UNITED NATIONS

ECONOMIC AND SOCIAL COUNCIL

E

LIMITED

E/CN.12/L.7
30 July 1965

ENGLISH
ORIGINAL: SPANISH

ECONOMIC COMMISSION FOR LATIN AMERICA

ECONOMIES OF SCALE IN THE COTTON SPINNING INDUSTRY

(Preliminary version)

65-21038

C. 2

Economies of scale in the cotton spinning industry.[1/]

1. Introduction

The aim of the present study is not only to focus attention on the factors governing the economies that could be achieved in different sizes of mills, but also to suggest a methodology for defining such factors.

In practice, a great many mills have been established in Latin America operating either with less than 1,000 spindles or, at the other extreme, with over 25,000. The small spinning mills are unable, as a rule, to make full use of their machinery or their labour force employed.

While it is true that in the larger mills labour is used more rationally, total investment is heavier, and it may be uneconomic to invest so much money in order to achieve a small saving in the variable costs.

The present study comprises an examination of the economy of up-to-date mills, both such small mills as those frequently found in many countries, and mills large enough to permit a balanced production flow. In the latter case a study is made of the savings that could be effected if the indivisible production element - the scutcher in a spinning mill, the slasher sizer in a weaving mill - operates for one, two, or three shifts. In a spinning mill, of course, if the scutcher operates on a three-shift basis like the rest of the mill, many more spinning and intermediate frames would be required to cope with the scutcher output. However, although it is obviously common practice not to make full use of a machine which in itself represents proportionally the heaviest investment, the lower investment in intermediate and spinning frames is a favourable factor, and even if lowest production costs were achieved by a fully balanced production with the whole mill operating on a three-shift basis, the saving obtained would be negligible compared with the very great difference in the volume of investment.

Exactly the same problem arises with respect to the slasher sizer in a weaving mill.

The methodology proposed below will help to determine what mill sizes permit the lowest production costs, in the light of the capital-intensity required by each type of mill.

1/ This document, which should be considered of a preliminary nature, is based essentially on a paper prepared for ECLA by a consultant, Mr. Roger Haour, in late 1964. ECLA is at present analysing this subject in further detail and expects to complete the corresponding report by the end of 1965.

/Admittedly, this

Admittedly, this methodology necessarily applies only to specific cases and to certain clearly defined conditions. In practice each case must be studied separately in the light of the output required by the market, and by the institutional and operational conditions in each country or part of a country.

Since so many variables are involved, the most rational and reasonably standardized operating conditions will have to be assumed. The study is actually based on cotton spinning, but the methodology could also be applied to weaving. However, since the variables in weaving differ even more widely, a study of particular instances in this section would be pointless, since it would cover only a few types of production processes instead of the endless combinations that would have to be considered in order to convey an idea of the real situation.

For the dyeing and finishing sections it is practically impossible to calculate the economy of any particular size, as so many alternative finishing operations would have to be applied to all the weaving combinations for each type of fabric produced. Moreover, the vertical integration of finishing with spinning and weaving is not always desirable.

However, the criteria and methods developed for spinning could be applied to both weaving and finishing, in order to ascertain whether to establish a vertically integrated industry that covers all stages from the raw cotton to the finished fabric, or a horizontally integrated industry confined to a single operation: spinning, weaving or finishing.

Subsequently, a detailed study of each proposed mill will have to be made taking into account all the specific factors affecting the adjustment of production to the market.

The following methodology will serve to establish the order of magnitude of a proposed mill, to determine what sizes ought to be eliminated from the outset, to estimate the investment needed and to gain a broad idea of the return obtainable from such a mill.

The example chosen for cotton spinning is a mill producing an average Ne 20 count yarn. If the average count is changed substantially, the mill will be out of balance, and will no longer produce the quantity for which it was originally designed unless its structure is modified and the number of machines changed. If in a mill producing 200 kilogrammes of 20 count yarn the average count is changed to 14, some of the spinning frames will remain idle. If on the other hand the average count is changed to 30, the mill can no longer produce 200 kilogrammes unless the number of intermediate and spinning frames is increased.2/

2/ Within a narrow range of counts this imbalance may not be very pronounced, but its effect becomes evident as the spread between counts increases.

