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# ECONOMIC ADVANTAGES OF THE CREATION OF IRON AND STEEL PLANTS FOR SMALL COUNTRIES ON A REGIONAL BASIS[1]

by

R. Robson,
Economic Commission for Africa



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

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# ECONOMIC ADVANTAGES OF THE CREATION OF IRON AND STEEL PLANTS FOR SMALL COUNTRIES ON A REGIONAL BASIS[1]

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## SUMMARY

The advantages of co-operation are first of all in securing larger markets which provide the possibility of constructing plants of an economic size thereby achieving substantial savings in investment and in operating costs, and of manufacturing economically a wider range of products and so, still further reducing dependence on imports. Secondly, it gives a wider access to resources which are only located in certain favoured areas.

The economies of scale are given for sizes of plants ranging from 50 to 400 thousand tons per annum and for the four categories, iron and steel production up to and including casting, bar and section rolling, and hot and cold rolled sheet. The economies are shown separately for investment, labour costs and other operating costs. Investment per ton for a plant of 100 thousand tons annual capacity is about 80% higher than in one of 400 thousand tons capacity for iron and steel making and three times higher for hot strip rolling. Labour costs per ton are correspondingly about 60% higher and other operating costs about 25% higher.

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The advantages of co-operation in securing larger markets and economies of scale are partly offset by the higher transport costs involved in distributing to a wider market, and an analysis is given of normal transport costs on steel and raw materials according to type of transport, i.e. rail, road and sea. The number of plants which can most economically supply a given market depends on the density of the market and the means of transport available.

The economies of specialisation consist of retaining economies of scale at the rolling stage while losing them at the steelmaking stage. Conversely, the establishment of re-rolling works supplied from a central integrated works retains economies of scale at the steelmaking stage but loses them at the rolling stage. Both these procedures may be desirable to secure co-operation in developing the iron and steel industry on a multi-national basis. The most suitable re-rolling operations are the re-rolling of bar and light sections from billets and the cold reduction of hot rolled strip.

Having regard to the higher processing costs at every stage the use of even slightly inferior local ores may have no advantage over the use of ores available on a sub-regional basis. In this connexion transport costs are vital and the location of a multi-national works can only be established after a careful calculation of costs of assembling raw materials and of distributing the finished product. In general, however, the attraction is towards the source of materials.

Detailed location calculations of this kind have been made in the West African and East African sub-regions and are summarised in the paper. In the West African sub-region it was found that the lowest over-all cost site for a single integrated works supplying the whole sub-region would be at Lower Buchanan in Liberia. Subsequently, in order to accommodate the views of other countries wishing to establish iron and steel manufacture, it was proposed to establish a number of re-rolling works based on the Liberian works. In East Africa a number of possibilities were evaluated including a single integrated works supplying the whole sub-region, two integrated works, three integrated works and also re-rolling works. Since in contrast to West Africa the main centres of consumption in East Africa are inland and transport costs therefore higher the argument in favour of a single integrated works is not so strong.

## 1. Introduction

Included in the scope of this study is a general account of the advantages, where small countries are concerned, of constructing iron and steel plants based on the resources and markets of several countries. This is followed by an analysis of the economies to be obtained in so doing and finally an account is given of some proposed groupings in this regard among African countries.

## 2. General Advantages

The advantages of access to larger markets are first those arising from economies of scale in the construction of large plants of an economic size. These economies lie mainly in the very considerable savings in investment cost and skilled labour required per unit of output and to a lesser extent in savings on fuel and power. The larger market can only be obtained, however, at the expense of higher distribution costs and these must be allowed for in calculating the net advantage of a large plant. Secondly, and associated with economies of scale are the advantages of specialization possible in a large market including not only those of scale but also those of being able to produce economically a wider range of products and varieties and so reduce still further the dependence on imports. A further aspect of specialization is the possibility of establishing re-rolling plants based on suitably located integrated works which not only may reduce transport and marketing costs but also gives rise to those general social and economic advantages accruing from a rational dispersal of industry.

