail to Ibadan)	46	700 (rail to Kano)	152
	Terminal & handling	10	Terminal & handling	10	Terminal & handling	10	Terminal & handling	10

Table 4.12 (Continued)

ORIGIN	DESTINATION							
	LAGOS		PORT HARCOURT		IBADAN		KANO	
	Miles	Cost/ Ton	Miles	Cost/ Ton	Miles	Cost/ Ton	Miles	Cost/ Ton
IDAH	470 (water to Lagos)	70	312 (water to P.H.)	53	180 (road to Ibadan)	135	200 (water to Makurdi)	40
	Terminal & handling	10	Terminal & handling	10	Terminal & handling	10	420 (rail, Makurdi to Kano)	112
							Terminal & handling	15
IKARE	320 (rail to Lagos)	54	100 (rail to Lokoja)	44	200 (rail to Ibadan)	68	780 (rail to Kano)	164
	Terminal & handling	10	360 (water, Loko Lokoja to P.H.)	60	Terminal & handling	10	Terminal & handling	10
			Terminal & handling	15				
PORT HARCOURT	315 (water to Lagos)	54	15 (rail to P.H.)	26	315 (water to Lagos)	54	708 (rail to Kano)	153
	Terminal & handling	10	Terminal & handling	10	120 (rail, Lagos to Ibadan)	46	Terminal & handling	10
					Terminal & handling	15		

Table 4.12 (Continued)

	DESTINATION							
	ENUGU		ZARIA		IJEBU-ODE		CALABAR	
ORIGIN	Miles	Cost/ Ton	Miles	Cost/ Ton	Miles	Cost/ Ton	Miles	Cost/ Ton
ENUGU	15 (rail to Enugu)	26	470 (rail to Zaria)	120	151 (rail to P.H.)	58	151 (rail to P.H.)	58
	Terminal & handling	10	Terminal & handling	10	315 (water, P.H. to Lagos)	54	315 (water, P.H. to Calabar)	35
					45 (road, Lagos to Ijebu-Ode)	66	Terminal & handling	15
					Terminal & handling	15		
LOKOJA	150 (water to Makurdi)	34	74 (water to Baro)	22	518 (water to Lagos)	75	523 (water to Calabar)	75
	137 (rail, Makurdi to Enugu)	55	262 (rail, Baro to Zaria)	83	45 (road, Lagos to Ijebu-Ode)	66	Terminal & handling	10
	Terminal & handling	15	Terminal & handling	15	Terminal & handling	15		
ONITSHA OR ASABA	70 (road to Enugu)	76	270 (water to Makurdi)	50	390 (water to Lagos)	62	395 (water to Calabar)	62
	Terminal & handling	10	333 (rail, Mak. to Zaria)	45	45 (road, Lagos to Ijebu-Ode)	66	Terminal & handling	10
			Terminal & handling	15	Terminal & handling	15		
LAGOS	315 (water to P.H.)	54	613 (rail to Zaria)	140	45 (road to Ijebu-Ode)	66	394 (water to Calabar)	63
	151 (rail, P.H. to Enugu)	58	Terminal & handling	10	Terminal & handling	10	Terminal & handling	10
	Terminal & handling	15						

Table 4.12 (Continued)

ORIGIN	DESTINATION							
	ENUGU		ZARIA		IJEBU-ODE		CALABAR	
	Miles	Cost/ Ton	Miles	Cost/ Ton	Miles	Cost/ Ton	Miles	Cost/ Ton
IDAH	62 (road to Enugu)	72	200 (water to Makurdi)	40	230 (road to Ijebu-Ode)	159	475 (water to Calabar)	71
	Terminal & handling	10	333 (rail, Mak. to Zaria)	92	Terminal & handling	10	Terminal & handling	10
			Terminal & handling	15				
IKARE	100 (rail to Lokoja)	44	693 (rail to Zaria)	152	200 (rail to Ibadan)	68	100 (rail to Lokoja)	44
	150 (water, Lokoja to Makurdi)	34	Terminal & handling	10	45 (road, Ibadan to Ijebu-Ode)	66	523 (water, Lokoja to Calabar)	75
	137 (rail, Makurdi to Enugu)	55			Terminal & handling	15	Terminal & handling	15
	Terminal & handling	20						
PORT HARCOURT	151 (rail to Enugu)	58	621 (rail to Zaria)	142	315 (water to Lagos)	54	163 (water to Calabar)	35
	Terminal & handling	10	Terminal & handling	10	45 (road, Lagos to Ijebu-Ode)	66	Terminal & handling	10
					Terminal & handling	15		

Table 4.12 (Continued)

	DESTINATION							
	PLATEAU		BENIN		WARRI		UMUAHIA	
ORIGIN	Miles	Cost/ Ton	Miles	Cost/ Ton	Miles	Cost/ Ton	Miles	Cost/ Ton
ENUGU	370 (rail to Jos)	104	115 (road to Benin)	122	151 (rail to P.H.)	58	50 (rail to Umuahia)	32
	Terminal & handling	10	Terminal & handling	10	269 (water, P.H. to Warri)	52	Terminal & handling	10
					Terminal & handling	15		
LOKOJA	150 (water to Makurdi)	34	150 (road to Benin)	120	330 (road to Warri)	56	170 (road to Umuahai)	130
	210 (rail, Makurdi to Jos)	72	Terminal & handling	10	Terminal & handling	10	Terminal & handling	10
	Terminal & handling	15						
ONITSHA OR ASABA	270 (water to Makurdi)	50	70 (road to Benin)	84	100 (water to Warri)	26	84 (road to Umuahia)	85
	210 (rail, Makurdi to Jos)	72	Terminal & handling	10	Terminal & handling	10	Terminal & handling	10
	Terminal & handling	15						
LAGOS	735 (rail to Jos)	156	325 (road to Lagos)	211	184 (water to Warri)	38	315 (water to P.H.)	54
	Terminal & handling	10	Terminal & handling	10	Terminal & handling	10	100 (rail, P.H. to Umuahia)	44
							Terminal & handling	15