/It is

It is therefore essential before planning a textile mill to carry out a thorough market study and determine exactly what average type of product (as well as the variations within that average) is to be manufactured. This principle holds true, for weaving and finishing as well as spinning.

Admittedly, the average count or fabric may represent of a combination of several different counts or fabrics, but the number should be limited if a minimum level of standardization is to be attained; in spinning this level is generally determined by the range of counts which can be manufactured on the basis of a common preparation. The number of yarn counts or fabrics is also determined by the number of spinning frames handled by one operator, since he will not be expected to produce different yarn counts. In weaving, the principle is much the same and an effort should be made to standardize the warp counts and to determine the number of looms per fabric in terms of the number of looms per weaver. Another basic principle is to avoid changing the type of manufacture with excessive frequency, as such changes are one of the main causes of reductions in output.

It should be noted that balanced production is not the only factor to consider in determining mill size. It is also essential to take into account the optimum level of employment, in particular of supervisors or mechanics who earn the highest wages. If one operator can look after 30 cards, a mill with 32 cards will need two workers, and consequently the workload is reduced to 16 cards per operator. Later in this study there will be further discussion of this point, which is particularly important in countries where labour costs are high, or relatively so.

In weaving, too, account must be taken of the lowest common denominator of the weaver's and mechanic's workload. If a mechanic can look after 80 looms, and a weaver 20, the minimum mill size will be 80 looms. If it is proposed to increase the weaver's workload to 25 looms, a very expert mechanic will be needed capable of supervising 100 looms; otherwise, the mill size will have to increase considerably to reach the level for optimum labour utilization.

Thus can be stated that the ideal technical balance is determined by the sum of the balance in both production flow and labour utilization.

Similarly, the economic balance of a cotton spinning or weaving mill is that existing between production costs and investment, i.e., the lowest production costs in conjunction with the lowest possible investment, which can be determined by one curve relating mill size to total cost per kilogramme, and another relating it to the financial cost per kilogramme.

The sizes conducive to the best economic balance are indicated by the points at which the curves are closest, since they represent technical equilibrium.

/2. Standard

2. Standard product and type of process selected

Latin America's textile industry is noted for the large number of separate mills, their widely differing sizes, and the great variety of products manufactured.

The product chosen for the present study on economies of scale is a carded cotton yarn count Ne 20 (corresponding to the metric number 34), which is within the range of the 15 to 21 that represents the average for Latin America.

The process selected is the traditional one, covering operations from the opening and scutching of the cotton to the cone winding, and assumes two passages through the drawing frame and one through the roving frame.

Combing is not covered, since this operation is required only for counts finer than 30, and represents only about 20 per cent of the region's total production.

Textile technology, which is relatively simple and related basically to mechanical processing, nevertheless covers a wide range of machines operating in a series of consecutive processes, the unit output of each varying considerably. It is very different from the technology of such continuous process industries as chemicals and pulp and paper, in which the machinery is often specially built to provide a given production capacity with a balanced production flow. Since textile machinery manufacturers sell standard types of equipment, the balance between the production capacity of the various sections that make up the whole processes will affect both production costs and economies of scale.

3. Mill size and types of machinery

For the purpose of explaining the methodology for determining the mill sizes that permit the lowest costs, the mill sizes selected were, in terms of spindles, 1,000, 2,000, 5,000, 9,500 and 13,000. Mills with 1,000 and 2,000 spindles were included because of the high proportion of such small mills in Latin America. The remaining sizes each represent a balanced production flow, under different operating conditions.

Calculations were based on the following production pattern:

- Opener with one or two pickers
- Cards (units)
- Drawing frames of minimum size (two heads)
- Roving frames (96 spindles)
- Spinning frames (380 spindles)
- Cone winders (spindles)

/The theoretical

The theoretical and actual unit outputs assumed were:

- Pickers: Theoretical unit output of 180 kg/hr at 90 per cent efficiency, or an actual unit output of 162 kg/hr.

