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Moscow, USSR, 19 September – 9 October 1968

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STEEL PLANT LOCATION IN DEVELOPING ECONOMIES: A CANADIAN VIEWPOINT [1]

by

R.B. Elver, G.E. Wittur and W.K. Buck,
Canada

1/ The views and opinions expressed in this paper are those of the authors and do not necessarily reflect the views of the secretariat of UNIDO. The document is presented as submitted by the authors, without re-editing.

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SUMMARY

The Canadian iron and steel industry was established and has grown under conditions similar to those in many other developing countries. Two papers[2/], prepared for previous United Nations conferences on iron and steel in 1963, reviewed respectively locational factors in and development of the Canadian iron and steel industry. It is hoped that Canadian experience as reviewed in the two previous papers and in this paper will be of assistance to economic planners in other countries.

In this paper we have approached the problem of steel plant location in the context of the overall national economy. In addition to specific location considerations such as raw material supply, process selection, transportation, and markets, we have

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* This is a summary of a paper issued under the same title as ID/WG.14/51.

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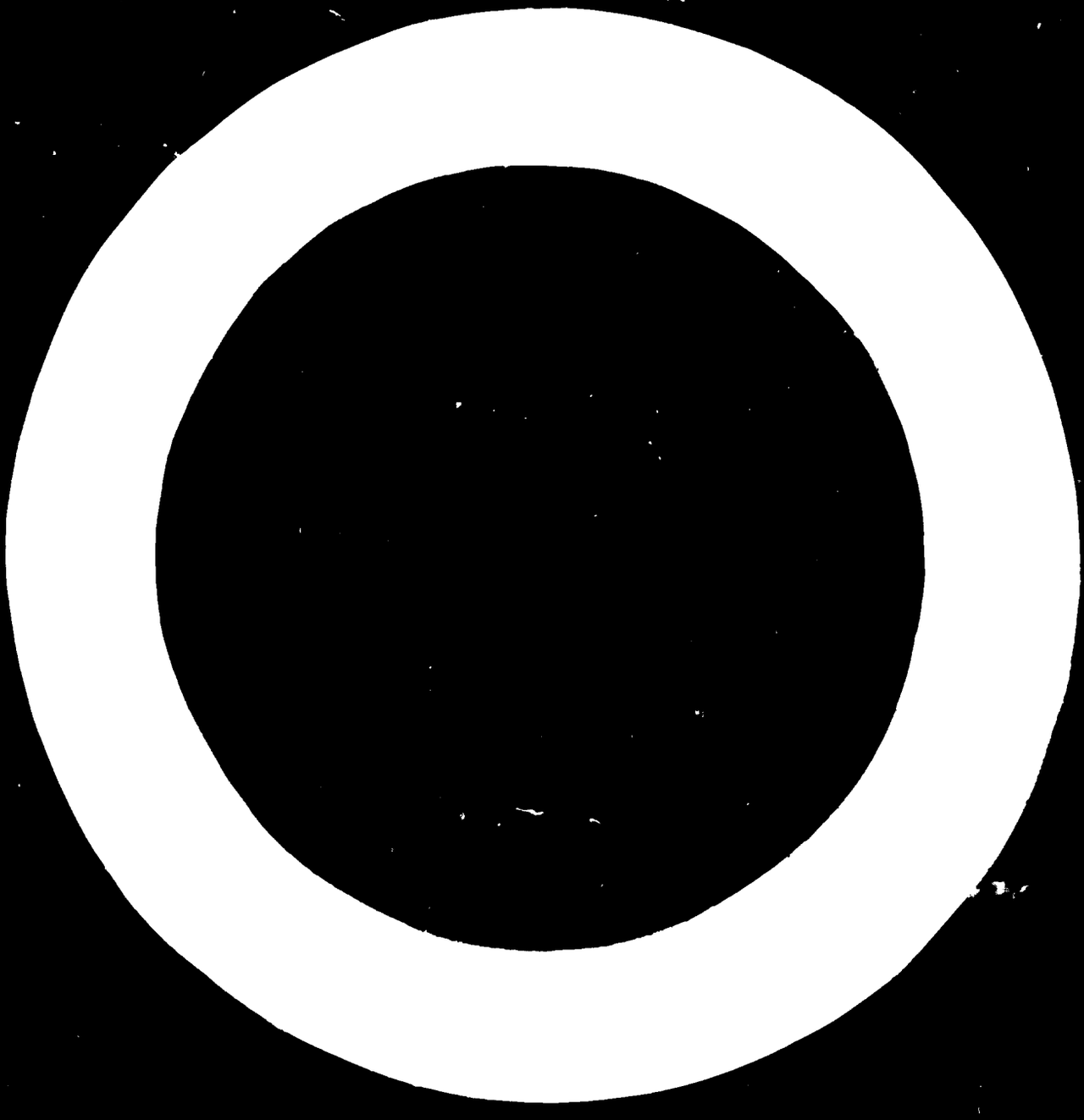
2/ Technical and Economic Factors in the Choice of Steel Plant Location, by R.B. Elver, T.H. Janes and J.H. Walsh, prepared for the United Nations Conference on the Application of Science and Technology for the Benefit of Less Developed Areas, Geneva, Switzerland, February 1963; and The Canadian Steel Industry - A Pattern of Growth, by W. Keith Buck and R.B. Elver, prepared for the United Nations Interregional Symposium on the Application of Modern Technical Practices in the Iron and Steel Industry in Developing Countries, Prague and Geneva, November 1963.



considered the scope of economic planning and the impact of investment on the economy as these factors affect the economic feasibility of a proposed steel project. The character of Canadian economic development, and the relationship of the primary steel industry to economic development, are also discussed to illustrate certain principles considered to be generally applicable to developing economies.

Part I points out that the price-market mechanism in a national economy is not likely to be sufficient, by itself, to allocate capital to fully meet national economic objectives. A measure of government economic planning is therefore necessary, especially in developing economies where the price mechanism and related institutions are not well established. Of course, government efforts should not neglect encouragement to improve the price-market mechanism.

The objectives of economic planning, and the many sources of conflict to be resolves in establishing an economic plan are mentioned. The need for assessing a steel plant proposal with reference to integrated national development and to alternative investments is emphasized. Furthermore, a plant's economic feasibility is shown to be influenced by the success of national economic management over time. For example, as the development process proceeds, balance-of-payments problems and differential rates of inflation can adversely affect the competitive position of a new steel plant. Therefore, a feasibility-location study in a single sector such as steel should be part of a much broader national economic planning effort.

In Part II of our paper, we have reviewed the specific factors that are considered in the selection of steel plant location. Emphasis is placed on the overriding importance of markets as a location determinant instead of raw materials. In a historical summary, we have shown how the importance of market location has evolved.

In our approach to specific location factors, we have begun by considering an ideal set of circumstances under which a steel plant could be built. Although these will unfortunately never exist in reality, real conditions can then be compared with the ideal to determine the extent of departures and to estimate the extra costs that will result. Departures from the ideal illustrate the degree of major sources of risk and uncertainties so that costs can be minimized while return on investment is maximized.