Table 4.12 (Continued)

ORIGIN	DESTINATION							
	PLATEAU		BENIN		WARRI		UMUAHIA	
	Miles	Cost/ Ton	Miles	Cost/ Ton	Miles	Cost/ Ton	Miles	Cost/ Ton
IDAH	200 (water to Makurdi)	40	80 (road to Benin)	28	120 (water to Warri)	28	100 (road to Umuahia)	91
	210 (rail, Makurdi to Jos)	72	Terminal & handling	10	Terminal & handling	10	Terminal & handling	10
	Terminal & handling	15						
IKARE	815 (rail to Jos)	165	80 (road to Benin)	84	150 (road to Warri)	120	100 (rail to Lokoja)	44
	Terminal & handling	10	Terminal & handling	10	Terminal & handling	10	150 (water to Makurdi)	34
							218 (rail,Makurdi to Umuahia)	70
							Terminal & handling	20
PORT HARCOURT	521 (rail to Jos)	126	232 (water to Onitsha)	45	269 (water to Warri)	52	70 (rail to Umuahia)	50
	Terminal & handling	10	75 (road,Onitsha to Benin)	80	Terminal & handling	10	Terminal & handling	15
			Terminal & handling	15				

TABLE 4.13

ESTIMATED TRANSPORT COSTS ON A TON OF FINISHED STEEL
(costs in shillings)

Origin	Destination											
	Kano	Plateau	Zaria	Ibadan	Ijebu -Ode	Lagos	Benin	Delta	Calabar	Enugu	Port Harcourt	Umuahla
Lagos	162	166	150	56	76	36	216	48	73	127	64	113
Lokoja	137	121	120	109	156	85	125	66	85	104	70	140
Enugu	143	114	130	182	198	127	127	125	108	36	68	42
Port Harcourt	163	136	152	115	135	64	135	62	45	68	36	60
Onitsha	177	137	110	200	143	72	94	36	72	86	55	95
Idah	167	127	147	145	169	80	94	38	81	82	63	101
Ikare	174	175	162	78	149	103	94	130	134	153	119	168
Asaba	177	137	110	200	143	72	94	36	72	86	55	95

TABLE 4.14

ESTIMATED TRANSPORT COSTS OF MARKETS OF DIFFERENT SIZES
OF 800,000 TONS OF STEEL PER YEAR
(Millions of shillings)

	DESTINATION												
ORIGIN	Kano	Plateau	Zaria	Ibadan	Ijebu-Ode	Lagos	Benin	Delta	Calabar	Enugu	Port Harcourt	Umuahia	Grand Total
Lagos	0.980	33.379	3.506	0.455	0.857	12.000	2.363	3.513	0.593	2.659	2.445	1.283	64.069
Lokoja	0.829	23.330	2.805	0.885	1.758	32.901	1.368	4.830	0.690	2.207	2.675	1.590	76.868
Enugu	0.865	22.923	3.039	1.478	2.232	49.158	1.393	9.148	0.877	0.660	2.598	0.477	94.945
Port Harcourt	0.987	27.347	3.553	0.934	1.522	24.773	1.477	4.538	0.366	1.443	1.190	0.681	68.375
Onitsha	1.071	27.548	2.571	1.625	1.612	27.869	1.023	2.635	0.585	1.825	2.102	1.079	71.550
Idah	1.012	25.537	3.436	1.179	1.905	30.966	1.028	2.781	0.658	1.740	2.407	1.147	73.796
Ikare	1.053	35.189	3.786	0.634	1.680	39.868	1.023	9.514	1.088	3.246	4.547	1.908	103.541
Asaba	1.071	27.548	2.571	1.625	1.612	27.869	1.028	2.635	0.585	1.825	2.102	1.079	71.550

TABLE 4.15

ESTIMATED TOTAL TRANSPORT COSTS ON MOVING STEEL TO THE MARKETS FROM PLANTS OF DIFFERENT SIZES

(Million ₦)

a. One Integrated Steel Works

Location	Cost
Lagos	3.203
Lokoja	3.843
Enugu	4.750
Port Harcourt	4.419
Onitsha	3.558
Idah	3.690
Ikare	5.177
Asaba	3.558

b. Two-Plant Combinations

Case	Combinations	Cost
1	Lagos/Lokoja	2.787
2	Lagos/Enugu	3.113
3	Lagos/Port Harcourt	2.793
4	Lagos/Onitsha	2.792
5	Lagos/Idah	2.645
6	Lagos/Ikare	4.243
7	Lokoja/Enugu	3.840
8	Lokoja/Port Harcourt	3.411
9	Lokoja/Onitsha	3.566
10	Lokoja/Ikare	4.726
11	Enugu/Port Harcourt	4.217
12	Enugu/Idah	3.736
13	Enugu/Ikare	3.384
14	Port Harcourt/Onitsha	3.365
15	Port Harcourt/Idah	3.340
16	Port Harcourt/Ikare	4.139
17	Onitsha/Idah	3.616
18	Onitsha/Ikare	3.123
19	Asaba/Idah	3.616
20	Asaba/Ikare	3.123
21	Lagos/Asaba	2.792
22	Lokoja/Asaba	3.566
23	Port Harcourt/Asaba	3.365