The advantages of a wider access to resources can be important in view of the complete independence in the location of markets and minerals, the best supplies of minerals often being located in the least densely populated areas. This circumstance profoundly influences the optimum location of iron and steel plants a detailed calculation of the costs of assembling materials, of manufacturing at the site and of distributing the finished steel being necessary to establish the optimum for each grouping of countries concerned.

## 3. Economies of Scale

For the purpose of analysing economies of scale the steelmaking processes may be usefully divided into integrated iron and steel production up to and including casting - most probably continuous casting, the rolling of bar and sections from such castings (billets) and the rolling of flat products, hot and cold, from slabs.

Dealing then first with economies in investment, an increase in integrated steel producing capacity of 10 per cent requires an increase in investment of about 6 per cent up to capacities of about 200,000 tons per annum, then of about 7 per cent up to half a million tons. For the production of hot rolled wide strip the corresponding increases in investment are only about 3 per cent up to a capacity of [illegible] per annum when reversing mills are no longer adequate and then of 6 per cent afterwards. For cold reduced strip, economies of scale are relatively small; up to about 300,000 tons capacity, an increase of 8 per cent in investment is required to obtain a 10 per cent increase in capacity after which it rises to 10 per cent, i.e. there are no further economies of scale. For bar and sections different installations are required at different levels of capacity but on the average an increase of 10 per cent in capacity is obtained by a 7 per cent increase in investment.

The following table gives estimated fixed capital cost per annual ton of product for the four processes.

**Fixed capital investment per annual ton of product** (US $)

| Capacity '000 tons per annum | | 50 | 100 | 200 | 300 | 400 |
|---|---|---|---|---|---|---|
| Iron and steel production and casting | | 350 | 265 | 200 | 175 | 150 |
| Rolling: | bar and sections | 155 | 125 | 100 | 90 | 80 |
| | hot rolled sheet | 410 | 240 | 140 | 100 | 85 |
| | cold reduced sheet | 185 | 160 | 140 | 130 | 129 |

In practice it would be possible to keep the investment per ton required to produce bar and sections at about $125 at lower levels of capacity by adopting less mechanized mills. Similarly, in the case of iron and steel production it is possible to secure a reduction in capital cost per annual ton at lower levels of capacity by dispensing with coke plant and sinter plant.

To realise these economies it is of course necessary to avoid the proliferation of plants, e.g., the investment required to produce 200,000 tons per annum of cold reduced sheet in two plants would be about $138 million compared with $100 million in a single plant.

4. The position in regard to labour is that labour actually operating machines remains virtually the same regardless of scale, maintenance labour roughly follows capital investment while there are substantial economies in administrative labour. On the other hand certain categories of labour, e.g. on packing and despatch are proportional to output and will become relatively more important at large capacity. In total therefore, labour per ton of output falls more rapidly than investment up to a level of capacity where these other categories make themselves felt. The following table gives estimated man-hours per annual ton, under African conditions, of product for the four processes.

**Estimated man-hours per annual ton of product**

| Capacity '000 tons per annum | 50 | 100 | 200 | 300 | 400 |
|---|---|---|---|---|---|
| Iron and steel production and casting | 20 | 14 | 10 | 9 | 8½ |
| Rolling: bar and sections | 16 | 8 | 6 | 5½ | 5 |
| hot rolled sheet | 16 | 6 | 5 | 4 | 3½ |
| cold reduced sheet | 12 | 8 | 6 | 6 | 5½ |

As will be seen from the following table a high proportion of the manpower required is technical or skilled and this proportion will be higher still at low levels of capacity.