Because transportation costs and competition are of such vital importance in the steel industry, we have used the concept of "economic distance" in our consideration of ideal conditions. Economic distance includes not only transportation and handling costs of raw materials and finished products, but also such variables as tariffs and other trade restrictions, export incentives of potential competing countries, relative foreign exchange rates and tax structures. These factors and others determine the cost of producing steel within a country compared with the prices for which competitors can supply it. The relationship between market size and optimum plant size, along with other variables affecting comparative costs, must be considered in an integrated feasibility study to identify a market situation in which a plant can be located to operate profitably. Since adequate national development cannot tolerate excessive steel prices, some competition from the international market is desirable to maintain relative national competitiveness.

The combined feasibility and location study will indicate whether or not a specific steel plant is justified. A viable steel industry can be a distinct national asset in any country. However, if adequate returns to scarce capital resources are not assured and if there is little or no potential net gain to the national economy above that of alternative investments in other sectors, then the capital should be channeled into more profitable sectors. The existence of a steel plant provides no guarantee for accelerated economic growth; neither does the lack of a steel plant necessarily represent a block to economic progress.

Part III provides a somewhat theoretical description of the character of general economic development in Canada and of the development of its steel industry. Canadian economic growth can be described as a process of development around an export base, initially of primary products with a gradual trend to diversification and more domestic processing and manufacturing. As exports grew, other sectors were induced to further process primary products, to replace imports, and to provide goods and services to the economy in general. The supply of domestic capital, entrepreneurs and skilled labour also developed to permit continuing development at a satisfactory rate.

The Canadian steel industry, established initially around the turn of this century, is shown to have grown through the replacement of imports on the basis of competitive delivered prices. Domestic market and plant size relationships were

the key determinants as to whether specific plants were able to achieve an acceptable competitive position. Analysis of change in plant sizes, tariffs, foreign exchange rates and differential rates of inflation is made to demonstrate the character of the Canadian steel industry and, in turn, to illustrate certain principles that relate to the problem of steel plant location.

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INTRODUCTION

1. The purpose of this paper is to discuss a Canadian approach to the problem of steel plant(a) location, with particular reference to the establishment of a steel industry in developing countries. The importance of specific locational factors in the development of the Canadian iron and steel industry, which was established and has grown under conditions similar to those in many other developing countries, was reviewed in a previous paper (b).

2. Other symposium papers on this topic include contributions from the U.S.S.R. and the U.S.A. Other papers on the theme of prerequisites for steel industry development are concerned with such topics as general prerequisites, multi-national plants, non-integrated plants, manpower, and technical assistance. Some of these topics will at least be referred to in this paper.

(a) The iron and steel industry operates coke ovens, blast furnaces, steel furnaces, and rolling mills. Besides capital and labor, the main inputs are coal, iron ore, limestone, and scrap. The first three are obtained from mines. Scrap is generated within the steel plant, although large tonnages are often purchased from steel consumers and scrap dealers. Coal is used to make coke. Coke is combined with iron ore and limestone to make pig iron in the blast furnace. Molten pig iron, scrap, and fluxes are charged into steel furnaces. Crude steel in the form of ingots or castings is produced. Steel ingots are first rolled in breakdown mills to produce semis (i.e., blooms, billets, and slabs). Semis are further rolled on product mills such as for rails and heavier structurals, bars and light structurals, sheet and strip, and plate. Products from these hot-mills are sometimes rolled or drawn on cold-mills before shipment. In addition, some steel is coated to produce such items as tinplate, galvanized steel, and pre-painted steel. This simplified outline of the flow of materials indicates the many stages involved in steelmaking. Of importance here is that the main products sold by the steel industry are from the product-rolling mills. Coke, pig iron, and crude steel are not usually major products sold by the industry in comparison with the importance of rolled-steel products. Although some firms control steel fabrication plants, most rolled steel is sold on the open market in competition with other producers, imports, and substitutes.

(b) Elver, R.B., Janes, T.H., and Walsh, J.H., Technical and Economic Factors in the Choice of Steel Plant Location, prepared for the United Nations Conference on the Application of Science and Technology for the Benefit of Less Developed Areas, Geneva, February 4 to 20, 1963.

3. A discussion of steel plant location can be approached in several ways. Here, the authors' hypothetically place themselves in the position of government economic planners concerned with assessing whether or not a steel plant can be economically justified somewhere in the country. The country is assumed to be at some early stage of development. It is also assumed to be influenced by some degree of central economic planning.

4. There is ample literature available on the subject of steel plant location. However, it is usually scattered among partly isolated branches of learning (e.g. economics, commerce, and engineering). Even within these main branches, specific disciplines do not fully reflect the knowledge of others. Thus, economic planners should make every effort to incorporate all available theory and practical experience on this multi-disciplinary subject.

5. This paper does not offer discussion on all variables that may affect the economic viability of a potential steel plant, if only for the lack of space. From an economic planner's viewpoint, however, the notion of location is discussed from various viewpoints. One concerns economic planning and the place of a single sector such as steel in a country's overall development program. Another concerns assessment of the impact and implications of a steel plant on the economy. Finally, the factors affecting site location within the country need be considered. These three orientations are explicitly and implicitly found throughout the text.

6. Another orientation for the planner is to continually relate points raised in the paper to such fundamental questions as: what is the

effect on the demand curve faced by a potential plant? What is the effect on the supply or cost curve of the potential plant? What economic and social impact might there be on the overall economy? What effects may be expected over time?

PART I

IMPLICATIONS OF ECONOMIC PLANNING FOR SINGLE-SECTOR STUDIES

1) The Necessity of Economic Planning

7. Economic planning implies that government is involved in activities to influence the country's economy. When economic development in developing countries is discussed, a large measure of economic planning is implicit. Theoretically-defined, centrally-controlled economies at one extreme and pure-market economies at the other rarely exist among either the developed or developing nations regardless of ideology; most economies can be described as 'mixed' and classified somewhere between the two polar cases.

8. The fundamental economic objective of government on behalf of a population might be stated to be that of increasing national output to provide continuing employment and rising real income per capita within the constraint of limited resources. The objective might also be described as that of achieving an optimum rate of growth and development while minimising such problems as balance-of-payments deficits and excess inflation.

9. To obtain a significantly higher level of per-capita income, a higher level of per-capita investment is required, given that existing capital stock is being utilized efficiently. In general, the price-market mechanism is usually satisfactory for allocating most resources, production, and distribution in a nation's economy. However, this mechanism works less well in achieving monetary stability in regulating the amount and composition of investment. Without some government role, the price-market mechanism is less likely to lead to an optimum allocation of capital because: (1) private returns on capital, rather than social returns, are maximized with the result that some associated benefits to the economy may be missed (eg. multiple resource-use projects and infrastructure) and necessary complementary industry investments may not be made, (2) the risk to private investors is likely higher and pay-back periods are often shorter than for an overall government-backed development program, and (3) the amount of private capital invested may be insufficient in impact to provide a self-generating growth process. These points are particularly relevant to developing countries where the price mechanism and related institutions are rarely present to the degree found in developed countries. There is, then, a need for government economic planning but efforts to improve the market mechanism should not be excluded.