Table 4.15 (Continued)

c. Three-Plant Combinations

Case	Combinations	Cost
24	Lagos/Port Harcourt/Onitsha	3.013
25	Lokoja/Onitsha/Asaba	3.851
26	Lokoja/Enugu/Lagos	3.133
27	Lokoja/Port Harcourt/Lagos	3.004
28	Lagos/Port Harcourt/Asaba	3.013
29	Enugu/Idah/Ikare	3.706
30	Lokoja/Enugu/Onitsha	3.841
31	Onitsha/Enugu/Idah	3.754
32	Lokoja/Enugu/Asaba	3.841
33	Asaba/Enugu/Idah	3.740
34	Idah/Asaba/Onitsha	3.533
35	Lokoja/Onitsha/Ikare	4.188

TABLE 4.16

ESTIMATED ANNUAL OVERALL COSTS: ONE INTEGRATED 800,000-TON PLANT

(Costs in ₦ Million)

Location	V_i	T_{ci}	A_i	Total Costs $V_i+T_{ci}+A_i$	Rank (1 = Optimum)
Lagos	44.07	18.84	3.20	65.93	8
Lokoja	41.26	6.04	3.84	51.14	1
Enugu	46.26	8.12	4.75	59.13	6
Port Harcourt	42.31	15.00	4.42	61.73	7
Onitsha	41.68	8.24	3.56	53.48	3
Idah	41.52	6.36	3.69	51.57	2
Ikare	44.43	9.36	5.18	58.97	5
Asaba	41.68	9.24	3.56	54.48	4

and Nigeria's largest steel market, Lagos, is about ₦19.44 million (43.13%) more expensive than the optimum location. Lagos also is the most expensive location.

2. Two Integrated 400,000-ton Steel Works

The second strategy assumes establishing two 400,000-ton plants at two different locations in different states. Table 4.7, which has been compiled, again using Tables 4.6, 4.11, and 4.15, shows the estimated total costs for various combinations of two small integrated plants. The least cost combinations, Case #9 (Table 4.17) is Lokoja and Onitsha with an estimated total annual cost of about ₦63.35 million ($192.0 million). Again, both Lokoja and Onitsha are essentially material sites. The highest cost combination is Lagos/Ikare, which is ₦12.05 million (19.02%) more expensive than the Lokoja/Enugu combination.

3. Three Integrated 267,000-ton Steel Works

Given the third strategy of establishing three 267,000-ton plants, each at different states, the total costs in combinations of three locations have been estimated, again using the information contained in Tables 4.6, 4.11, and 4.15. The least-cost combination is Idah/Asaba/Onitsha (Case #34, Table 4.18) with an estimated total annual cost of about ₦70.73 million ($210.0 million). This combination are all largely

TABLE 4.17

ESTIMATED ANNUAL OVERALL COSTS: TWO 400,000-TON PLANT COMBINATIONS

(Costs in ₦ Million)

Case No.	Combinations	V_i	TC_i	A_i	Total Cost	Rank (1=Optimum)
1	Lagos/Lokoja	53.65	12.44	2.79	68.88	13
2	Lagos/Enugu	56.33	13.48	3.11	72.92	21
3	Lagos/Port-Harcourt	54.45	16.92	2.79	74.16	22
4	Lagos/Onitsha	54.13	13.54	2.79	70.46	18
5	Lagos/Idah	54.05	12.60	2.65	69.30	16
6	Lagos/Ikare	57.06	14.10	4.24	75.40	23
7	Lokoja/Enugu	54.94	7.08	3.84	65.86	5
8	Lokoja/Port-Harcourt	53.06	10.07	3.41	66.54	7
9	Lokoja/Onitsha	52.74	7.04	3.57	63.35	1
10	Lokoja/Ikare	55.63	7.70	4.73	68.06	8
11	Enugu/Port-Harcourt	53.74	11.10	4.22	69.06	15
12	Enugu/Idah	55.34	7.24	3.74	66.32	6
13	Enugu/Ikare	56.82	8.74	3.38	68.94	14
14	Port-Harcourt/Onitsha	52.54	11.62	3.37	68.53	12
15	Port-Harcourt/Idah	53.46	11.68	3.34	68.48	11
16	Port-Harcourt/Ikare	56.47	12.18	4.14	72.79	20
17	Onitsha/Idah	53.14	7.3	3.62	64.06	3
18	Onitsha/Ikare	56.15	8.8	3.12	68.07	9
19	Asaba/Idah	53.14	7.8	3.62	64.56	4
20	Asaba/Ikare	56.15	9.03	3.12	68.30	10
21	Lagos/Asaba	54.13	14.04	2.79	70.96	19
22	Lokoja/Asaba	52.74	7.64	3.57	63.95	2
23	Port-Harcourt/Asaba	53.54	12.42	3.37	69.33	17

TABLE 4.18

ESTIMATED ANNUAL OVERALL COSTS: THREE 267,000-TON PLANT COMBINATIONS

(Costs in £ Million)