Classification of labour in a modern integrated iron and steel works

| | | per cent |
|---|---|---|
| Managers and senior technicians | | 4 |
| Junior technicians: | Foremen | 4 |
| | Technical | 4 |
| | Clerical | 8 |
| | General | 10 |
| Skilled and semi-skilled operatives: | | |
| | Craftsmen, i.e. welders, joiners, bricklayers, fitters, electricians | 11 |
| | Other maintenance workers and repairers | 8 |
| | Drivers and transport | 5 |
| | Production operatives | 30 |
| Unskilled operatives: | | |
| | Labourers<br>Cleaners | 16 |
| | Total | 100 |

The managerial category may be further classified as follows:

| | | |
|---|---|---|
| Managers and assistants: | | 15 |
| Engineers: | Mechanical | 12 |
| | Electrical | 5 |
| | Chemical | 8 |
| | Metallurgy | 10 |
| | Design | 13 |
| Clerical: | Secretaries | 13 |
| | Accountant and commercial | 18 |
| Miscellaneous | | 6 |
| | Total | 100 |

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The remaining category of cost includes a great variety of items, some such as raw material including ferro-alloys being constant per ton of product, others such as fuel and power and maintenance materials, declining with increasing capacity but not so rapidly as investment, or others including some bought services being proportional to output. Actual costs, especially of raw materials, depends on the distance over which they have to be transported and the following is

local ores.

**Materials and power cost per annual ton of product** (US $)

| Capacity '000 tons per annum | 50 | 100 | 200 | 300 | 400 |
|---|---|---|---|---|---|
| Iron and steel production and casting | 75.0 | 62.2 | 56.2 | 52.5 | 52.0 |
| of which ores, coke, fuel oil | 28.0 | 27.9 | 27.8 | 27.6 | 27.6 |
| Bar and sections | 10.0 | 9.0 | 8.8 | 8.4 | 8.2 |
| Hot rolled sheet | 10.0 | 7.0 | 4.9 | 4.2 | 3.8 |
| Cold reduced sheet | 8.0 | 7.0 | 6.3 | 6.0 | 5.8 |

In combining these three sets of figures to obtain total costs a great deal depends on the return required on capital and to a lesser extent on the level of wages. Under African conditions a rate of return of 10 per cent has been proposed but up to 25 per cent might well be necessary. Wages under African conditions average $0.8 per man-hour; in other developing countries where wages are higher their incidence may be offset by higher productivity.

4. Transport costs

Transport costs including running costs, handling costs and terminal costs vary greatly according to the type of transport, e.g. sea transport is characterized by high terminal charges and low running costs while at the other extreme road transport has no terminal charges but comparatively high running costs. They also vary from country to country, e.g. they are lower in the U.A.R. and in South Africa than in other African countries and mineral rates especially are often subsidized. Nevertheless the following rates are typical of European countries and average African conditions.

(cents)

| | | | Handling per ton | Terminal per ton | Running per ton/km. |
|---|---|---|---|---|---|
| Rail: | mineral | | 10 | 50 | 0.6 |
| | steel | | 40 | 80 | 1.2 |
| Road: | mineral | | 10 | - | 1.2 |
| | steel | | 40 | - | 1.8 |
| Ship: | ocean going: | mineral | 150 | 300 | 0.05 |
| | | steel | 350 | 600 | 0.05 |
| | coastal: | mineral | 75 | 150 | 0.08 |
| | | steel | 175 | 300 | 0.08 |

If then for example the location of market centres is such that the market can be doubled by incurring an additional average distance of 1,000 kilometres transport the extra cost by rail transport would be $12 per ton and by sea less than $1 per ton. The saving in costs of production of bar and rod at an integrated works would be (assuming 10 per cent return on capital) about $21 a ton in increasing capacity from 100,000 to 200,000 tons per annum and about $14 in increasing from 200,000 to 400,000 tons per annum and at 25 per cent return $35 and $25 respectively. A great deal depends therefore on return on capital and on whether the various countries seeking to co-operate to the extent of establishing a single works to supply all requirements are coastal or inland. Conversely it would appear that two inland works would have lower overall costs of production and distribution than a single [illegible] a single works were more than about [illegible] markets it would be economic to have two works of [illegible] tons per annum capacity instead of one of a million tons if the extra transport distance to the single works were more than about 400 km by rail.