2) <u>The Nature of Economic Planning</u>

10. Economic planning is not an exact science. It involves: (1) the evaluation of natural, human and financial resource potentials and market opportunities, (2) the recognition of society's economic, social and political characteristics, (3) the formulation of national objectives and their translation into programs and actions, (4) the establishment of criteria for

choosing among alternatives in the light of limited resources and conflicting objectives, and (5) a management to coordinate and carry out the plan. The planner will be subject to various sources of conflict: long-run vs. short-run goals, regional vs. national goals, economic vs. social and physical objectives, individual vs. society's expectations, and private vs. public responsibility. Furthermore, the plan must be: (1) operative within the present and future institutional framework, (2) financially feasible, and (3) sufficiently flexible to accommodate changes in conditions.

11. A single sector study should ideally form part of a broader economic planning program so that other sectors and inter-sector relationships can be considered. This will permit cross-checking for consistency, and comparison with the return from potential investment in other sectors. A comparison can also be made between planned output on one hand and resource availability and effective demand on the other.

12. Moreover, overall economic planning or the lack of it can have other important implications for a single-sector plan such as steel. For example, consider balance-of-payments in the development process. When the rate of investment increases, some inflation occurs due primarily to a shortage of consumer goods and the inflexibility of agriculture. Inflation can become excessive if imports or additional consumer industries are not provided for because, as wages tend to rise with higher investment, the demand for consumer goods tends to increase at a faster rate than domestic output. In addition, agricultural productivity must rise in response to increased demand and because, it is hoped, there are relatively fewer farmers as some move to other sectors. As national output rises, imports will tend to rise even faster because of the need for more consumer goods just mentioned and for capital goods. Thus, there is a need for accelerated growth in exports to maintain a healthy balance-of-payments position. If trade deficits increase because of higher imports and

stronger internal demand, then depreciation of currency may follow. This could be beneficial for increasing the volume of exports but, depending on external demand conditions, the value of exports may or may not increase. Also, the price of necessary capital imports would rise and adversely effect the economy's international competitive position. This problem is more complex than indicated here and conclusions on net effects relate to specific cases. However, it will be apparent that, for planners concerned with the steel sector, these related aggregate trends are important for assessing future costs, prices, markets, and competition.

13. The foregoing illustrates the importance of encouraging exports. In developing countries, exports are likely to consist of primary products. From an expanding export base, economic development can spread back into the economy in several ways: (1) exports may be further processed before export, (2) more consumer goods may be produced domestically, and (3) more capital and intermediate goods may be produced domestically to supply the export industries and the consumer goods industries. Given a potential comparative advantage, production to replace imports may be largely restricted if the domestic market is insufficiently large to justify the minimum size of an efficient plant. Export expansion and diversification is important both for balance-of-payments reasons and to create a broader domestic market for domestic manufactures. A planner concerned with steel is faced with less uncertainty if these issues are actively and correctly pursued.

PART II

FACTORS AFFECTING THE SELECTION OF STEEL PLANT LOCATION

1) Introduction

14. Determination of site location is one of the most important decisions affecting the future economic success of a steel plant. A large number of factors must be considered. However, the relative importance of each factor has changed throughout the history of steelmaking and future changes should be anticipated. In general, the most important change has been from resource-based to market-based plants. Before discussing location variables separately, a brief review of some historical trends is warranted because both economic and technological development are interrelated evolutionary processes. The past often provides some insight into the future.

2) Historical Trends in Locational Factors

15. The historical use of iron dates back at least 5,000 years. The earliest source of metallic iron was undoubtedly meteorites since natural occurrences of native iron are almost unknown. Iron ore, in the form of oxides, sulphides, and carbonates, is difficult to smelt compared with ores of base metals. However, ores of iron are very abundant and widespread. Therefore, when man first learned to reduce iron ore to metal, the prime "locational factor" was technological knowledge; others included availability of iron ore and fuel. Because of their high unit value, iron products were carried long distances to markets. Quantitative development in iron production was very slow until the 18th century and locational factors did not change significantly except that technology gradually spread to many nations. The inherent qualities of iron ore became increasingly important, however, and some localities became very famous for the high quality of their iron.

16. With the growing substitution of coal and coke for charcoal early in the 19th century, coal became a dominant locational factor because greater quantities of coal than ore were used to make iron. Local ore deposits were normally sufficient to meet initial, still-limited needs. With the beginning of the so-called industrial revolution, however, the "age of iron" began as demand for iron accelerated due to increased availability at lower cost. The most important ironmaking centres developed in areas that were fortunate in having large deposits of both coal and iron ore. Other important factors were availability of skilled or trainable labour, convenient and low-cost water transport, and an environment that permitted the development of entrepreneurs. Technological knowledge was still an important locational factor early in this stage of evolution. Thus, certain nations became dominant in the world iron industry. However, technology tended to spread, thereby beginning an industry tradition that exists today. Few industries can match the steel industry in the rapid dissemination of technical knowledge.

17. The market tended to develop around ironmaking centres in the form of regional industrialization. The idea of iron and steel as a 'basic' industry thus originated during this era. The "age of steel", beginning after the middle of the nineteenth century, reinforced the importance of the above locational factors. However, improved transportation networks (ie. inland-water and ocean carriers, and railways) facilitated the movement of iron ore and/or coal greater distances.

18. With increased efficiency in the utilization of coal and the introduction of other energy forms such as petroleum and electricity about 1900, the importance of coal as a locational factor began to decline. During this early period, the physical volume of steel production was rapidly increasing,

technology was changing, iron and steel scrap was becoming an important substitute for virgin pig iron, and markets were diversifying but agglomerating. All of these changes influenced the trend to market location as the dominant locational factor; since World War II, the trend has been reinforced through increasing number of producing areas and changing world supply/demand balances.

19. In recent decades, other locational factors have emerged. The great increase in world trade in both steelmaking raw materials and finished steel has encouraged the establishment of new steel plants at coastal locations. Such plants are not only able to obtain raw materials from a variety of advantageous sources but are also able to serve nearby domestic steel markets as well as export markets. The steel industries of large industrial countries, including those that originally had ample domestic raw materials, are increasingly substituting higher-quality, imported iron ore and coal.

20. Finally, there is a growing awareness in developing countries of the importance of a domestic steel industry. The desire for steel industry development originates from several considerations. For example, once a nation achieves political independence, a desire to achieve economic independence follows. If a competitive steel industry can be established, that nation possesses an important asset that can provide the base for growth in secondary manufacturing and general economic development. Specific motives may include objectives such as national or regional industrial development, increased employment, reduced foreign exchange needs, assurance and stability of steel supply, an increase in national returns from resources being exploited, or simply the making of a profit.

21. However, the existence of a steel plant provides no guarantee of economic growth and development. Neither does the lack of a steel plant determine whether or not there is economic advance. If it is to be a national asset, investment in a steel plant should bring about a net gain to the economy and the net gain should be larger than from alternative investment opportunities in other sectors.

3) The Steel Plant Location Problem

22. The objective of a steel plant location study is more than the delineation of the best possible site within a specific country or area. The real objective is the determination of a situation in which an economic-size plant can be established and efficiently operated to provide sufficient profits to service invested capital.

23. For discussion purposes, the "ideal" situation will first be considered. Variations from this "ideal" to reflect reality will then be considered. Such variations differ among plants. Although the ideal situation may be more closely reached in a large industrialized country, these same countries sometimes demonstrate errors to be avoided. For this reason, the importance of detailed and objective study is extremely important when a new steel plant is being considered in a developing country.

