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INFLUENCE OF THE SIZE OF THE MARKETS ON THE IRON AND STEEL INDUSTRY IN LATIN AMERICA

CONTENTS

INFLUENCE OF THE SIZE OF THE MARKETS ON THE IRON AND STEEL INDUSTRY IN LATIN AMERICA

1. Introduction

Under document L.87, a paper, "The Influence of Local Factors on the Iron and Steel Industry in Latin America" was presented for study to the Expert Working Group on Iron and Steel Industry in Latin America. This paper analysed the influence on cost and investment structure of all factors related to geography, raw materials, and wage rates. In the present paper, considerations are added concerning size of the markets; this, by governing the size of plants, exerts considerable influence on the cost and investment pattern. To examine the situation and possibilities of the industry in the region, both papers should be considered jointly.

To determine the influence of locational factors, it was assumed in document L.87 that, at given sites in each of the seven Latin-American countries offering the best possibilities for installing iron and steel industries, plants with an output of 250 thousand tons of finished steel a year were operating. It was further assumed that a similar plant existed at Sparrows Point, on the Atlantic seaboard of the United States. This provided a basis for comparison with the industry outside the region.[1/]

Information was obtained covering almost all important data for each respective country and site, while general assumptions were used for less important figures. These assumptions may, with minor changes be taken as generally valid; they improve comparability between the various solutions, and, at the worst, introduce only a slight margin of error. An exception is transport, a factor with an important bearing on aggregate costs. The figures to evaluate transport costs more or less correspond to the average of those in the United States in 1948. In most cases, where plants already

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1/ The sites selected for these imaginary plants correspond to locations for which most information was available in each respective country; this does not imply an opinion concerning their comparative advantages over any others.

/exist at

exist at the selected sites, the current rates paid for different types of transport were available, but preference was given to uniform assumptions, because no industries exist at several sites. It may be assumed that the present figures will change once such an industry is installed, with its heavy demand for transport. Moreover, many of the current rates are scarcely related to costs but are affected by subsidies and by many other considerations.

The values indicated in both these papers have been converted into dollars at 1948 value. The exchange rates used for countries with multiple systems were those for steel import payments in 1948. While facilitating comparison with the output of more industrialized countries, this has done much to simplify calculations.

Finally, the process analysed in the papers contemplates coke blast furnaces for iron ore reduction,[1] basic open hearth or a combination of 20 per cent Bessemer and 80 per cent basic open hearth for steelmaking, or Thomas converters in the case of Colombia. Rolling mills are of the conventional type. In every case it has been assumed that the same assortment of products would be produced, broken down as in Table 8 of document L.87.

The resulting figures were thus grouped to permit considerable flexibility in analysis, as for example:

a) Assembly costs, which represent the aggregate cost for mining and purchase and transport of raw materials to the plant, are usually higher in Latin America than in industrialized countries.[2] This is due to the great

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1/ Even in Peru, where an iron and steel plant is being built at Chimbote, for an annual capacity of 53 thousand tons, based on Tysland-Hole electric furnaces.

2/ Belencito, in Colombia, is a notable exception to this almost general rule.

distances involved and the relative shortage of coking coals. Such assembly costs have been compared, in document L.87, with those for Sparrows Point in the United States, on the assumption that iron ore from Venezuela would be used there. As a result costs are higher than is usually the case in the United States. Consequently, some Latin-American assembly costs, which compare favourably in the paper with those of Sparrows Point, may in fact be high compared with those for the principal iron and steel centres of the United States and Europe.

Nevertheless, if the transport costs for the finished products to the coast are added to assembly costs of the industry in the main centres of the United States, then Sparrows Point appears in a more favourable position as regards exports to Latin America. Similarly, the addition to assembly costs, both in Europe and Latin America, of the respective transportation charges to the markets of the region, generally results in advantages for Latin-American plants.

b) Wage rates, which are lower in Latin America, have an important bearing on the costs of finished steel, as shown in Table 8 of document L.87; therefore, except in Venezuela, where wages are higher than in the United States, all the Latin-American labour costs are more favourable than those for Sparrows Point. It is inconceivable that a small unit with an annual capacity of 250 thousand tons would actually operate in the United States; by producing a complex assortment of steel products, it would lack the advantages of large scale operation and specialization. Therefore, the data in Table 8 are unrealistic, except for assessing the comparative position of Latin America, once its markets have developed sufficiently to permit the erection of large scale units, similar to those in the United States.

/ c) It is

c) It is probable that such development will inevitably lead to higher wage rates in Latin America, so that one of its present advantages would disappear. But the shortage of capital now prevailing in the region would also disappear. Table 16, column D of document L.87 illustrates a case in which these two factors become equal to the rates prevailing in the United States. Results differ considerably, but in general the values would tend to approach those of Sparrows Point.

The final results of document L.87 show that, from purely locational factors, differences of only a small percentage arise between the cost of steel for the various sites. These differences are much smaller than those caused by changes in the plant size, as noted later. The comparability of the results of both papers is assured by using, as far as possible, the same data and methods of calculation. The basis for this was described in detail in Paper L.87.

2. Influence of the Size of the Plant on Production Costs

The main influence which the size of the installation exerts on production costs, in plants making the same assortment of products, is due to variations in two different factors: a) the greater productivity of labour as the scale of operations increases, and b) the lower investment required per unit of output in larger plants.[1] In order to permit analysis of the influence of plant size on costs, with locational factors remaining constant, Tables 1, 2 and 3 have been compiled showing output costs corresponding to different stages of production in plants of 50, 250, 500 thousand and one million tons a year, respectively.[2]

1/ A third factor may be added here, the greater facilities for specialization which exist in a broader market. Similarly, although there is no numerical expression for it, with many products, such as sheet, for instance, the quality produced by modern plants cannot be achieved with the use of small-scale equipment.

2/ These plants are assumed to have been designed expressly for their respective sizes. This does not correspond exactly to the facts in Latin America, where expansions are usually considered in advance and reflect on investments.

Sparrows Point has been selected as the site for this example. However, due to higher wages there than in Latin America (except Venezuela), the influence of size on the wage costs is somewhat exaggerated in comparison with the usual position in the region. The opposite is the case with the influence on capital charges.

Table 1 Pig Iron Production Costs at Sparrows Point, in Plants Having Different Capacities of Finished Steel

(dollars of 1948 per ton)

Item Finished steel capacity in tons per year	50,000	250,000	500,000	1,000,000
Iron ore	17.93 a/	16.37 b/	16.37 b/	10.90 c.
Coal	10.71 d/	9.74	9.74	9.74
Limestone	1.08 e/	1.03	1.03	0.92
Minus credit for blast furnace gas	-1.90	-1.90	-1.90	-1.90
Assembly costs	27.82	25.24	25.24	19.66
Direct wages	6.75	1.22	0.68	0.63
Indirect wages and salaries	5.40	1.57	0.87	0.80
Total salaries and wages	12.15	2.79	1.55	1.43
Cooling water	0.46	0.42	0.40	0.36
Repairs and general expenses	5.90	2.10	1.72	1.48
Minus net credits from the coke plant	-1.17 d/	-1.06	-1.06	-1.06
Total for conversion costs	5.19	1.46	1.06	0.78
Direct cost	45.16	29.49	27.85	21.87
Capital charges	8.16	7.00	5.80	5.76
Total cost	53.32	36.49	33.65	27.63

a/ Freight for El Pao ore, Venezuela, at the normal rate, without dredging the Orinoco River.
b/ Freight for El Pao ore, Venezuela, at the normal rate, with the Orinoco River dredged.
c/ Freight for El Pao ore, Venezuela, at a low rate and with the Orinoco River dredged.
d/ Estimated cost 10 per cent higher than that for the 250 thousand tons a year plant.
e/ Limestone cost estimated 5 per cent higher than for the 250 thousand tons a year plant.