Case No.	Combinations	V_i	TC_i	A_i	Total Costs	Rank (1=Optimum
24	Lagos/Port-Harcourt/ Onitsha	60.34	13.88	3.01	77.23	11
25	Lokoja/Onitsha/Asaba	59.20	7.84	3.85	70.89	7
26	Lokoja/Enugu/Lagos	61.69	10.75	3.13	75.57	9
27	Lokoja/Port-Harcourt/ Lagos	60.23	13.15	3.00	76.38	10
28	Lagos/Port-Harcourt/ Asaba	60.34	14.22	3.01	77.57	12
29	Enugu/Idah/Ikare	61.87	7.95	3.71	73.53	8
30	Lokoja/Enugu/Onitsha	60.87	5.46	3.84	70.17	6
31	Onitsha/Enugu/Idah	60.92	7.58	3.75	72.25	3
32	Lokoja/Enugu/Asaba	60.87	7.80	3.84	72.51	4
33	Asaba/Enugu/Idah	60.92	7.91	3.74	72.57	5
34	Idah/Asaba/Onisha	59.25	7.95	3.53	70.73	1
35	Lokoja/Onitsha/Ikare	60.15	7.88	4.19	72.22	2

material sites. The next best combination, Lokoja/ Onitsha/Ikare, is also essentially material and about ₦1.49 million (2.11 per cent) more expensive. The highest combination is Lagos/Port Harcourt/Asaba, which is about ₦9.5 million (9.67 per cent) more expensive.

10. Summary

Figure 4.3 is a graphical interpretation of the results of the present chapter. It shows the various location factors in the proposed integrated steel works in Nigeria. After cost comparison at alternative locations, Lokoja was established as the optimum location for one 800,000-ton plant, Lokoja and Enugu were established as the optimum locations for two 400,000-ton plants, and Idah, Asaba and Onitsha were established as the optimum locations for three 267,000-ton plants.

Also, for the disucssion of various costs in the proposed steel works by location and strategy, it was demonstrated that breaking down the products of one integrated works between two or three locations means increasing expenses for Nigeria on the steel industry. Whereas a national integrated works at the optimum location, by the analysis of this present paper, would cost an estimated sum of about ₦51 million per annum, that cost would increase by well over ₦46 million (nearly 24 per cent) when two small integrated works replace

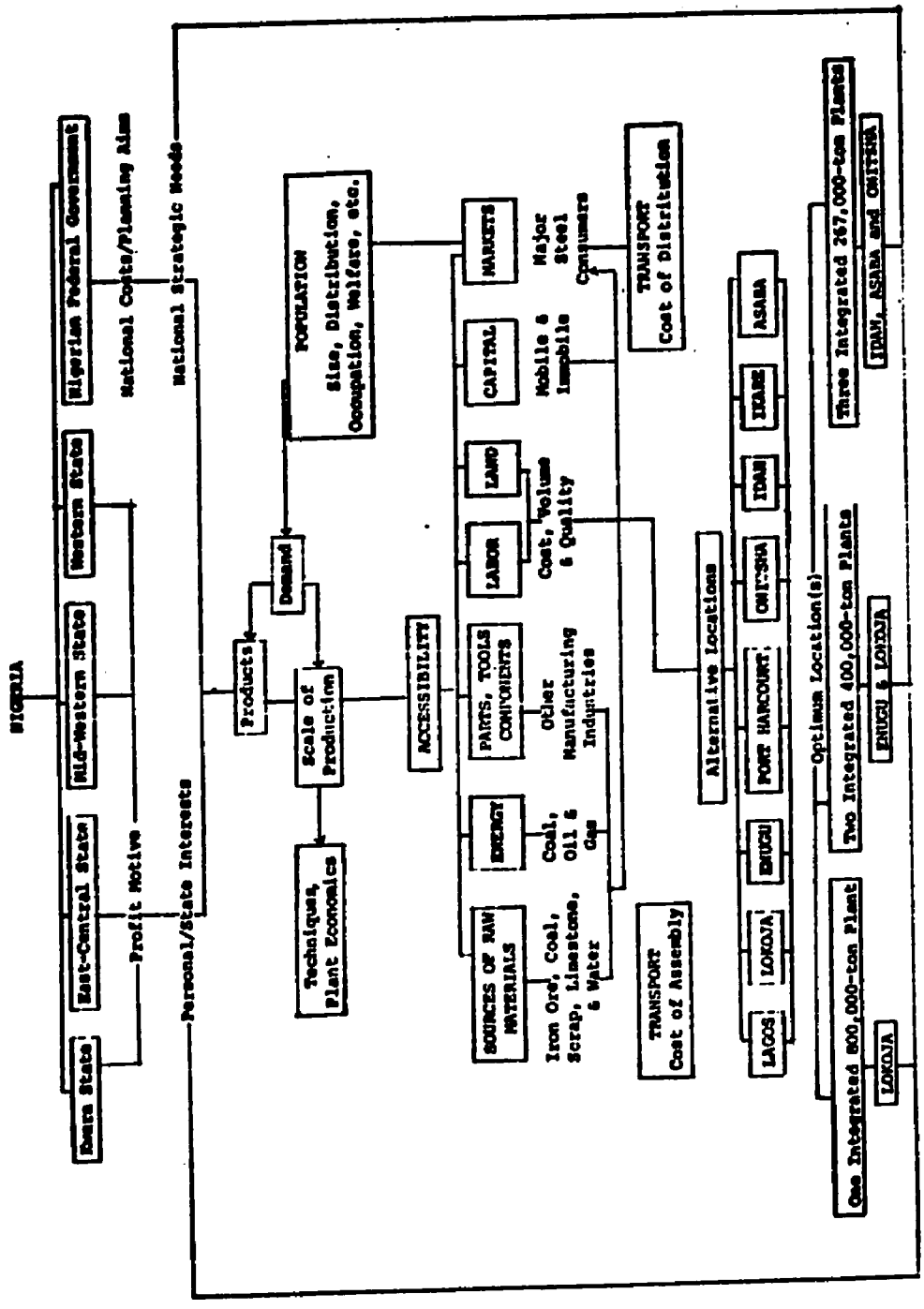


Figure 4.3--A model of the important factors in the location of the proposed integrated steel works in Nigeria.