4) Ideal Conditions

24. Risks and uncertainties would be minimized or eliminated if the planners of a new steel plant were faced with "ideal" conditions such as:

a) Perfect knowledge of:

- present and future national and international economic conditions,
- the nature and structure of demand,
- the nature and total costs of all raw materials, land, labour and capital, and
- comparative advantage in terms of the costs of domestic production and delivery compared with those of potential competitors and of competitive materials.

b) Economic distance: In the general sense applied here, the concept of economic distance includes all costs of delivering raw materials to the plant and products to the consumer. It is therefore a function of distance and unit transport cost, plus such variables

as levels of protection through tariffs and other trade barriers, exchange-rates, tax structure, and subsidies. Thus, economic distance is partly a function of government policies and administrative procedures. Ideally, economic distance would be zero for all inputs and outputs. That is, all raw material and intermediate inputs would be available adjacent to the plant in the quantities, qualities, prices, and times required to render the maintenance of inventories unnecessary. All consumers of the plant's output, including byproducts, would also be adjacent the plant. In addition, the adjacent markets would be sufficiently large and diversified to permit the steel plant to fully utilize an optimum-size plant for its product range. In contrast, there would be sufficient economic distance between the market and all of the steel plant's competitors such that the steel plant could sell its output at a price that would provide a "reasonable" return on investment. In turn, the price would reflect the international market under normal competitive conditions.

c) Factors of production: All capital, labour, engineering and entrepreneurial skills and other inputs are readily available in the quantity, quality, and cost required.

d) Time: Since profits are a function of time, the steel plant and related facilities would be instantaneously available, ready to begin production. Also, its overall technological and competitive position would not deteriorate during its capital recovery period.

e) Social environment: Sufficient education, housing, and social services would be available. Workers and the population would also be willing and able to adapt to changing conditions and seek out new opportunities.

5) Real Conditions

25. The "ideal" condition will never exist. Therefore, the objective of a steel plant location study is to analyze departures from the ideal in terms of the effect on costs of plant construction, steel production and delivery, and of the prices at which competitors can deliver steel to the proposed plant's market areas. A decision on location must be based essentially on a study of relative costs. All costs must be estimated in advance for a number of general or specific locations.

26. Locational factors can be divided into technical and economic factors on one hand and political factors on the other. Political factors include tariff and trade policy, subsidies and incentives, and investment assistance. In developing countries, it may be considered desirable to discount certain economic or technical factors to achieve political objectives, but planners must be fully aware of the extra costs that inevitably result.

27. Economic and technical factors to be considered in determining the physical location of a proposed steel plant include market characteristics (eg. areal extent, prices, volume, product range, growth trends, and competition); raw material supply (eg. type, source, quality, and cost); services during and after plant construction; transportation facilities (eg. type, existing or projected, and costs); availability of skilled or trainable labour, and availability of community and social services.

28. The market: The importance of the market cannot be overemphasized. Ideally, economic distance to the market would be zero and the market size large enough to take the entire output of an optimum-size plant. In reality, the market will be widespread, diversified and possibly not large enough initially to absorb all steel produced. In most instances, the market will not justify a policy of self-sufficiency in all of the shapes, sizes, and grades of steel products consumed. However, under normal circumstances, a decision on plant size should be based only on the domestic market, with the possible inclusion of some nearby natural export markets.

29. Although exports of finished steel may be possible, the export market is generally more competitive and variable, and trade mechanisms such as tariffs increase economic distance. Furthermore, the type of steel products likely to be produced in a developing country (eg. standard rebars, small merchant shapes, wire products, etc.) are the same products that move most easily in foreign trade. They are produced economically in very large tonnages in industrial countries at comparatively low prices and are consequently subject to severe price competition.

30. One proposal that has been advocated for developing countries is the pooling of the domestic markets of two or more adjacent countries to permit the establishment of a single, optimum-size steel plant. Such a proposal raises a number of political problems but, ideally, it has economic merit and is worth consideration.

31. None of the benefits of an iron and steel industry can be fully achieved in a developing country until there is sufficient internal demand to warrant the establishment of economically-sized plants. Consumption of each product to be manufactured must be high enough to support the equipment needed to produce it. Unless this condition is met, the cost to the economy may be prohibitive; alternative investments may be much more productive financially and of greater benefit to the overall economy.

32. The first stage of a location study will therefore be a market study. Since perfect knowledge of the market is not possible even in the most advanced nations, lack of reliable data will be even more pronounced in developing countries which do not have well-established statistical services and economic research organizations. Therefore, improvisation and estimation, based on available statistics and field surveys, will be necessary to reduce risks as much as possible.

33. An approximation of current and past steel consumption can often be made from existing national statistics, from trade statistics of leading exporting countries, and from existing domestic consumers. The market study should indicate domestic consumption by product and by geographical location as precisely as possible, to permit projection of future consumption. The probable accuracy of a projection will decline as it is extended into the future and it is dangerous to base the initial establishment of a new plant on a market projection of more than 10 years, even if the primary objective is to promote industrialization. Thus, with a period of two to five years for plant construction, the 10-year projection will cover a production span of five to eight years. Market projections would reflect analyses of the rate of population growth; changes in consumers' purchasing patterns and purchasing power; and the direction of primary and secondary industrial growth and development.

34. Market characteristics are important in a locational study from two aspects. First, they determine the size and types of rolling mills that might be warranted. This, in turn, determines the size and type of primary iron and steel facilities that can be justified. Second, the geographical relationship between the market and the plant has a very important bearing on the competitiveness of the plant.

35. Market size and distribution relative to the size of the country concerned is another important consideration. In Canada, where nearly all the steel is consumed within a belt less than 300 miles wide and some 4,500 miles long, the location of specific market concentrations is the prime determinant of a steel plant's ability to compete successfully for a share of the market. Experience has proven that plants not located close to major market concentrations have been less successful than those that are. The physical location of the market may not, of course, be as important in developing countries of small to moderate size.

36. A steel plant located close to its market area (eg. most sales within say 200 miles and serviced by adequate transport facilities) has a number of important competitive advantages over more distant producers. For example, there is the advantage of lower delivery costs, coupled with the possible availability of scrap that can be returned to the steel plant. Delivery times are shorter, smaller inventories are required, and the producer is able to recognize and react to market trends earlier. Consumers often have a tendency to buy locally-produced goods. Finally, as the demand for more sophisticated steel products increases, the necessary close liaison between steel producer and consumer is made easier by mutual proximity.

37. The size, geographical distribution, and product-mix of steel demand have important influences on, and may modify the importance of, the various technical locational factors. For example, if the market is large enough to support an integrated plant, factors such as raw material supply and transportation are very important. If, however, the market is limited and only a small rolling mill with an electric, scrap-melting furnace is justified, factors such as scrap and power supply are more important.

38. Another aspect of the market study is the source of current supply, in terms of delivered price and quality, because this leads to an assessment of the competition faced by the new plant. Factors that influence price and quality of competitive sources include size of production units, processing methods, and costs of raw materials, labour, capital, and transportation, augmented by the degree of world competition. In addition, government trade policies and administrative procedure, in both the originating country (eg. tax rebates and other export incentives) and importing country (eg. tariffs, quotas, import taxes, and customs charges), affect the delivered price and therefore the level of consumption and degree of competition.

39. Raw materials: The next stage of study is the assessment of raw materials to be used to produce primary steel for rolling. The major raw materials (ie. iron ore, scrap, semi-finished steel, coal, petroleum, natural gas, electricity, limestone, and water) are of main concern since transportation costs are large relative to their unit value.