/Table 1

Table 1 shows that pig iron costs in a plant having an annual capacity of a million tons are 50 per cent lower than those of a small plant producing 50 thousand tons of finished steel a year. Conversely, it may be observed that the 250 thousand ton annual capacity, selected as an example for the installations considered in document L.87, approaches the point on the curve where the influence of the size of operation on costs begins to decline. In fact, doubling output to 500 thousand tons, reduces total costs by 8 per cent, while raising it four times to a million tons reduces them by 24 per cent. Two thirds of the second reduction, or 15 per cent of the total cost, are due to economies through using larger ships and better ports, as justified by a greater annual traffic.

Wage costs per ton fall by almost 50 per cent when passing from a 250 thousand ton plant to one of a million tons, although this reduction only represents 4 per cent of total costs. On the other hand, the difference in labour costs between a 250 thousand ton plant and one of 50 thousand tons a year, is about 400 per cent, representing 25 per cent of the total cost of the former.

/Table 2

Table 2 Production Cost of Steel Ingots in Plants of Various Capacities Located at Sparrows Point

(dollars of 1948 per ton)

Item Finished steel capacity per year	50,000	250,000	500,000	1,000,000
Liquid pig iron (768 kgs.)	41.00	28.02	25.95	21.20
Circulating scrap (199 kgs.)	9.55	6.54	6.03	4.95
Purchased scrap (102 kgs.)	4.90	3.35	3.09	2.54
Ferroalloys	2.30	1.92	1.90	1.90
Total cost, ferrous material	$ 57.75	$ 39.83	$ 36.97	$ 30.59
Direct wages	8.45	4.74	3.20	2.67
Indirect wages	1.85	1.05	0.95	0.84
Total wages	$ 10.30	$ 5.79	$ 4.15	$ 3.51
Fuel oil (88 kgs.)	1.30	1.06	1.02	0.85
Lime and refractories	1.40	1.10	1.10	1.00
Maintenance materials	0.54	0.50	0.45	0.40
Overhead materials and services	0.70	0.57	0.55	0.50
Total fixed manufacturing costs	$ 3.94	$ 3.23	$ 3.12	$ 2.75
Total direct costs	$ 71.99	$ 48.85	$ 44.24	$ 36.85
Capital charges	$ 5.00	$ 4.40	$ 3.18	$ 3.17
Total cost	$ 76.99	$ 53.25	$ 47.42	$ 40.02

The cost per ton of steel ingots, produced in a plant of a million tons a year, is 48 per cent lower than that for a plant with an annual production of 50 thousand tons. The difference is thus very slightly lower than that shown for pig iron, where the difference is 50 per cent. Doubling capacity to 500 thousand tons a year, reduces steel shop costs by 11 per cent, as compared with 8 per cent in the case of pig iron, while in plants of a million tons, the reduction is almost the same as in the blast furnace, that is, 25 per cent.

/Table 3

Table 3 Cost per Ton of Finished Steel in Plants of Different Size Located at Sparrows Point

(dollars of 1948 per ton)

Item				
Annual production capacity of finished steel	50,000	250,000	500,000	1,000,000
Steel ingots (1,333 kgs.)	102.65	71.00	63.23	53.36
Fuel, blast furnace gas	0.88	0.88	0.88	0.88
Credits for circulating scrap	-12.73	- 8.72	- 8.04	- 6.60
Raw materials per ton	90.80	63.16	56.07	47.64
Rolling mill wages	28.10	15.98	7.85	5.59
Maintenance wages and general expenses	9.70	3.20	2.18	1.98
Total wages	37.80	19.80	10.03	7.07
Refractories and replacements	4.00	2.00	2.00	2.00
Overhead maintenance materials and services	2.90	1.45	1.45	1.45
Electricity	2.40	1.20	1.20	1.20
Total materials and services	9.30	4.65	4.65	4.65
Total direct cost	137.90	86.99	70.75	59.36
Capital charges	17.76	13.94	13.04	12.56
Total cost	155.66	100.93	83.79	71.92

In the rolling mill, the influence of the size of operations on wages is considerably larger than in the preceding steps, because of the various degrees of mechanization appropriate to the different sizes. In fact, finished steel costs, in a plant producing a million tons a year, are 54 per cent lower than in a thousand tons a year plant. In turn, doubling the 250 thousand ton plant produces a cost reduction of 17 per cent, compared with an 11 per cent difference at the steel shop, and 8 per cent at the blast furnace.

The results shown in Tables 1 and 3 have been converted into indices in Plate 1, taking the data for the 50 thousand ton plant as the base. The chart shows costs: a) of finished steel in the four plants; b) per ton of pig iron; and c) for the value added per ton of steel in the rolling mill.