Patterned after Hamilton, F.E.I. "Models of Industrial Location" in R. C. Chorley and P. Haggett, eds., Models in Geography, London, 1967, PP. 361-424, especially P. 365.

one. Still more, should three small integrated plants be established in place of one, annual costs would increase by an estimated sum of approximately ₦20 million (about 38 per cent).

Given the above facts, should Nigeria still decide to open more than one integrated plant will examplify how politics can bring about investment strategies that otherwise would have been eccentric to undertake from purely the economic point of view. This will be more so should the plant or plants be located in places which are not optimum under the various strategies examined in the present paper.

Footnotes

[1]United Nations, "Memorandum on the Establishment of an Iron and Steel Plant in Liberia" (unpublished monograph, 1965), p. 14.

[2]International Monetary Fund, International Financial Statistics, Vol. XXVII, No. 3 (New York: United Nations, March, 1974), pp. 272-73, 372-73.

[3]Werner Baer, The Development of the Brazilian Steel Industry (Nashville, Tenn.: Vanderbilt University Press, 1969), p. 114.

[4]Ibid., p. 114.

[5]See Chapter III of this present paper.

[6]Of course, this assumes about 70-75 per cent magnetite and hermatite.

[7]Gerald Manners, The Changing World Market for Iron Ore, 1950-1980 (Baltimore: Johns Hopkins Press, 1971), p. 35.

[8]This estimate assumes that Nigeria purchases the scrap from Western Europe and there, scrap price per ton is about $31.00 (see Kiyoshi Kawahito, The Japanese Steel Industry (New York: Praeger, 1972), p. 89). Transporting the scrap to Nigeria will cost an additional $13.00 per ton (Kawahito, op.cit., p. 89, points out that transporting a ton of scrap from the United States (Seattle) to Japan (Tokyo), a distance of about 5,000 miles, costs about $13.00. Since Western Europe (London) to Nigeria (Lagos) is about 4,500 miles, transporting a ton of scrap from the former to the latter is assumed also to be about $13.00). Thus, a ton of scrap delivered to Nigeria is assumed to cost about $43.00 per ton.

[9]Paul Craig, "Location Factors in the Development of Steel Centers," Papers and Proceedings of the Regional Science Association, Vol. III (1957), pp. 256-59.

[10]Gerald Manners, op.cit., p. 14.

[11]Nigeria, Energy in Nigeria and Attendant Opportunity for Industrial Development (Lagos: Nigerian National Press, 1963), p. 92.

[12]Gerald Manners, op.cit., p. 264.

[13]Organization for Economic Cooperation and Development (OECD), The Iron and Steel Industry in 1970 and Trends in 1971 (Paris, 1971), pp. 66-67; Hindustan Steel Limited, Statistics for Iron and Steel Industry in India (Ranchi, India, 1970), pp. 4, 142.

[14]OECD, op.cit., pp. 66-67.

[15]Werner Baer, The Development of the Brazilian Steel Industry (Nashville, Tenn.: Vanderbilt University Press, 1969), p. 103.

[16]Ibid., p. 104.

[17]Nigeria, Digest of Statistics, Vol. 22, No. 2 (Lagos: Nigerian National Press, April 1973), p. 19.

[18]"Kainji Dam Opened in Nigeria," External Affairs Vol. XXI (Ottawa: Queen's Printer, April 1969), pp. 170-72.

[19]Nigeria, Annual Report and Accounts, Niger Dams Authority (Lagos: Nigerian National Press, March 31, 1970), p. 32; (March 1964), p. 10; (March 1965), p. 11; (March 1966), p. 13.

[20]Carl Liedholm, The Indian Iron and Steel Industry, An Analysis of Comparative Advantage (East Lansing: Michigan State University, 1972), p. 119.

[21]Ibid., p. 83.

[22]United Nations, The Iron and Steel Industry in Africa (Economic Commission for Africa and Center for Industrial Development, Symposium on Industrial Development in Africa, Cairo, 27 January-10 February 1966), unpublished monograph, p. 6.

[23]Ibid., p. 119.

[24]Ibid., p. 90.

[25]Nigerian Railway Corporation, Railway Passenger and Goods Services, Tariff No. 7 (Lagos: Nigerian National Press, 1970), pp. 118, 127-28, 130.

[26]Ibid., pp. 93, 100, 102-103.

CHAPTER V

SCALE ECONOMIES AND DOMESTIC STEEL PRICES

The results of the present study help to emphasize scale economies as plant capacities are increased and vice-versa. For example, at its optimum location, the estimated total annual overall costs of one integrated works is about ₤51.14 million or ₤63.93 per ton of delivered finished steel. On the other hand, total costs in two 400,000-ton plants amount to about ₤63.35 million, i.e., an average delivered cost of ₤79.19 per ton of steel. When three 267,000-ton plants are located, total costs rise still further to ₤70.73 million or ₤88.41 per ton of delivered finished steel. This also means that the larger the plant, the cheaper the steel in the market and vice-versa.

Apart from knowing the average delivered price of steel, it is worthwhile knowing the factory prices of steel in the domestic plants and to compare these prices with the average c.i.f. import price of steel. This will help to reveal whether or not a domestic plant or plants can offer steel to domestic consumers than foreign suppliers can. Again, in this observation, only the prices at the optimally located one, two and three plants are considered.