40. Ideally, all raw materials are readily available in the quantity and quality required. These conditions are never met. Study should first centre on possible domestic sources. The desire of nations to utilize domestic raw materials is understandable. In fact, the availability of some steelmaking raw materials often provides the initial impetus to the planning of a steel industry; a major consideration is the saving in foreign exchange through the use of domestic resources.

41. Domestic sources of raw materials should be evaluated with respect to cost, quality, and available reserves. This often requires extensive geological investigation and metallurgical testing; an adequate study may require several years. Similarly, the domestic resource study will point out deficiencies which must either be filled by substitutes (scrap or semi-finished steel for iron

petroleum or electricity for coking coal, etc.) or be imported. A study of scrap supply should also be undertaken. Once the preliminary "national inventory" is completed, domestic sources are then evaluated to identify possible savings by using imports. Domestic self-sufficiency in the major steelmaking raw materials is not a necessity for a primary iron and steel industry, as experience in Canada and such countries as Japan and Italy attests. If only low-quality iron ore reserves are available, for example, steel production costs may be lower and steel prices more competitive if imported ores are used, even if foreign exchange problems exist. Once all sources have been fully evaluated, the data can be applied to the locational analysis of a set of possible sites.

42. The supply of raw materials will have an important influence on the processes considered for the steel plant. Ferrous metallurgists have been resourceful in developing techniques to utilize various combinations of raw materials; other papers presented at this Symposium discuss the technical combinations that may be considered. These range from fully-integrated plants using conventional blast furnaces and steel furnaces, through specialized integrated plants using miniature blast furnaces, electric iron furnaces or direct reduction processes, to non-integrated plants. Non-integrated plants may consist merely of a re-rolling mill based upon imported billets or slabs, or they may include steelmaking furnaces based upon scrap, pig iron, or sponge iron, each of which may have to be imported.

43. Transportation: Under ideal conditions, there are no off-plant transportation costs; both raw materials and steel markets are adjacent the plant. In reality, large tonnages of freight move into and out of a steel plant; this often involves distances of hundreds or thousands of miles.

Transport and handling costs may therefore represent a major portion of delivered costs of both raw materials and finished steel. Transport costs will normally outweigh cost differentials of land, power, etc. at various plant locations being considered. Thus, transportation is one of the most important parts of a locational study.

44. Transportation can be considered in detail only upon completion of studies on markets, raw material sources, processing methods and a preliminary survey of several potential plant sites. The transportation study will establish aggregate transport costs for raw material assemblage and product distribution for each potential site. The magnitude of goods transported is illustrated below. An integrated iron and steel plant uses, for each 100 tons of crude steel or 65 to 70 tons of rolled steel, the following approximate quantities of raw materials, depending upon processing methods.

Iron ore	100 to 150 tons
Coking coal	45 to 65 tons
Limestone	18 to 25 tons
Purchased scrap	to 30 tons
Alloys, etc.	2 to 5 tons

In addition, energy materials such as fuel oil, natural gas and electricity are used. Integrated steel plants in Canada, for example, use 15 to 30 gallons of fuel oil and up to 2,500 cubic feet of natural gas for each ton of crude steel. Thus, a plant producing one million tons of crude steel annually will receive about 2.5 million tons of raw materials and will ship 650,000 to 750,000 tons of rolled steel.

45. Unit transport costs vary widely according to the type of carrier and the product being shipped. Low-value, bulky materials shipped in large quantities can be handled on a large scale with automated equipment at comparatively low cost. On the other hand, finished steel and packaged products must be handled carefully. They require special equipment and covered storage, and they need more man hours for handling and accounting.

46. Transportation media may range from highway trucks to conveyorways, railways, pipelines, inland waterways and ocean shipping. Unit transportation costs follow approximately the same pattern, with light trucks on the high end of the scale and large, ocean-going, bulk-carriers on the low end. Cost may range from as low as 0.035 cents (U.S.) a metric-ton-mile for large bulk ore carriers to several cents a ton for rolled steel via truck haulage. Although freight rates vary widely according to individual circumstances, the following data illustrates approximate shipping costs.

	U.S. cents a metric-ton-m
Ocean - iron ore in large bulk carriers	0.035 to 0.10
- steel rolling mill products	0.40 to 0.70
Inland Waterway - iron ore in bulk carriers (Great Lakes)	0.20 to 0.30
Rail - iron ore	0.50 to 1.00
- steel	1.50 to 5.00
Pipeline - coal (several hundred miles)	0.50 to 0.70

In addition to shipping costs, handling costs are incurred at each end of the journey and at each transfer point. For short distances, these can account for a large share of the total cost and road transport, even at high unit ton-mile cost, may be the lowest, total-cost media. Finally, allowance should be made for inventory costs since they can be significant. In general, the greater the transportation distance, the larger will be inventories.

47. Other factors of production: The ideal condition assumed that capital, labour, technical and management skills, and other factors of production were available in the quantity and quality, and at the cost, required. It is in these areas that difficulties faced by developing versus industrialized countries are often the greatest. Almost invariably capital is scarce; there is a shortage of trained labour, technicians and managers; and the industrial sector is not well developed.

48. The steel industry is highly capital intensive; even a modest-sized plant requires large investments relative to its annual output. Investment in terms of annual capacity of rolled steel may range from about $20 an annual ton for a simple re-rolling mill to more than $400. per annual ton for a fully-integrated plant.

49. If the analysis of a proposed steel plant indicates a reasonable chance for economic success, financing may be available from many sources, including loans from national or foreign governments, from international organizations such as the World Bank, or from commercial banks; bond or

equity financing; or extended credit from suppliers of steelmaking machinery and equipment. Alternatively, consortia of equipment manufacturers or suppliers of semi-finished steel may exchange capital equipment for an equity in the new plant. This implies some degree of external control but it provides necessary expertise.

50. Nearly all personnel at a steel plant, from top management down to individual workers, must be skilled. Seldom is the local supply of skills adequate for a new steel plant in developing countries. Provision can therefore be made for a training program. This may be arranged either through equipment suppliers or with established producers. Selected workers can be trained to assume technical operation of the newly-built plant and, in turn, to train other workers. Such trainees are usually assisted during the break-in period, even for the first few years of operation, by skilled operators from equipment firms or by hired personnel from foreign countries.

51. Time: Time itself is another important consideration. Heavy capital expenditures must be made in building a plant that may not begin production for several years; these must be repaid from operations over periods of 10 to 20 years. Construction of the plant must be well planned to minimize the period of time when invested capital is not generating earnings. The location of the plant may have an important bearing upon the length of this period, particularly if major transportation facilities such as railways must first be installed.

52. Unpredictable change through time leads to risks and uncertainties. The problem to be faced is the changing competitive position through technological progress or from world steel market conditions. Thus, assessments must reflect not only current conditions but future expectations. Compounding this difficulty is the fact that different methods used to assess feasibility vary in the manner in which adjustments for time are considered; these differences may lead to conflicting conclusions.