/In accordance

CHART I

INFLUENCE OF SIZE OF PLANT ON PRODUCTION COSTS PER TON

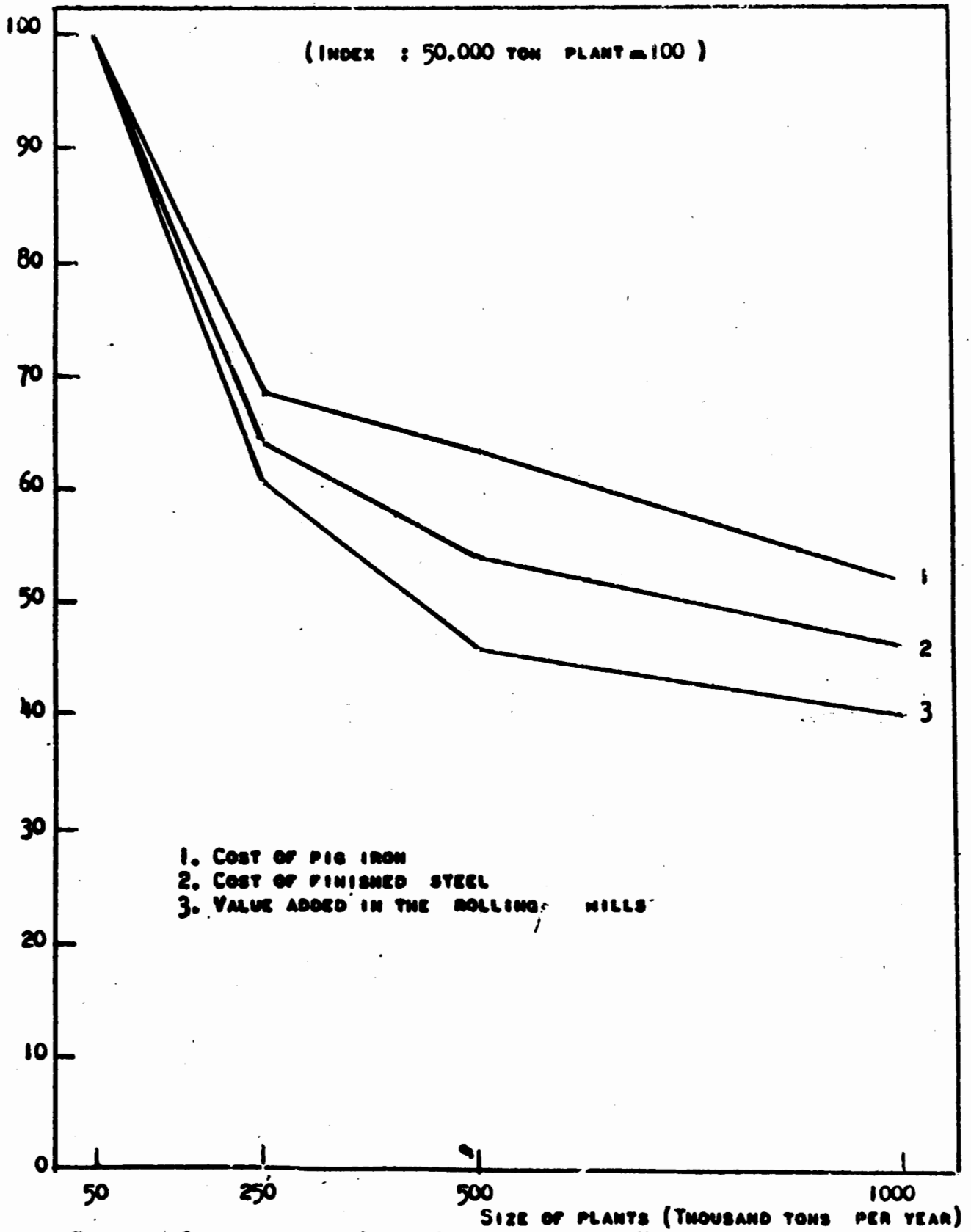

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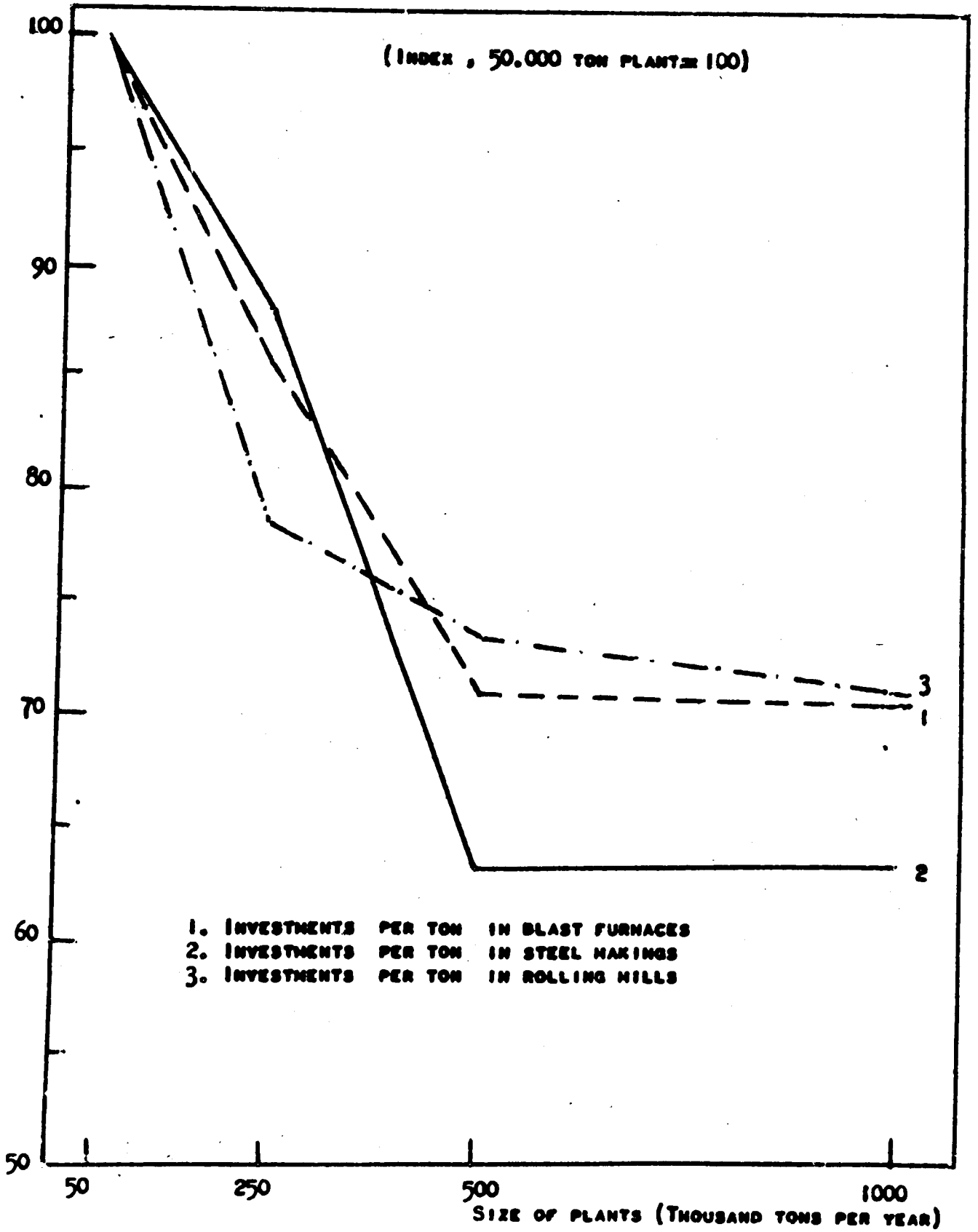
CHART 2

INFLUENCE OF SIZE OF PLANTS ON INVESTMENTS PER TON PER YEAR



ECONOMIC COMMISSION FOR LATIN AMERICA , UNITED NATIONS.

In accordance with the preceding analysis, the curve corresponding to the steel plant should be so close to that for pig iron that, to avoid confusion, it has been omitted. The chart on Plate 1 shows that the influence of the size of operation is lowest at the blast furnace and highest at the rolling mill.

This fact is important in order to examine possibilities of Latin-American intraregional trade.[1] Indeed, a country having a large market and high assembly costs can only expect a relatively small reduction in pig iron costs as a result of expanding its blast furnaces. On the other hand, for a country having low assembly costs and a small market, it might be beneficial to suppress rolling operations, which would be very costly, and to exchange pig iron for finished steel. If the positions of some special products are examined, such as tubes, railway tyres, etc., instead of taking an assortment of steel products such as that considered in this paper, it is very likely that fruitful combinations could be found.

Plate 2 shows similar indices concerning investments. It is apparent that the investment required for the blast furnace remains almost constant beyond an output around 500 thousand tons. This is because calculations have been based on maximum units of 1,400 tons a day, and the addition of more of them if necessary. The indices for value added at the rolling mill are anomalous, as they appear with an abnormally low concentration of investment in the 250 thousand ton plant. Thus, the flat products installation as from a unit of 500 thousand tons a year (which would have to roll 185 thousand tons annually of tinplate and sheet), has been planned on the basis of a semi-continuous mill. Such units are much more expensive and are not justifiable for small tonnages; but they produce a cheaper and better quality material in greater quantities than the hand-operated mills considered in the smaller plants. This should also be taken into account when studying possible combinations for intraregional trade.