5. Specialization

The economies of specialization are mainly those of scale and consist normally of retaining these economies at the rolling stage while losing them at the steelmaking stage. As an example, if the total market is for 400,000 tons of finished steel of which half is bar and half flat products the alternative costs - at 10 per cent return on capital and wages at $1 per man-hour are:

(a) Two works each producing both requirements: bar $120 per ton flats $163 per ton.

(b) Two works specializing on bar and flats: bar $115 per ton flats $145 per ton.

It follows that (b) will be lower overall cost provided the extra transport cost involved in supplying the whole market is not too high, i.e. involves an extra distance by rail of less than about 1,000 kilometres. The market for specialized products is likely however to be strongly located so that the average distance through which they have to be transported from specialized works instead of being greater may well be considerably less than the distance through which such products would have to be transported if originating from unspecialized works.

Alternatively it may still be desirable to establish such specialized works in order to secure the advantages of co-operation between a number of small countries even if a single unspecialized works should have lower overall costs.

The co-operation of small countries may also be facilitated by establishing a number of re-rolling works supplied with semi-finished steel from a suitably located integrated works. This is the converse of specialization in the sense that in this case economies of scale are retained up to the steelmaking stage but lost at the rolling stage. Offsetting this loss is some advantage in transport cost arising from the fact that handling charges and running charges on semi-finished products are usually slightly lower than on finished products while in addition the latter may suffer damage in transit and/or require special packing.

The most suitable re-rolling operations are the re-rolling of bar and of light sections from billets and the cold reduction of hot rolled strip. In the former the loss occasioned by a reduction in capacity at the rolling stage from 400,000 to 200,000 tons per annum is about $3½ per ton and in the latter only $2.

Moreover, there will be a reduction in selling costs and some improvement in planning production as a result of proximity to the market.

6. Access to resources

In most developing countries some materials e.g. ferro-alloys, refractories and spares have to be imported while other minor materials are locally available so that the critical locating resources are those of iron ore and coal and other forms of energy.

The main element in the cost of such materials is transport cost; the ex-mine cost of iron ore is of the order of $3 per ton but if this should be transported some 300 kilometres to the coast then placed on a ship for transport over say 5,000 kilometres to a coastal works, the delivered price would rise (see above table) to about $12 per ton. If on the other hand to avoid this inferior local ores are used there may be little advantage since inferior ore which in practice usually means a lower iron content and a correspondingly higher silica content reduces output per unit of capital labour and fuel at the iron making stage.

Broadly speaking, using a local ore of 50 per cent Fe and 10 per cent silica content as compared with an imported ore of 60 per cent Fe and 5 per cent silica content would require, even after sintering (which would use 20 per cent more coke breeze), about 15 per cent more coke, twice as much limestone and would only give 85 per cent of the yield so that the cost of iron would be about $6 per ton higher.

There are therefore substantial advantages if a grouping of small countries can be found in one of which there are deposits of high quality iron ore to supply an integrated works.

As already indicated the actual location of such a works can only be decided after taking into account all elements of cost of production at the site, costs of assembling materials and costs of distributing finished steel to the various market areas. In general however, since to produce one ton of finished steel requires about three tons of material and since the transport cost per ton/km on finished steel is rarely more than twice that on materials and since further there are several market concentrations and only one or two material concentrations the attraction is towards the source of materials.

7. Some African examples

Detailed calculations of this kind have been commissioned by the ECA for the West African and East African sub-regions.