53. Social environment: Successful operation of a steel plant, and of the steel-based industries that tend to develop nearby, requires an adequately-developed social environment. This is a very important consideration. Although one objective in building a steel plant may be to encourage development of an outlying section of a country, the costs of establishing the required social services must be considered. The success or failure of a plant could depend solely on whether or not a satisfactory environment is provided. For example, suitable housing accommodation, public health facilities, education at the appropriate academic and technical levels, domestic utilities such as water, fuel and electricity, and recreation, are all important. An environment that encourages employee self-advancement, both economically and culturally, will also promote general progress of the country.

54. Factors such as water supply, local geography, population, market location, climate, local taxes, access, subsurface structure, and existing facilities will all be considered in a general way to delineate potential site areas. Information for each site will then be assessed in an integrated analysis from which final conclusions on technical and economic feasibility can be derived. Special or unusual plant construction and operating costs must be considered for each site; these costs will be indicated in a preliminary engineering evaluation. Finally, the competitive position for each site is considered relative to other domestic sites and imports.

PART III

CANADIAN EXPERIENCE

1) Nature of Canadian Economic Development

55. Canadian settlement and economic growth can be described as a process of development around an export base; exports were and still are a leading factor in the Canadian economy. Following discovery by Europeans in the 16th century, economic activity was initially characterized by exports of raw materials and foodstuffs and by imports of manufactured and consumer goods, development capital, entrepreneurial skills, and labor. Economic growth as measured, for example, by the rate of increase in real per capita income was determined by the character of the export staple, the adequacy of the resource base, international supply/demand conditions for goods and factors, the international transportation network, and the international political and economic power structure.

56. The technical-economic character of the export staple, therefore, determines the scale of production units and the degree of possible substitution among factors of production. These in turn determine the demand for factors of production and intermediate inputs, the distribution of income, and the possibilities for further processing. In turn, economic development is affected and can be discussed in terms of three demand linkages:

(1) Backward Development Linkage: investment in production of inputs consumed by the export sector (e.g. machinery and transportation services) to reduce imports and facilitate exports.

(2) Forward Demand Linkage: investment in production using the output of the export sector as an input (i.e. further processing). This will increase the unit value of exports and may reduce imports.

(3) Final Demand Linkage: investment in production of consumer goods and services for those employed in other sectors (e.g. production of radios for workers in the steel industry). This can also reduce imports and possibly become, in part, an export-oriented activity.

57. The export sector also can induce an increase in the supply of factors of production, an essential in the development process. Consider four dimensions of supply:

(1) Entrepreneurs: foreign entrepreneurs are important for the export sector, particularly if they possess technical and marketing skills and capital. For full development, however, domestic supply of entrepreneurs is essential for the development of all domestic opportunities. The supply of domestic entrepreneurs is a function of attitudes towards business as a profession, the educational system and existence of social mobility.

(2) Labour: the labour force increases with population growth and net immigration. Encouragement to family formation and ability to compete for immigrants are important. Education affects the quality and mobility of the labour force.

(3) Capital: domestically generated capital will also become important relative to total capital needs. This depends, however, on the extent to which the domestic public and private sectors share in export-generated income compared with the amount received by foreigners. It also depends on incentive for investment of domestically-controlled capital within the country.

(4) Technology: as the economy develops, and the supply of domestic entrepreneurs, skilled labour and capital increases, research will increase and will likely be related to domestic requirements and opportunities.

58. For long-run growth, unfavourable changes in supply of and demand for a particular staple will affect the economy. Improved marketing and productivity can help maintain a competitive position. Increased insulation from the full force of international fluctuations is obtained by diversifying exports and through production for domestic use. Also, lack of inhibiting traditions will facilitate factor mobility.

59. In Canada, a favourable set of conditions has resulted in satisfactory development with rising per capita income and population; with increasing supply of domestic entrepreneurs and capital; with increasing secondary manufacturing to replace imports and diversify exports; and with staple exports and manufactured imports falling relative to total national output and trade.

60. However, continued growth requires an ability to adapt to new foreign and domestic markets. Foreign markets require favourable external demand. Production for the domestic market requires a population base and level of per capita income that permit economies-of-scale in modern plants. Domestically, social characteristics favourable to transformation are required. For example, if the original staple commodity becomes depleted or loses its comparative advantage, and the resource base does not permit other

developments, stagnation may occur. Population will continue to increase and unless emigration occurs, persistent unemployment and lower income may prevail.

61. If the staples developed are conducive to strong linkage effects that are adequately exploited, then the economy can grow and diversify so that eventually the term 'staple economy' is less appropriate. This is now partly true for the Canadian case. But for present and future long-run development perspective, the staple approach still provides a good framework for considering the process of Canadian development.

2) Steel in the Canadian Development Process

62. The Canadian primary steel industry throughout its history can be characterized as an import-replacer and international price-taker. As the domestic primary steel market grew, investment in rolling mills, steel furnaces, and blast furnaces became justified within the technical-economic constraints that determine the size of efficient plants. In general, only when effective demand appeared to justify such plants were investments made; otherwise needs were filled from imports. However, conditions in the international steel market were an important factor in influencing the necessary scale of plant to replace imports. Since the point of reference for determing cost feasibility was the price of landed imports in the domestic market, the industry was not in a position to be a price-leader in the international market. Thus, the essential determinants of whether or not a steel plant could be established in Canada were, and still are, the

relationship between plant and market size, and the international steel market. Other variables affecting the demand available to the domestic steel industry include tariffs and other barriers to trade, changes in exchange rates, differential rates of inflation, and changes in the structure of demand.

63. Given the above environmental factors of demand, the task of the entrepreneur, often with some governmental influence or assistance, is to assemble and utilize labour, capital, and materials in such a way as to realize sufficient income to provide acceptable returns to the factors of production. Thus, the entrepreneur must be able to forecast when demand conditions will warrant commencement of production. Once the entrepreneur has identified that a steel plant might be economically located in Canada, the simultaneous question is - where in Canada? In the Canadian case, market-oriented plants have been more successful than resource-oriented plants. Technical-economic trends have reinforced this fact. However, the path to a successful Canadian primary steel industry is marked with cases where demand was overestimated or costs of supply underestimated.

64. Between 1895 and 1010, three of the present four major integrated steel plants were established [(c)]. Table 1 shows that under conditions of increasing consumption, domestic production increased from 6 to 42 per cent of consumption between 1900 and 1910. However, the absolute level of imports also increased. Although tariffs were moderate, they were not decisive to investment decisions on new steel plants in this early period.

(c) Buck, W. Keith and Elver, R.B., The Canadian Steel Industry - a Pattern of Growth, prepared for the United Nations Interregional Symposium on the Application of Modern Technical Practices in the Iron and Steel Industry in Developing Countries, Prague and Geneva, November 11 to 26, 1963.

TABLE 1. CANADIAN STEEL IMPORTS, PRODUCTION, AND CONSUMPTION, 1900-1910

	1900	1905	1910
	(thousands of short tons and percentage distribution)		
Imports	416 (94)	843 (85)	1,005 (58)
Production	26 (6)	159 (15)	740 (42)
Consumption	442 (100)	1,002 (100)	1,745 (100)

65. The industry grew and obtained adequate returns until about 1918. For the next two decades, only one of the three plants can be considered to have been financially successful. In general, growth in consumption tended to occur in products not produced by the industry and for which domestic demand was insufficient to warrant new facilities. The problem for the industry in this period was to increase efficiency and to maintain solvency. In hindsight, overexpansion occurred in the 1900-1910 period relative to subsequent demand because of the unforseeable depression in the 1930's and the shift in demand from one steel-consumption mix to another. Nevertheless, a central authority would likely have found justification for only two of the three plants that were established between 1900 and 1910.