1/ No possibility of planning industries designed to supply more than one country, has been considered in this paper.

3. The Size of the Markets

The plants for the seven sites selected as examples in paper L.87, are considered in the present analysis as supplying the entire consumption of the domestic market. To estimate requirements, the consumption for 1947 was usually taken, a year of high demand for iron and steel in Latin America. It was reduced by 20 per cent, since it was considered that no matter how varied the production of a given plant might be, the country would still have to import certain special products, the manufacture of which could not be justified on economic grounds. As 1947 consumption figures have been exceeded in many of the countries, the estimate so obtained is low and would therefore tend to give very conservative cost and investment figures for Latin America.

Nevertheless, the above general rule was not followed in the cases of: a) Chile, where consumption figures for 1951-52 were used, due to their increase over those for 1947 as a result of the new production of the Huachipato plant; b) Colombia, Peru and Venezuela, where there is no integrated industry, and where it may be assumed that an increase in consumption would result from the installation of such an industry; this would raise consumption to figures which can be estimated with the aid of the correlations set forth in document L.86. This has been done and the analysis has been based on two different market sizes in each country: a) one on 1947 consumption figures; and b) one corresponding to a possible expansion in consumption following the installation of the industry. The respective figures for Colombia are 105 thousand tons per year;[1/] for Peru, 50 thousand and 150 thousand tons; for Venezuela, 200 thousand and 300 thousand tons.

Pig iron and steel ingot outputs indispensable for finished steel production, corresponding to the estimated consumption, are shown in Table 4.

1/ The 105 thousand ton plant represents the Belencito project and does not include flat products, so that it differs from the assortment of steel products used for all other plants.

/Table 4

Table 4 Plants Considered in This Paper and Their Annual Capacities

(tons per year)

Plant	Pig iron	Steel ingots a/	Finished products
San Nicolás	862,000	1,135,000	850,000
Volta Redonda	735,000	955,000	716,000
Huachipato	236,000	307,000	230,000
Belencito	120,000	140,000 b/	105,000
	286,000	333,000	250,000
Monclova	436,000	573,000	430,000
Chimbote	51,200	67,000	50,000
	154,000	200,000	150,000
Barcelona	205,000	267,000	200,000
	308,000	400,000	300,000
Sparrows Point	1,024,000	1,333,000	1,000,000

a/ Steel ingot demand has been calculated as an average of 1.340 tons per ton of finished steel.

b/ Includes scrap resmelted in the electric furnace.

According to Table 4, only in Argentina, Brazil and Mexico, have the 1947 consumption figures been maintained in the table and, being too low at present, would tend to illustrate unfavourable costs. Actually, this does not occur, as, in these three countries, more than one steel plant has been installed or is in the planning stage. The respective tonnages considered in this paper, therefore, are really more favourable than those of existing plants.

4. Use of Special Ships and Return Cargoes

A further difference between the basic assumptions used in this paper and in document L.87 is that, in the present case, provision has been made for every possibility for reducing transport costs, especially maritime freight. It has been assumed that, where economically justified by the scale of operations, specially built ships and ports would be used.

/Where this

Where this procedure was not justifiable, return cargoes would be employed where there is regular trade.

The comments on Table 1 pointed out that some of the variations in assembly costs for different sizes of plants located at Sparrows Point arose from reductions of transport costs by the above methods. It is obvious that some cost reductions are also feasible in plants with a capacity of 250 thousand tons a year, such as those used to illustrate the influence of locational factors. Table 5 shows finished steel costs; the adjustment has been made adding, for comparative purposes, the costs obtained in document L.85 using normal transport rates.

Table 5 Costs of Finished Steel in 250 Thousand Tons a Year Plants With and Without the Use of Special Means of Transport for Raw Materials

(dollars of 1948 per ton)

Plant	Costs at normal rates	Costs at special rates using return loads	Difference %
San Nicolás	105.34	102.47	2.7
Volta Redonda	102.08	95.74	6.2
Huachipato	83.62	81.14	3.0
Belencito	76.12	75.59	0.8
Monclova	89.94	89.94	..
Chimbote	81.79	80.20	2.2
Barcelona	117.20	112.20	4.3
Sparrows Point	100.25	94.67	5.6

The plants benefiting most from these possibilities are, in order of precedence, Volta Redonda, Sparrows Point and Barcelona, while only very small economies are possible for Mexico and Colombia. Reduction

/of costs

of costs at Sparrows Point is particularly important, this location having been selected for comparing costs in Latin America with those of the steel exporting countries.

5. Costs of Pig Iron, Steel Ingots and Finished Products, in Plants Appropriate to Latin-American Markets

Annexes I, II and III detail production costs corresponding to the three stages of steel manufacture, for plants appropriate to the size of the markets and located in the same sites as those in document L.87. The information contained therein is summarized in Tables 6, 7 and 8, which also show costs corresponding to 250 thousand ton plants.[1/]

1/ The figures used in Table 5 have been used for this comparison, that is, those of paper L.87, after introducing the reductions in freight costs through the use of special ships or return loads.

/Table 6

Table 6 Cost Structure for Pig Iron in Plants Appropriate in Size to Domestic Markets a/

(percentages and dollars of 1948)

Plant and annual capacity of the blast furnaces in thousands of tons	Assembly costs b/ (%)	Salaries & wages (%)	Other expenses (%)	Capital charges (%)	Totals (US$)	250 thousand ton plant with low freight rates (US$)
San Nicolás c/						
862	78.1	1.4	2.5	18.00	42.97	45.76
Volta Redonda						
735	75.0	1.7	3.2	20.1	38.97	41.46
Huachipato						
236	60.0	2.8	5.8	31.4	30.30	30.08
Belencito						
120	47.7	6.0	10.9	35.4	30.26	27.49
285	52.2	3.9	9.2	34.4	27.49	27.49
Monclova						
436	69.9	1.5	4.3	24.3	34.09	35.93
Chimbote						
51	38.8	9.5	22.6	29.1	37.83	29.70
153	46.2	4.1	17.2	32.5	31.85	29.70
Barcelona						
205	54.2	12.4	5.9	27.5	35.62	34.19
308	57.9	9.7	5.4	27.0	33.32	34.19
Sparrows Point						
1024	71.2	5.2	2.8	20.8	27.63	31.02

a/ Costs are expressed in dollars per ton and the four items making up the costs as percentages of these.

b/ Deducting the credit for blast furnace gas.

c/ Using Sierra Grande ore and imported coal.