In the case of West Africa, the proposition was evaluated of the optimum site for a single coastal integrated plant supplying bar and light sections to the whole market. Three of the various coastal sites investigated were Lower Buchanan in Liberia, Port Harcourt in Nigeria and Tema in Ghana. The first of these is at the rail terminus to rich ore deposits while the two latter have inferior local deposits. In all cases coke was to be imported. The results were as follows:

Comparative overall costs of integrated production of bar and sections (US $ per ton)

| | Lower Buchanan | Port Harcourt | Tema |
|---|---|---|---|
| Iron ore | 9.0 | 14.9/14.5 | 14.6/21.1 |
| Coke and fuel | 18.6 | 20.0/22.8 | 19.7/21.4 |
| Electricity | 1.7 | 3.4 | 2.9 |
| Other processing materials | 3.7 | 4.3/8.1 | 4.2/4.6 |
| Wages | 3.9 | 3.8 | 3.3 |
| Other processing costs | 20.5 | 20.5/21.7 | 20.6 |
| Capital costs | 31.1 | 30.0/32.8 | 30.2/30.7 |
| Distribution costs | 12.3 | 11.6 | 10.6 |
| Total | 100.7 | 108.5/118.6 | 105.8/115.3 |

The two sets of figures for Port Harcourt and Tema relate to the use of imported ore (from Liberia) and local ore respectively. Distribution costs were not great because the main consumption centres are coastal and sea transport is used and for the same reason the differences between Lower Buchanan and Tema to iron ore was the main locating factor. Where local ore of inferior quality was proposed as at Port Harcourt, processing costs and capital costs were raised by some 10 per cent.

The proposal for a single works was subsequently modified to take account of a proposal to establish in due course an inland works and to allow for the possibility of an integrated works being established in Nigeria. Certain other countries also indicated their intention of proceeding eventually to the manufacture of iron and steel products. In order to accommodate these views and at the same time to retain economies of scale, it was proposed to establish re-rolling plants both for billets and sheet in a number of countries which would be supplied with billets or slabs or hot rolled coil from the central works at Lower Buchanan. The scale of the proposed billet re-rolling works ranged from 30,000 to 200,000 tons per annum and of the slab or hot coil re-rolling works from 150,000 to 215,000 tons per annum.

The scale of the central integrated works was approximately one million tons per annum. The implementation of these proposals requires inter alia the removal of barriers to trade between the participating countries and the scheme will be submitted to the Council of Ministers established in the sub-region to promote economic co-operation.

In the case of the East African sub-region which consists of twelve countries the total estimated demand for steel in 1980 of the types considered practicable to manufacture amounted to 1,440,000 tons of which 670,000 was bar and light sections, 125,000 medium sections, 300,000 hot rolled strip and 350,000 cold reduced strip. The smallest country had a prospective demand of only 1,000 tons and the largest 390,000 of which 180,000 was bar and sections, 80,000 medium sections and 130,000 flats.

Transport costs are considerably more important in this region than in West Africa since the main centres of consumption are inland and in the case of a single works supplying the whole region would amount to $31 per ton. Three of the various possibilities considered are as follows:

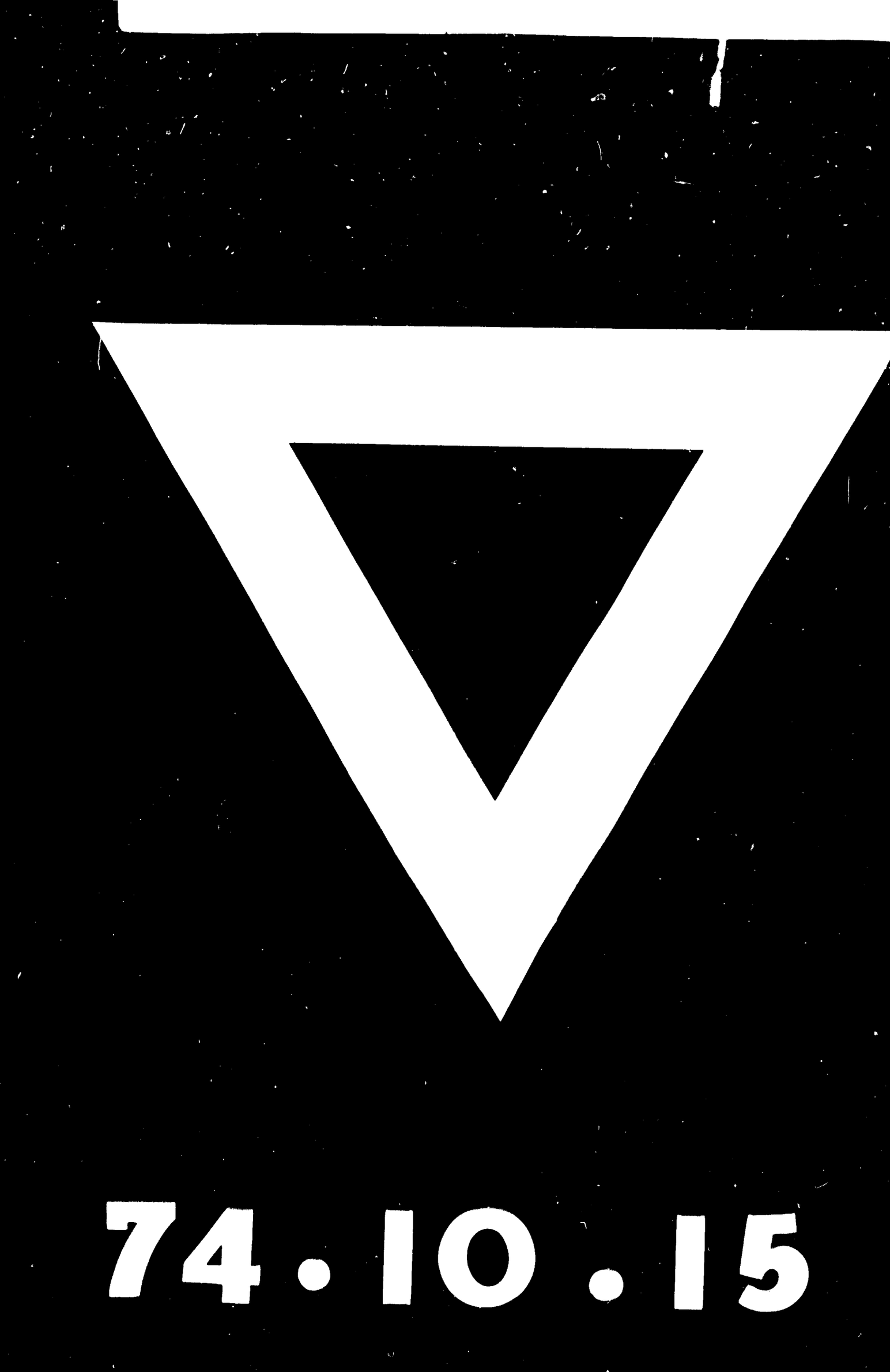
$ per ton

| | Manufacturing cost (incl. return) @ 25% on capital @ 25% (a) | @ 10% 10% (b) | Distribution Cost (a) | | Surplus (b) | To eq im pr |
|---|---|---|---|---|---|---|
| Single integrated works at Que Que (Rhodesia) | 90.5 | 52.8 | 31.0 | 49.5 | 87.2 | 17 |
| Two integrated works Que Que and Tororo (Uganda) | 105.8 | 60.1 | 19.4 | 45.8 | 91.5 | 17 |
| Integrated works at Que Que and re-rolling at Mombasa (Kenya) | 109.6 | 67.9 | 15.6 | 45.8 | 87.5 | 17 |

It will be noted that a heavy reduction is obtained in transport costs by having two works instead of one to supply the sub-region and that whether two works have an overall lower cost than a single works depends on the return on capital. In relation to imported prices all three are highly profitable. It should be observed however that the capital required to establish a single works is much lower than that required to establish two works namely $362 million, $429 million and $399 million respectively.

The situation in North Africa is different from that in the other sub-regions in that integrated steelworks already exist in the U.A.R. and Tunisia and that another is in course of construction in Algeria and possibly one for Morocco. All that can be done is to retain as far as possible economies of scale by means of specialization.

Therefore, an agreement to this effect may already have been arrived at by the Market countries and since all the main centres of consumption are on the coast the benefits of specialization can be obtained at very small additional transport cost.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