The factory price of steel would be determined by the amount of value added in production, i.e., by $V_i + TC_i$ as estimated earlier in this present study. (It will not include A_i, i.e., the cost of transporting finished steel from the domestic plants to the markets just as the average c.i.f. import price of steel does not.)

The estimated factory price of steel ($V_i + TC_i$) at the optimally located 800,000-ton plant (Lokoja) is about ₦47.30 million for both plants or ₦59.13 per ton of finished steel. The estimated factory price of steel at the two best located 400,000-ton plants (Lokoja and Enugu) is about ₦59.78 million for both plants or ₦74.73 per ton of finished steel. Finally, the estimated factory price of steel at the three best located 267,000-ton plants (Lokoja, Enugu and Onitsha) is about ₦67.2 million for the three plants or about ₦84 per ton of finished steel. If the various estimated factory prices per ton are lower than the average c.i.f. import price of steel, then the domestic consumers would benefit from the cheaper steel prices. If not, then the Nigerian government must have to impose protective barriers on foreign steel and either subsidize the plants or pass the burden of higher steel prices to the consumers.

The estimated average c.i.f. import price of steel in Nigeria is about ₦48 per ton.[1] This implies that foreign steel would be cheaper in Nigeria than domestic steel would. In fact, this means that the one-plant

strategy at best would be about ₦11 per ton more expensive, that the two-small-plant strategy at best would be about ₦27 per ton more costly and that the three-small-plant strategy at best would be about ₦36 per ton more expensive for domestic steel users than imported steel would. Thus, to be competitive at home with foreign suppliers, Nigeria would have to pay about ₦8.8 million subsidy to the one single plant, about ₦21.6 million in subsidy to the two small plants, and about ₦28.8 million subsidizing the three small plants. An alternative to paying the estimated subsidies lie in imposing tariff against foreign steel thereby forcing domestic steel users to buy domestic steel. Neither approach is healthy to domestic tax payers, and steel consumers and reactions from these people against the government can have serious repercussions against national development as a whole.

Of course one can argue that by increasing the capacity of the single optimally located plant it is possible to gain scale economies and reduce production cost per ton of steel below ₦59 per ton or below the estimated average c.i.f. import price, ₦48 per ton, sell any excess above domestic demand overseas and take advantage of the current world energy crisis which one might hope would cause steel prices and production costs to rise higher in the advanced western steel-producing countries than it would in the present oil-rich Nigeria. This sort of planning strategy has to be better calculated, however.

First, much depends on how much transportation costs would be involved to get to overseas markets. Second, what if the overseas producers agree to lower their selling prices, enlarge their plants' capacities, and produce at cheaper price and/or subsidize foreign consumers. Third, the plain type of steel which Nigeria is likely to produce at the initial learning stage may not attract overseas consumers who might prefer steel of higher quality. Finally, what if for political reasons, as some West African countries may probably do, overseas buyers impose tariffs against Nigerian steel and/or open their own plants? In fact, a number of West African countries are making plans to establish and protect their own mills;[2] yet, in realistic terms, these are Nigeria's main potential overseas markets.

In Figure 5.1 is demonstrated the possible consequences of excess steel production in Nigeria under the various uncertainties discussed above. The shape of the planning curve AB was established by establishing production cost per ton of steel at various steel capacities. Costs are already established in the present paper to be about ₤59 per ton, ₤75 per ton, and ₤84 per ton in an 800,000-ton, 400,000-ton, and 267,000-ton plants respectively. Costs per ton given an annual capacity of 100,000 tons and 1.5 million tons were estimated respectively in two steps. First, since much about scale economies and diseconomies in Latin America plants have so far been