/Table 7

Table 7 Cost Structure for Steel Ingots in Plants Appropriate to Size of Markets a/

(percentages and 1948 dollars)

Plant and capacity of the steel mill (thousands of tons)	Raw materials (%)	Salaries & wages (%)	Sundry expenses (%)	Capital charges (%)	Total cost (US$)	250,000 thousand ton plant (US$)	250,000 ton plant with low freight rates (US$)
San Nicolás b/							
1,135	69.1	4.9	7.2	18.8	56.66	64.40	61.74
Volta Redonda							
955	67.3	4.8	7.8	20.1	51.35	62.09	56.12
Huachipato							
307	54.5	5.1	10.3	30.1	44.24	46.21	43.96
Belencito c/							
140	36.5	7.0	19.5	37.0	43.52	38.47	38.01
335	39.1	6.3	16.8	37.0	38.01	38.47	38.01
Monclova							
573	61.5	5.1	9.6	23.8	47.76	51.29	51.26
Chimbote							
67	44.2	7.9	19.7	28.2	53.93	44.91	43.46
200	46.2	7.5	16.0	30.3	47.26	44.91	43.46
Barcelona d/							
267	47.7	19.3	8.7	24.3	55.76	58.23	53.69
400	49.8	17.3	8.9	24.0	51.74	58.23	53.69
Sparrows Point							
1,333	61.1	11.5	8.4	19.0	40.12	52.63	47.57

a/ Total costs are expressed in dollars per ton and the four cost items as percentages of these.

b/ Using Sierra Grande ore and imported coal.

c/ Discounting Thomas slag.

d/ Using coke made from imported coal

/Table 8

Table 8 — Cost Structure for Iron and Steel Production in Plants of Size Appropriate to Domestic Markets a/

(pig iron - steel ingots - finished products)
(percentages and 1948 dollars)

Plant and annual capacity in finished steel (thousands of tons)	Raw materials (%)	Salaries & wages (%)	Other expenses (%)	Capital charges (%)	Totals (US$)	Cost in 250,000 ton plant (US$)	250,000 ton plant with low freight rates (US$)
San Nicolás b/							
850	46.5	7.4	11.0	34.1	91.66	--	102.47
Volta Redonda							
716	44.1	7.4	12.4	36.1	85.41	--	95.74
Huachipato							
230	31.2	10.5	13.0	45.3	82.44	--	81.14
Belencito c/							
105	19.1	13.7	19.6	47.6	76.56	--	75.59
250	18.0	14.0	17.4	50.2	75.59	76.12	75.59
Monclova							
430	38.2	8.2	13.0	39.9	83.10	--	89.94
Chimbote							
50	23.1	15.3	18.4	43.2	102.22	--	80.20
150	25.0	11.7	16.4	46.9	89.93	81.79	80.20
Barcelona							
200	22.9	34.5	9.2	33.4	121.47	--	112.20
300	26.0	30.6	10.3	33.1	105.03	117.20	112.20
Sparrows Point							
1,000	37.4	18.4	12.7	31.5	71.92		94.67

a/ Total costs are expressed in dollars per ton and the four items composing them in percentages of these.

b/ Using Sierra Grande ore.

c/ Discounting Thomas slag.

d/ Using coke made from imported coal.

/It is

It is probably a mere coincidence that the locations showing the highest assembly costs in L.87, Argentina and Brazil, are favoured in the present cost calculations because of the greater size of their markets. Inversely, those sites where assembly costs are lower correspond to countries with the smaller markets: Chile, Colombia and Peru. As a result, in Latin America as a whole, consideration of the scale of operation tends to reduce the differences between costs.

As explained earlier, two solutions are presented for Venezuela: a 200,000 ton plant, based on the 1947 market; and one for 300,000 tons, corresponding to potential demand, estimated according to document L.86. While the cost of finished steel in the first amounts to 121 dollars per ton, it is only 105 dollars in the second. This figure, considerably higher than that for the other sites, is due to the high wage rates. It is interesting to note that the considerable influence of the size of plant, in this case, is mainly due to the high level of wages.

Finally, costs at Sparrows Point (which did not differ substantially from those referring to the other plants in paper L.87) are very much lower as a result of the large size assigned to the plant (1 million tons a year).

Table 9 shows the average costs for the eight locations, including Sparrows Point, both when capacity equals 250,000 tons, and when it is appropriate to the size of the markets.

/Table 9

Table 9 — Comparisons Between Average Costs in the Seven Latin-American Countries and at Sparrows Point

(percentages and dollars of 1948 per ton)

	Pig iron	Steel ingots	Finished products
A) 250 thousand tons a year plants using reduced freight rates			
Average costs in the seven plants	35.24	50.07	91.34
Differences between extreme costs in relation to average	52%	47%	40%
Difference of average with respect to Sparrows Point costs	+ 12%	+ 5%	- 4%
B) Plants appropriate to the size of the markets in Latin America a/			
Average costs in the seven plants b/	34.14	48.14	87.59
Differences between extreme costs in relation to average	45%	38%	33%
Differences between average and Sparrows Point costs	+ 19%	+ 17%	+ 18%

a/ Selecting the larger plants in those cases where plants of two sizes have been studied for one location.

b/ Arithmetic average. If weighted averages are used, results are slightly more favourable.

The influence of the scale of operations has drawn cost figures closer together. The spread between the maximum and minimum in relation to the average has fallen by 7 to 9 per cent of the total cost. Differences between the average and cost at Sparrows Point have increased considerably, to the disadvantage of Latin-American plants: 7 per cent for pig iron ; 12 per cent for steel ingots and 22 per cent in finished products. These variations in the percentages reflect the different influence of size on the three steps of steel production.

The grouping of plants by sizes, as shown in Table 10, brings out the importance of the scale of operations more clearly.

/Table 10

Table 10 Differences Between Production Costs for Finished Steel in Plants Appropriate to Size of the Markets and in Plants Having a Capacity of 250,000 Tons

(percentages and dollars of 1948 per ton)

Location	A Annual capacity (thousands of tons)	B Costs per ton In plants of adjusted size (US$)	C Costs per ton In 250,000 ton plants (US$)	D Percentage difference B - C / C
Chimbote	50	102.22	80.20	+ 28
Chimbote	150	89.93	80.20	+ 12
Barcelona	200	121.47	112.20	+ 8
Huachipato	230	82.44	81.14	+ 2
Belencito a/	250	75.59	75.59	..
Barcelona	300	105.03	112.20	- 6
Monclova	430	83.10	89.94	- 8
Volta Redonda	716	85.41	95.74	- 11
San Nicolás	850	91.66	102.47	- 11
Sparrows Point	1,000	71.92	94.67	- 24

a/ The 105,000 ton plant being built at Belencito has not been included, since, as an exception to the others, flat products will not be produced there. The plant is of special design with no blooming mill, and the steel ingots will thus be small.

Variations as regards costs of 250,000 ton plants range from a 28 per cent increase in the 50 thousand ton plant to a reduction of 24 per cent in the one million ton plant.

6. Utilization of Resources by the Iron and Steel Industry

Table 11 shows the utilization of labour in man-hours per ton, as well as value added by the industry. These figures are useful to ascertain whether a steel industry should be created in a country, or a larger volume imported. As stated in paper L.87, the table is based on the assumption that labour in the Latin-American plants has reached a similar efficiency as in the United States. Naturally this will only occur after

/some years

some years of operation, if there has been no previous iron and steelmaking experience.