66. Although some inefficiencies in resource allocation occurred, the groundwork was laid for the emergence in the 1950's of an internationally-competitive industry. For example, many of the foreign entrepreneurs and skilled workers that immigrated became Canadians; these new Canadians helped stimulate development of additional domestic entrepreneurs, labour, and capital; domestic consumers became better serviced; and the development of a domestically-controlled industry helped assure that domestic expansion in the 1950's would proceed in the interest of Canada.

67. The 1950-1967 period demonstrates some of the many variables that can affect the steel industry. If one assumes that an integrated steel plant below one million tons a year is likely of inefficient size, and that those above two millions are approaching an optimum size, then the data in Table 2 indicate that three of the four integrated firms realized important economies-to-scale between 1950 and 1967.

TABLE 2. PLANT SIZE IN THE CANADIAN STEEL INDUSTRY, 1950 and 1967

	1950		1967	
	Annual Capacity(b)	Percentage	Annual Capacity(b)	Percentage
Stelco	1,247	34.2	4,250	36.9
Algoma	866	23.7	2,600	22.6
Dofasco	378	10.4	2,150	18.7
Dosco	713	19.5	1,100	9.6
Subtotal	3,204	87.8	10,100	87.8
Others(a)	447	12.2	1,402	12.2
TOTAL	3,651	100.0	11,502	100.0

NOTE: (a) Others include four firms in 1950 and twelve firms in 1967 that produce rolled steel in non-integrated scrap-melting plants and which mostly serve geographically-restricted markets.

(b) Thousands of net tons of 2000 lb.

68. Trends in recent years suggest that optimum size plants may approach four to five million tons of capacity a year. Depending on rolling mill product-mix, the author's are of the opinion that most economies-to-scale can be realized by a plant of two million tons. For international perspective, reference to Table 3 shows that Canadian plant sizes, and the distribution within the range of plant capacities, compare favourably with the major industrial nations. The Canadian industry is not overburdened with an excessive number of small plants as in Europe. However, if size alone is important, some economies-to-scale are yet to be realized in Canada.

TABLE 3. SIZE OF PRIMARY STEEL PLANTS IN SELECTED COUNTRIES, 1965

	Over 4	4 to 3	3 to 2	2 to 1	1 to .5	Below .5	Total
	(based on steel ingot capacity in millions of net tons a year)						
A. Number of Plants							
Canada	-	1	2	-	1	12	16
U.S.A.	7	7	16	17	15	32	94
Britain	-	1	2	9	9	20	41
E.C.S.C.	1	1	11	16	31	46	106
Japan	2	3	2	7	4	31	49
Total	10	13	33	49	60	141	306
B. Share of National Capacity(%)							
Canada	-	35.9	42.2	-	9.8	12.5	100
U.S.A.	29.1	13.9	25.0	16.4	7.2	8.4	100
Britain	-	9.6	13.4	36.3	19.7	21.0	100
E.C.S.C.	4.8	3.2	26.4	21.3	21.2	23.1	100
Japan	21.4	22.9	10.7	23.8	6.5	14.7	100
Total	16.8	12.2	22.8	20.4	12.6	15.2	100
C. Steel Ingot Production (millions of tons)							
Canada	-	3.59	4.26	-	0.99	1.26	10.10
U.S.A.	38.27	18.28	32.88	21.57	9.47	11.05	131.52
Britain	-	2.90	4.05	10.96	5.95	6.34	30.20
E.C.S.C.	4.54	3.03	25.00	20.17	20.08	21.88	94.70
Japan	9.72	10.04	4.86	10.81	2.95	6.67	45.41
Total	52.53	38.20	71.05	63.51	39.44	47.20	311.93
Average Size in Group	5.25	3.22	2.15	1.30	0.66	0.33	1.02

Source: Steel Review, #44 October 1966 (British Iron and Steel Institute)

69. Figure 1 illustrates key aspects of the Canadian steel industry since 1945, as summarized below:

(a) The rate of consumption accelerated,

(b) Production grew faster as new capacity was added,

(c) A position of net self-sufficiency was approached in the 1960s through import replacement and rising exports, and

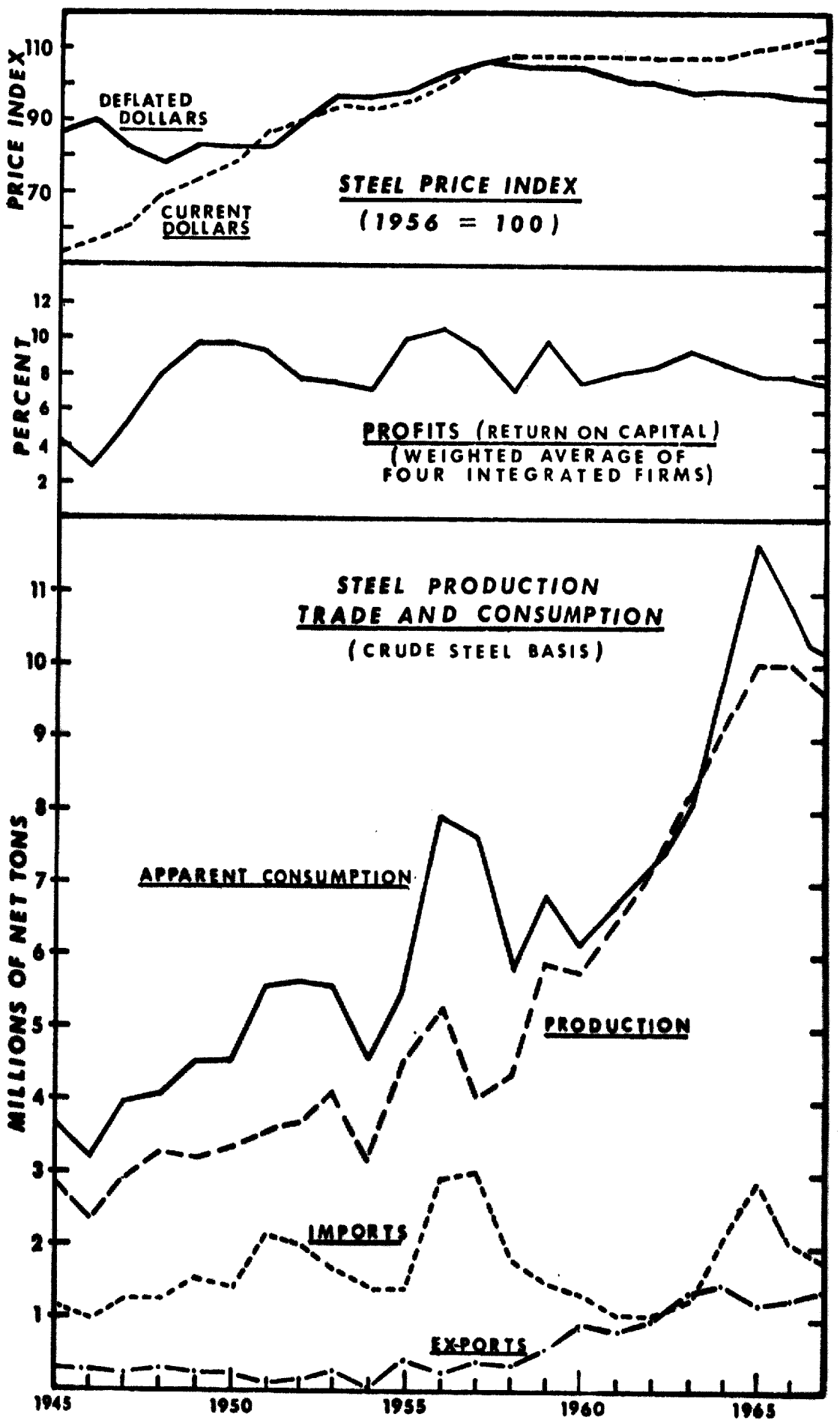
(d) With relaxation of wartime price controls, prices and profits increased rapidly until the early 1950s. Prices then rose gradually until 1957, then remained constant until 1965 after which small increases were made. In deflated terms, prices declined gradually after 1957. Profits, or return on capital, tended to be constant in the 1950s but generally trended downward in the 1960s to levels that barely provide an adequate return.