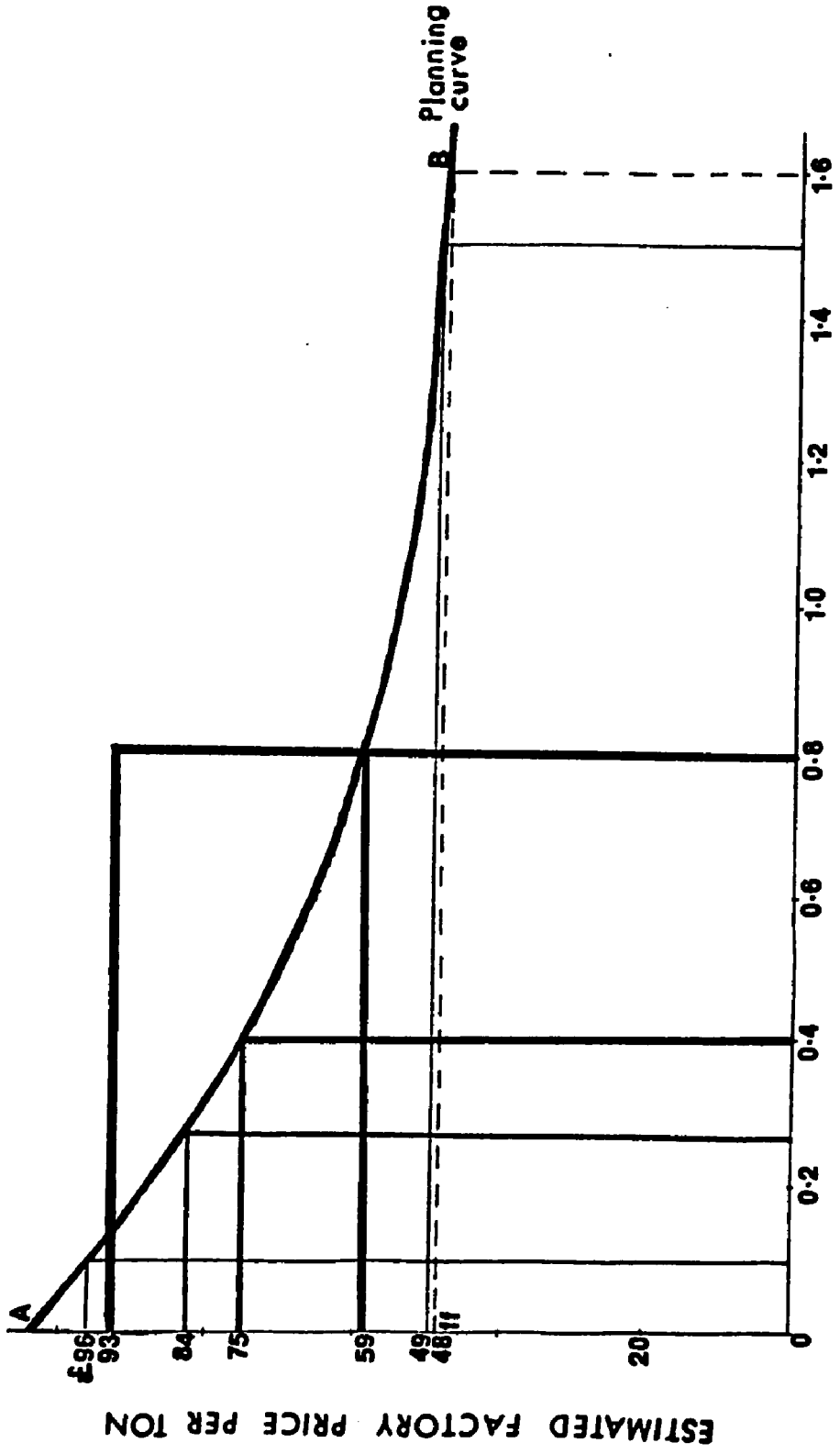


Figure 5.1--Nigeria: Comparison Between Estimated Average c.i.f. Import Price per Ton of Steel and Estimated Factory Price per Ton of Steel in Plants of Different Annual Capacities. (ff = £48 = estimated average c.i.f. import price per ton of steel.)

assumed applicable to Nigeria, the Latin American ratios are used at this stage again. Studies in Latin America showed that by increasing the annual capacity of steel plants from 800,000 tons to 1.5 million tons, 17 per cent was gained in scale economies, and that by decreasing annual capacity of steel plants from 267,000 tons to 100,000 tons, about 14 per cent was lost in scale diseconomies.[3] Thus, given the fact that the estimated production costs in a 800,000-ton plant in Nigeria was ₤59 per ton, production costs in a 1.5 million ton plant would be about ₤49 per ton. Also, given that costs in a 267,000-ton plant in Nigeria was ₤84 per ton, costs in a 100,000 ton plant would be about ₤96 per ton.

Since the estimated average c.i.f. import price of steel in Nigeria is about ₤48, and since factory price per ton in an 800,000-ton plant at the optimum location is about ₤59 per ton, which would require that domestic steel users pay a higher price per ton of steel, one could argue for establishing a larger plant which could produce steel at costs lower than the estimated average c.i.f. import price, i.e., ₤48. One could argue, for example, that by producing 1.5 million tons per annum (800,000 tons for domestic market and 700,000 tons for overseas markets), factory price would fall to roughly ₤49 per ton (Fig. 5.1). If we assume that steel is sold at factory prices, an 800,000-ton plant at ₤59 per ton would earn about ₤47.3 million per year whereas a 1.5 million ton plant

at ₦49 per ton would earn about ₦74 million per year, which implies an additional ₦27 million in government revenue. This situation would be quite favorable both to domestic steel users who would pay less per ton of steel and to the Nigerian government who would earn an additional ₦27 million per year in steel revenue. It is important to look at the other side of the argument, however.

Suppose the Nigerian domestic plant produces about 1.5 million per year at ₦49 per per ton and due to such political rivalries and economic uncertainties refered to earlier, the excess 700,000 tons per year above domestic demand could not find overseas markets. This means that to break even, i.e., for total revenues to meet total cost per ton, the Nigerian steel users consuming only 800,000 tons per year must be made to pay about ₦93 per ton of steel, which is about ₦45 per ton above the average c.i.f. import price of steel. This situation would be uncomfortable to domestic steel users whose violent reactions such as steel boycott would have serious repercussions on nation socioeconomic development as a whole. It is for this sort of reason that the author of the present paper has stood on a firm ground that a country such as Nigeria, whose overseas steel market is on serious shaky grounds, should experiment with producing steel for domestic users at the initial stage of the industry and expand annual capacity at a later

date subject to improvement in the iron and steel politics, particularly in West Africa.

Ideally, the best policy would be to produce only 800,000 tons for the domestic market and to subsidize the steel mills about ₤11 per ton (i.e., ₤8.8 million per plant) so that the mill could sell steel to domestic consumers at world price of ₤48 per ton. This will have the advantage for boosting rather than retain the growth of steel-using industries in Nigeria.

Footnotes

[1]By dividing total value of imported steel in 1969 (about ₤20 million) by total quantity of imported steel in 1969 (about 420 thousand tons), an estimated c.i.f. import price of ₤48 per ton was obtained. Data on both quantity and value of steel in 1969 was obtained from: United Nations, Yearbook of International Trade Statistics, 1973 (New York: United Nations, 1970), p. 631.