Table 11 Utilization of Labour in the Iron and Steel Industry

(man-hours, tons and dollars of 1948)

Plant	Capacity (thousands of tons)	Man-hours per ton	Tons of steel produced per man	Value of production per man-year	Value added to raw materials per man-year a/
Chimbote	50	38.3	63	6,430	4,950
Chimbote	150	25.7	93	8,363	6,270
Barcelona	200	20.7	116	14,090	10,960
Huachipato	230	19.7	122	10,057	6,918
Belencito	250	17.7	136	10,280	8,388
Barcelona	300	16.0	150	15,754	11,658
Monclova	430	13.9	172	14,293	8,832
Volta Redonda	716	12.1	211	18,021	10,073
San Nicolás	850	12.0	213	19,523	10,443
Sparrows Point	1,000	8.5	300	21,576	9,189

a/ The figures correspond to the hypothesis that raw materials are purchased from independent companies. Where the mines are directly owned, value added per worker falls on an average by 14 per cent, due to the low price of the minerals.

Table 11 shows the substantial influence exerted by the size of the plant on productivity. The million ton plant at Sparrows Point requires, per ton of steel, less than half the manpower needed by the 250,000 ton plant at Belencito. The projected 50 thousand ton plant at Chimbote requires, per ton, more than double the manpower of the 250,000 ton plant. There is thus a ratio of almost 5 to 1 between the extremes. The scale of operations on productivity is large anough to compensate for the reduction in the cost, and results in increases of value added to the raw materials in the larger plants. These increases, however, are lower than that of total

production per man-year, because in the larger plants a greater volume of raw materials is also transformed per worker.

While the value added per man is approximately doubled when passing from a 50 thousand ton to a one million ton plant, value of production per man increases more than threefold. The two plants analysed for Barcelona, in Venezuela, show higher figures for total production and value added than would correspond to their position within the order of size. This is because the wage rates are unusually high.

Finally, the sharp jump as regards labour requirements between the 850,000 ton and the one million ton plants, is due to the assumption that a continuous wide strip mill would be used for flat products in the latter case.

Table 11 shows that the primary iron and steel industry yields a considerable output per man employed: between 6,430 and 21,576 dollars a year. Also the value added to raw materials is high: between 4,950 and 11,658 dollars. In other words, labour intensity is rather small in the industry. Alternatively, capital intensity is large, as may be seen from Table 12.

/Table 12

Table 12 — Utilization of Investment in the Iron and Steel Industry

(tons and dollars of 1948)

Plant	Capacity (thousands of tons)	Investment per ton-year	Tons of steel (per 100 dollars invested)	Annual output (per 100 dollars invested	Value added to raw materials (per 100 dollars invested)
Chimbote	50	491	0.203	20.75	15.96
Chimbote	150	469	0.213	19.16	14.36
Barcelona	200	451	0.222	26.96	20.97
Huachipato	230	415	0.241	19.86	13.66
Belencito	250	422	0.237	17.91	14.61
Barcelona	300	386	0.259	27.20	20.13
Monclova	430	368	0.272	22.60	13.97
Volta Redonda	716	343	0.292	24.93	13.94
San Nicolás	850	355	0.282	25.84	12.02
Sparrows Point a/	1,000	283	0.353	25.38	15.89

a/ The lower investment at Sparrows Point is partly due to the assumption that transportation, combined with lesser facilities as regards mechanical workshops, increase equipment costs by 20 per cent in Latin America, as compared with those for a similar plant in the United States.

b/ These columns compare capital with what has been termed "production cost" in papers L.87 and L.91. Such cost consists of the operating costs, including repairs and amortization, plus 4 per cent a year on investments. Therefore, the value added and the value of production do not refer to selling prices, which is the usual way of expressing these relationships.

c/ In compiling this table, it has been assumed that the plants would acquire their raw materials from third parties. If mines are directly owned, as is the case in an integrated plant, value added per 100 dollars invested improves on the average by 4 to 5 per cent, because of relatively smaller investments in the mines.

/The investment

The investment per ton of annual output declines with the increased size of the plant, but in a lesser degree than does productivity.

As mentioned in note b/ of Table 12, value of production and that added to raw materials are being compared here with a figure termed "production cost" which includes only part of the profits and no provision for tax reserves and other items, which usually make up the selling price. The coefficients obtained in this paper are therefore somewhat smaller than usual.

In order to obtain a figure representing the average selling price in some export markets for the products assigned to the Latin-American plants, the so-called "Composite Finished Steel" price was selected. It has been compiled and published for many years by American Metal Market. The average value of that weighted price was 86.20 dollars per ton, placed in Pittsburgh, in 1948.

To this sum, steel transport costs from Pittsburgh to the markets in Latin America should be added, while deducting transport costs from the selected regional plants to their respective markets. According to available data, the difference between freight rates from the Atlantic seaboard of the United States minus the cost of local transport, amounted in 1948 to: 10 dollars per ton for Venezuela, 12 for Colombia and Mexico, 14 for Brazil and Peru, 15 for Chile and 19 for Argentina. Supplementary transport costs between the United States iron and steel producing centres, and the Atlantic seaboard, may be estimated at some 10 dollars per metric ton.

On the basis of these figures output and value added per year for each 100 dollars invested are shown in Table 13, which to facilitate comparison, also reproduces figures based on hypothetical costs.

/Table 13

Table 13 Comparison of Value of Output and Value Added to Raw Materials, in the Iron and Steel Industry, either Delivered Costs or Delivered Selling Prices a/

(thousands of tons and dollars of 1948 per 100 dollars invested)

Plant	Capacity	Dollars per ton based on estimated costs		Dollars per ton based on possible selling prices	
		Annual output	Value added to raw materials	Annual output	Value added to raw materials
Chimbote	50	20.75	15.96	22.37	17.57
Chimbote	150	19.16	14.36	23.47	18.68
Barcelona	200	26.96	20.97	23.57	17.59
Huachipato	230	19.86	13.66	26.79	20.60
Belencito	250	17.91	14.61	25.64	22.34
Barcelona	300	27.20	20.13	27.50	20.43
Monclova	430	22.60	13.97	29.43	20.79
Volta Redonda	716	24.93	13.94	32.17	21.15
San Nicolás	850	25.84	12.02	32.48	20.46
Sparrows Point	1,000	25.38	15.89	33.95	19.41

a/ Selling prices have been estimated, adding to the average "Composite Finished Steel" price in Pittsburgh in the base year, transport costs from Pittsburgh to the Latin-American markets, and subtracting transport transport costs from Latin-American plants to their respective markets.

The total output-value per 100 dollars invested annually, in the seven Latin-American countries, averaged 22.50 dollars, rising to 28.21 for total value of production; at selling prices for value added the averages were 14.67 and 20.64 dollars respectively. The last figure means that the capital coefficient in this industry would have been about 4.8 units of capital for one of value added in manufacture.

This relationship improves still further to about 4.5, in the case of integrated plants, since in this instance the plant also owns and works the

/mineral deposits.

mineral deposits.

These figures indicate that the capital intensity of steelmaking is very substantial. Therefore, before deciding to construct a new plant, careful study of its advantages and disadvantages appear to be indicated. The alternative might be to develop other industries earning foreign exchange and to base steel supplies upon increased imports. Some data is given in paper L.88 concerning the structure of the primary and secondary iron and steel industries. This enumeration of the indirect advantages inherent in the establishment of steel transforming industries in Latin America, should also be borne in mind when reaching a decision, since the primary industry might be necessary to ensure a more regular supply of steel products. Foreign currency resources are notoriously scarce in most of the Latin-American countries. Table 14 shows those items in the cost of steel which correspond to foreign currency disbursements.