70. An important feature is three periods of high consumption (ie. 1952-1953, 1956-1957, and 1964-1966) with the following characteristics:

(a) imports rose rapidly and domestic capacity was inadequate.

FIGURE 1

CANADIAN STEEL INDUSTRY OUTPUT, PRICES AND PROFITS, 1945–1967.



(b) exports declined as the domestic industry used its output to satisfy more of the domestic market; this would likely be more profitable than exports,

(c) production rose,

(d) prices rose, although in the 1964-1966 period price increases appear to have lagged the rise in consumption,

(e) the rapid rise in imports induced an increase in capacity that became available towards the end of each period. The new capacity was available for the next surge in demand and resulted in import replacement,

(f) return on capital tended to decline during peak demand and probably reflected surges in capital investment, and

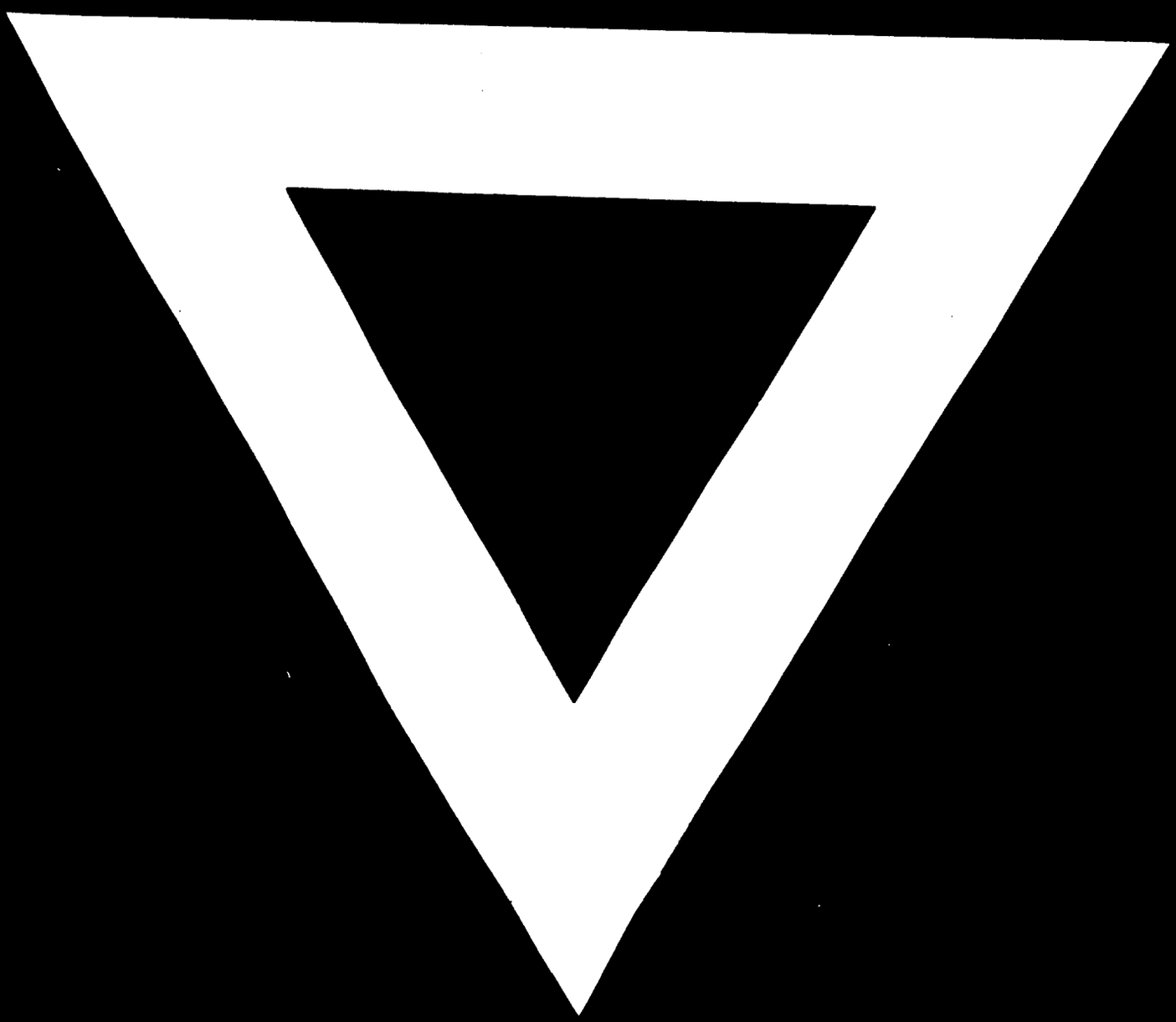
(g) exports tended to recover in periods between the peak-import periods.

71. The domestic industry receives net protection from tariffs and the exchange rate vis-a-vis the United States dollar. Tariffs in the entire period were generally constant and moderate (i.e. effective weighted average of about seven per cent ad valorem). Changes in the Canada-United States exchange rate lowered protection in the 1951-1961 period. In this latter period, import replacement and increasing exports became well established, largely at the expense of United States producers. This situation was facilitated by the economies-to-scale mentioned earlier and by a faster rate of general inflation in the United States than in Canada in the 1950s.

72. In 1962, the Canadian dollar was devalued and pegged to provide an increase in protection that was greater than the tariff. However, prices and profits tended downward in the 1960s because of: a new source of import competition (i.e. Japan and Europe) that became important by 1959 and intensified continuously in the 1960s; recent rapid increases in

investment for which full operating efficiency has yet to be achieved; and recent rapid increases in labour costs which may be overcome as increased productivity from new investment is fully realized. Finally, the international market situation in the 1960s that is characterized by excess world capacity and changes in competitive position among world producers and exporters, has given rise to a problem of dumping or near-dumping conditions. The effect is higher imports and lower prices in the domestic steel market. Such trade practices are disruptive to the orderly development of what is otherwise a competitive industry.

73. This discussion on a few aspects of the Canadian steel industry and the character of Canadian economic development has been made to indicate the importance of assessing the location or position of a steel industry in a national and international context under dynamic conditions. A static, restricted, partial-equilibrium analysis of location can lead to serious miscalculations.



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