[2]United Nations, "Request for United Nations Development Programme Assistance to the Republic of Liberia for Economic Evaluation of an Integrated Steel Plant in Liberia," unpublished mimeograph, 1965; Gerald Manners, The Changing World Market for Iron Ore 1950-1980, An Economic Geography (Baltimore: Johns Hopkins Press, 1979), pp. 89-90; United Nations, World Trade in Steel and Steel Demand in Developing Countries (New York: United Nations, 1968), p. 155 concerning Central African Republic, p. 156.

[3]Werner Baer, The Development of the Brazilian Steel Industry (Nashville, Tenn.: Vanderbilt Press, 1969), p. 114.

CHAPTER VI

CONCLUSIONS

The main significance of this study lies in a number of conclusions that may be drawn for both national and international interests. First, the decision of Nigeria to establish an integrated steel complex at some location represents her genuine desire to progress with industrialization for the benefit of all of its citizens. On the other hand, the political propaganda campaigns and insistence by both Kwara State on the one hand and East-Central State on the other, that the proposed steel complex should be located in their states, represent a certain narrowness of view on the part of local political figures who are more concerned with local politics and state interests than they are concerned with the interest of the country as a whole.

Second, the political rivalry over the location of the proposed steel complex represents a continuation of political struggle over the location of economic activities in Nigeria. Hance has observed how greatly "the very substantial regional authority in Nigeria has resulted in a greater dispersion of industry than would otherwise have occurred,"[1] and he was loud to condemn

such degree of "regional me-tooism"[2] as detrimental to rapid national advancement. It is not unusual for Nigerian politicians, in order to establish their reputations among their political supporters, to press strongly for the location of projects with socioeconomic opportunities in their own areas or States, i.e., where their friends and kin would benefit directly either in terms of employment or in terms of services,[3] no matter what the economic viability of the project might be in that location. The catastrophic implications of such actions as are described above in terms of national progress led Onyemulkwe to caution Nigerian decision makers that:

> The undue influence which politicians sometimes sought in matters of appointments, recruitments and promotion even in private industry was not a help to efficiency and morale. The pressures that were sometimes used to force unprofitable investments, the idea that everything should come to "my" region, irrespective of its total effect on the Nigerian economy, were ills which harassed the practice of professional industrial management. In the publicly-owned industrial establishments, managers have sometimes had to keep looking behind their backs in order to reconcile the various extraneous political issues, sometimes at the cost of what they know is right.[4]

Indeed, Onyemulwe's conclusions parallel Lebefer's observations concerning the act of forcing investments into particular areas for purely political reasons. Lebefer warned that:

> Balanced regional growth is the dream of politicians. Unfortunately the conditions under which equiproportional regional growth can also be efficient for any and all political regions are limited to constant return to scale in all activities, as

> well as a suitable distribution of resources in all regions. Forcing investment into economically inefficient areas may result in equiproportional growth, but only at the expense of diminishing the rate of national growth. The level of employment may be increased in the regarded regions, but as a consequence, the rate at which national unemployment is absorbed must also decrease.[5]

Lebefer's remark indicates that although many politicians are usually after "equal" distribution of socioeconomic opportunities among the various politicial divisions in a country, this venture is not often as benefitial to the entire nation as it would otherwise have been if an optimal location has been sought at the outset.

Really, it was demonstrated in the present study that the products of the one economically best located plants are more expensive for domestic consumers than imported steel. Also, the fact that a two-plant strategy would increase cost by about 24 per cent and a three-plant strategy by about 38 per cent means that steel from these plants would be much more expensive. This means that unless a tariff is imposed against foreign steel to protect domestic plant or plants, domestic consumers are likely to boycott domestic steel. A possible boycott of steel altogether of a shift of emphasis to less steel-consuming industries in response to a protective policy and consequent higher steel prices, means a possible gradual decline in national industrial and economic development as a whole. To avoid such a situation, the best policy would be to subsidize the steel mills so that they would sell at

world prices and therefore not restrain the growth of steel-using industries in Nigeria. However, Nigeria cannot afford the "luxury" of establishing and protecting small integrated plants and passing the price to consumers and tax payers. It is obviously much more economic to have one large plant than two or three small ones.

The final remark upon this study concerns its implications for further work. It is not impossible for some of the assumptions of the present study regarding technology, labor productivity, growth in domestic steel consumption, international pricing policies and trade relationships, and the current world energy crisis to cause some difficulties if they do not hold for the future. For this reason, the changing steel technologies and the changing steel prices in the advanced steel-producing countries should be carefully watched. Also, market demands for steel in Nigeria and international trade relationship between Nigeria and other West African countries must need a constant review. A possible enlarged market at home, an improved relation with the West African neighbors, and a continued energy crisis in the West may give oil-rich Nigeria advantage in steel production some day.

Footnotes

[1]William A. Hance, The Geography of Modern Africa (New York: 1964), p. 261.

[2]Ibid.

[3]C. C. Onyemulkwe, Problems of Industrial Planning and Management in Nigeria (New York: Longmans, Columbia University Press, 1968), p. 205.

[4]Ibid., p. 205.

[5]L. Lebefer, "Economic Development and Regional Growth," in Transport Investment and Economic Development, C. Fromm (ed.), (Washington, D.C.: Brookings Institution, 1955), pp. 108-22. It should be noted that Lebefer's expression does not apply only to capitalistic economies; it applies to socialist economies also since in all places, resources are limited and every nation must seek, through its own means to maximize the return to its scarce resources. This is often fulfilled through competition in capitalist and through planning in socialist countries.

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