Table 14 Foreign Currency Payments Per Ton of Finished Steel

(percentages and dollars of 1948)

Plant	Imported fuel	Wages & salaries	Ferro-alloys	Sundry expenses	Capital charges	Total payments in foreign currency	Percentage of cost at the plant
Percentages of foreign currency	(100%)	(5%)	(50%)	(33%)	(75%)		
San Nicolás	23.28	0.34	1.27	3.63	23.47	51.99	57%
Volta Redonda	12.84	0.31	1.04	3.47	23.14	40.80	48%
Huachipato	3.07	0.43	1.28	3.55	27.97	36.30	44%
Belencito (250,000)	..	0.52	0.93	4.33	28.47	34.25	45%
Belencito (105,000)	..	0.52	1.12	4.97	27.33	33.94	44%
Monclova	..	0.34	1.31	3.78	24.89	30.32	44%
Chimbote (50,000)	3.11	0.78	1.53	6.20	33.15	44.77	44%
Chimbote (150,000)	3.11	0.47	1.15	4.84	31.56	41.13	47%
Barcelona (200,000)	12.20	2.10	1.40	3.66	30.43	49.79	41%
Barcelona (300,000)	12.20	1.60	1.15	3.56	26.12	44.63	43%

/Considerable saving

Considerable saving in foreign currency arises in all cases as a result of iron and steel production in Latin America. Payments in foreign exchange amount to 46 per cent of the average costs (considering only the most favourable plants) in those countries in which more than one solution has been included. The percentage of foreign exchange savings shown in Table 14 is of course lower than in reality, since, as noted earlier, the average prices which the region must pay for imports exceed the costs estimated for the United States by some 22 dollars per ton. If this figure is used as a basis, the savings in foreign exchange would correspond to 64 per cent of the purchase price in domestic markets.

7. Steel Costs in Latin-American Plants Compared with Delivered Cost of Imported Steel

It was concluded from Table 9 that steel produced at Sparrows Point, in a one million tons plant, would be 18 per cent cheaper placed at the plant, than the average of seven Latin-American plants. It is therefore interesting to compare the costs of domestically produced steel with the costs at which steel imported from the United States might be delivered to the markets of the region.

In connexion with Table 13, such terms as "Composite Finished Steel" and "Transport Cost Differentials" have been explained. The latter represents in reality the advantage in transport costs which occurs to Latin-American steel plants due to the short distances to their respective markets. Its addition to costs or prices in the respective production centres in exporting countries,[1/] permits direct comparison with the figures obtained throughout these studies. The selection of 1948 figures for the United States selling price is due to the use of dollars at 1948 values, throughout these papers.

1/ The terms "Delivered cost of imported steel" and "Delivered price of imported steel", which have been applied to this addition, for the sake of simplicity, are therefore arbitrary, as the corresponding figures do not represent real selling prices or costs.

Delivered costs and prices for imported steel, thus obtained, are shown in Table 15. It is evident this delivered price in different Latin-American locations requires two conditions to be valid: a) that the selling price for export steel should be the same as that prevailing in the United States market, which is not always the case, and b) that there should be no additional profits, premiums nor surcharges.

Table 15 Steel Production Costs in Latin America Compared with Costs of Imported Steel

(thousands of tons and dollars of 1948)

Plant	A Capacity (thousands of tons)	B Cost per ton	C Delivered cost of Sparrows Point steel	D Delivered selling price of Pittsburgh steel in 1948
Chimbote	50	102	86	110
Chimbote	150	90	86	110
Barcelona	200	121	82	106
Huachipato	230	84	89	111
Belencito	250	76	88	108
Barcelona	300	105	82	106
Monclova	430	83	84	108
Volta Redonda	716	85	86	110
San Nicolás	850	92	91	115
Sparrows Point	1,000	72		

a/ Cost at Sparrows Point, plus transport cost differentials (see Table 13).
b/ Composite finished steel price in Pittsburgh in 1948 plus transport cost differentials. Freight costs from Pittsburgh to United States port have been estimated at 10 dollars per ton.

The table shows:

A) That production costs, at 200,000 tons a year in Venezuela, would exceed the delivered sales price of United States steel placed on the market there.
B) That costs at the slightly larger plant of 300,000 tons, would be equivalent to the delivered selling price of imported steel, and would exceed delivered cost by more than 20 per cent.
C) That cost in the two plants in Peru will lie in between the delivered cost and the delivered selling price of imported steel amounting to 16 per cent over the 50 thousand ton plant and 5 per cent higher in the case of the 150,000 ton plant.
D) In all the other plants which have been considered, cost in Latin America would be the same or below the delivered cost of imported steel. Colombia is in the most favourable position, with an advantage of 16 per cent.

Latin American production costs are based on the assumption that the plants are working at full capacity, and efficiency of its labour force; in countries with no previous experience of the iron and steel industry, it would only occur several years after the plant had been in operation.

Annex I A — Pig Iron Costs in Plants Appropriate to Size of the Markets

(Dollars of 1948 per ton)

Plant	San Nicolas	Volta Redonda	Huachipato	Belencito		Sparrows Point
Annual Capacity[a]	850 [b]	716	230	105	250	1,000
Iron ore	11.39	9.55	6.50	6.46	6.46	10.90
Coal	23.00	19.68	12.60	8.75	8.75	9.74
Limestone	1.08	1.90	0.97	1.13	1.13	0.92
Credit for blast furnace gas	-1.90	-1.90	-1.90	-1.90	-1.90	-1.90
Total assembly costs	33.57	29.23	18.17	14.44	14.44	19.66
Direct wages	0.26	0.29	0.37	0.80	0.47	0.63
Indirect wages and salaries	0.33	0.37	0.47	1.02	0.60	0.80
Total wages and salaries	0.59	0.66	0.84	1.82	1.07	1.43
Cooling water	0.37	0.38	0.43	0.57	0.42	0.36
Additional coking cost						
Coking plant credits	-0.86	-0.67	-0.81	-0.88	-0.88	-1.06
Repairs and overheads	1.56	1.54	2.13	3.60	2.49	1.48
Total miscellaneous conversion costs	1.07	1.25	1.75	3.29	2.53	0.78
Direct cost	35.23	31.14	20.76	19.55	18.04	21.87
Capital charges	7.74	7.83	9.54	10.71	9.45	5.76
Total cost	42.97	38.97	30.30	30.26	27.49	27.63

a/ In thousands of tons
b/ Using Sierra Grande ore

/Annex I B

Annex I B Pig Iron Costs in Plants Appropriate to Size of the Markets

(Dollars of 1948 per ton)

Plant	Monclova	Chimbote		Barcelona		Sparrows Point
Annual Capacity[a/]	430	50	150	200	300	1,000
Iron ore	15.50	8.06	8.06	8.70	8.70	10.90
Coal	9.56	7.44	7.44	11.91	11.91	9.74
Limestone	0.68	1.09	1.09	0.60	0.60	0.92
Credit for blast furnace gas	-1.90	-1.90	-1.90	-1.90	-1.90	-1.90
Total assembly costs	23.84	14.69	14.69	19.31	19.31	19.66
Direct wages	0.23	1.59	0.58	1.94	1.42	0.63
Indirect wages and salaries	0.29	2.02	0.74	2.46	1.80	0.80
Total wages and salaries	0.52	3.61	1.32	4.40	3.22	1.43
Cooling water	0.44	0.94	0.42	0.45	0.42	0.36
Additional coking costs		+ 2.40	+ 2.40			
Coking plant credits	-0.76			-0.65	-0.65	-1.06
Repairs and overheads	1.77	5.21	2.67	2.30	2.02	1.48
Total miscellaneous conversion costs	1.45	8.55	5.49	2.10	1.79	0.78
Direct cost	25.81	26.85	21.50	25.81	24.32	21.87
Capital charges	8.28	10.98	10.35	9.81	9.00	5.76
Total cost	34.09	37.83	31.85	35.62	33.32	27.63

a/ In thousand of tons.

/Annex II A

Annex II A — Costs of Crude Steel in Plants Appropriate to Size of the Markets

(dollars of 1948 per ton)

Plant	San Nicolás	Volta Redonda	Huachipato	Belencito		Sparrows Point
Annual capacity[a]	850[b]	716	230	105	250	1,000
Liquid pig iron	32.61	29.93	23.27	25.93	23.56	21.20
Circulating scrap	7.85	6.98	5.43	5.58	5.07	4.95
Purchases scrap	3.91	3.58	2.78	2.75	2.50	2.54
Ferroalloys	1.90	1.55	1.92	1.68	1.40	1.90
Credit for Thomas slag				-6.50	-6.50	
Total ferrous material cost	46.27	42.04	33.40	29.44	26.03	30.59
Direct wages	2.00	1.60	1.33	0.90	0.90	2.67
Indirect wages and salaries	0.35	0.36	0.29	0.60	0.60	0.84
Total wages and salaries	2.35	1.96	1.62	1.50	1.50	3.51
Fuel oil	1.32	1.06	1.06			0.85
Limestone and refractories	1.00	1.00	1.10	1.95	1.45	1.00
Maintenance materials	0.50	0.50	0.50	1.10	0.80	0.40
Miscellaneous materials, services and overheads	0.45	0.50	0.57	1.35	0.97	0.50
Purchased electric power				1.26	1.00	
Total fixed conversion costs	3.27	3.06	3.23	5.66	4.22	2.75
Direct costs	51.89	47.06	38.25	36.59	31.75	36.85
Capital charges	4.77	4.29	5.99	6.93	6.26	3.17
Total cost	56.66	51.35	44.24	43.52	38.01	40.02

a/ In thousands of tons
b/ Using Sierra Grande ore

/Annex II B

Annex II 3 Costs of Crude Steel in Plants Appropriate to the Size of the Markets

(dollars of 1948 per ton)

Plant	Monclova	Chimbote		Barcelona		Sparrows Point
Annual capacity a/	430	50	150	200	300	1,000
Liquid pig iron	25.87	29.05	24.46	27.36	25.59	21.20
Circulating scrap	6.23	6.78	5.70	6.38	5.97	4.95
Purchased scrap	3.10	3.47	2.92	3.27	3.06	2.54
Ferroalloys	1.95	2.30	1.92	2.11	1.92	1.90
Credit for Thomas slag						
Total ferrous material cost	37.15	41.60	35.00	39.12	36.54	30.59
Direct wages	1.72	1.24	1.24	6.04	5.30	2.67
Indirect wages and salaries	0.30	0.27	0.27	1.34	1.17	0.84
Total wages and salaries	2.02	1.51	1.51	7.38	6.47	3.51
Fuel oil	1.32	1.27	1.17	1.06	1.06	0.85
Limestone and refractories	1.10	1.43	1.10	1.10	1.10	1.00
Maintenance materials and services	0.50	0.64	0.50	0.50	0.50	0.40
Miscellaneous materials and overhead	0.57	0.73	0.57	0.57	0.57	0.50
Purchased electric power						
Total fixed conversion costs	3.49	4.07	3.34	3.23	3.23	2.75
Direct cost	42.66	47.18	39.85	49.73	46.24	36.85
Capital charges	5.10	6.75	6.40	6.03	5.50	3.17
Total cost	47.76	53.93	46.25	55.76	51.74	40.02

a/ In thousands of tons.

/Annex III A

Annex III A — Finished Steel Cost in Plants Appropriate to Size of the Markets

(dollars of 1948 per ton)

Plant	San Nicolás	Volta Redonda	Huachipato	Belencito		Sparrows Point
Annual capacity a/	850 b/	716	230	105	250 c/	1,000
Steel ingots (1,333 kgs)	75.55	68.47	58.99	58.03	51.07	53.36
Fuel, blast furnace gas	0.88	0.88	0.88	0.88	0.88	0.88
Credit for circulating scrap	-10.47	-9.31	-7.24	-7.44	-6.76	-6.60
Total raw materials	65.96	60.04	52.63	51.47	45.19	47.64
Rolling mill wages	2.28	2.33	4.69	4.43	6.11	5.59
Wages for maintenance and overhead	0.75	0.72	0.94	2.00	1.22	1.98
Total wages and salaries	3.03	3.05	5.63	6.43	7.33	7.07
Refractories and spare parts	2.00	2.00	2.00	1.60	2.00	2.00
Supplies for maintenance and overhead	1.45	1.45	1.45	1.16	1.45	1.45
Electric power	2.12	1.77	1.20	0.96	1.20	1.20
Total supplies and services	5.57	5.22	4.65	3.72	4.65	4.65
Direct cost	74.56	68.31	62.91	61.62	57.17	59.36
Capital charges	17.10	17.10	19.53	14.94	18.81	12.56
Total cost	91.66	85.41	82.44	76.56	75.98	71.92

a/ In thousands of tons.

b/ Using Sierra Grande ore.

c/ The 250,000 ton plant rolling the complete assumed assortment of products, the 105,000 ton plant, only bars and light rails, shapes and structures.

/Annex III B

Annex III B Finished Steel Cost in Plants Appropriate to Size of the Markets

(Dollars of 1948 per ton)

Plant	Monclova	Chimbote		Barcelona		Sparrows Point
Annual capacity a/	430	50	150	200	300	1,000
Steel ingots (1,333 kgs)	63.61	71.91	61.67	74.35	68.99	53.36
Fuel, blast furnace gas	0.88	0.88	0.88	0.88	0.88	0.88
Credit for circulating scrap	-8.31	-9.04	-7.60	-8.51	-7.96	-6.60
Total raw materials	56.18	63.75	54.95	66.72	61.91	47.64
Rolling mill wages	2.82	7.34	5.62	23.00	16.80	5.59
Wages for maintenance and overhead	0.78	2.54	0.12	4.60	3.40	1.48
Total wages and salaries	3.60	9.88	5.74	27.60	20.20	7.07
Refractories and spare parts	2.00	2.00	2.00	2.00	2.00	2.00
Supplies for maintenance and overhead	1.45	1.45	1.45	1.45	1.45	1.45
Electric power	1.87	1.20	1.20	1.20	1.20	1.20
Total supplies and services	5.32	4.65	4.65	4.65	4.65	4.65
Direct cost	65.10	78.28	65.34	98.97	86.76	59.36
Capital charges	18.00	23.94	22.95	22.50	18.27	12.56
Total cost	83.10	102.22	88.29	121.47	105.03	71.92

a/ In thousands of tons.