- Cards (with rigid clothing): Theoretical output of 15 kg/hr at 90 per cent efficiency, or a practical output of 13.5 kg/hr.

- Drawing frames (high speed): 180 m/min. at 85 per cent efficiency.

- Roving frames: A speed of 1,000 r.p.m. at 85 per cent efficiency.

- Spinning frames: A speed of 10,000 r.p.m. at 90 per cent efficiency.

- Cone winders: A speed of 1,000 m/min. at 75 per cent efficiency.

4. Determination of machinery needs

As regards machinery, the textile industry may choose among various technological alternatives, ranging from the most primitive labour-intensive scale to the most advanced capital-intensive level of automation. The technology adopted for the purposes of this study represents a high level of technical progress, in the form of up-to-date equipment which nevertheless does not reflect the most recent innovations in the highly industrialized countries. This is consistent with the existing institutional conditions in Latin America, where labour is plentiful but capital is scarce.

Table 1 shows the number of machines needed in each stage of the process, and the number of hours worked by each. The picker need work only 3.2 hours a day in a 1,000-spindle mill, 6.4 hours in a 2,000-spindle mill, and 16 hours in a 5,000-spindle mill. For 9,500 and 13,000 spindles, two pickers are needed operating 15.1 and 20.6 hours, respectively. It should be noted that in the two highest size categories more rational use is made of the opener-picker unit, since this is the point at which the opener begins to operate with two pickers, which is the number it would normally supply.

Similarly, in the 1,000-spindle category the drawing and roving frames are worked for one shift, while in the 2,000-spindle category the same number of drawing heads and roving frames are worked for two shifts. From 5,000 spindles on, three shifts are worked. Thus, as the mill size increases, the machinery is used more rationally.

As manufacturers of textile machinery supply the market with units of a certain size, the actual number of spindles is not exactly the same as that of the corresponding size category used in the study.

Table 2, on machinery costs, includes an index for the cost of the machinery in each size category, with the cost for the 13,000 spindle mill as the base.

/Table 1

Table 1

USE OF MACHINERY

	Mill size (spindles)									
	1 000		2 000		5 000		9 500		13 000	
	Number of units	Hours of work	Number of units	Hours of work	Number of units	Hours of work	Number of units	Hours of work	Number of units	Hours of work
Scutchers	1	3.2	1	6.4	1	16	2	15.6	2	20.6
Cards	2	22.5	4	22.5	9	22.5	17	22.5	22	22.5
Drawing heads	4	8	4	16	8	22.5	12	22.5	18	22.5
Roving frames	66	8	66	16	116	22.5	218	22.5	300	22.5
Ring spindles	1 140	22.5	2 280	22.5	5 320	22.5	9 500	22.5	13 300	22.5
Cone winders (spindles)	18	22.5	36	22.5	88	22.5	164	22.5	226	22.5

Table 2

COST OF MACHINERY

(F.o.b. price in dollars)

	Mill size (spindles)				
	1 000	2 000	5 000	9 500	13 000
Openers and scutchers	37 500	37 500	37 500	64 200	64 200
Cards	21 400	42 800	96 500	182 000	235 000
Drawing frames	10 740	10 740	21 500	32 200	48 400
Roving frames	15 000 a/	15 000 a/	26 500	50 000	69 000
Spinning frames	58 000	115 800	270 000	483 000	675 000
Cone winders	2 300	4 600	11 250	21 000	29 000
Total cost of machinery	144 940	226 440	463 250	832 400	1 120 600
Cost of machinery for each size as percentage of cost for 13 000-spindle size	13	20.2	41.4	74.4	100
Cost per spindle	144.94	113.22	92.65	87.50	86.30

a/ A slight saving in over-all investment may be achieved if smaller roving framer than those postulated here were used.

The index increases from 13 for the smallest size to 100 for the largest. The table also shows the cost of the machinery in dollars per spindle, which declines from 144.94 dollars in the 1,000-spindle category, to only 86.40 dollars in the largest mills.

The machinery prices were based on machinery manufacturers' quotations on the world market. Transport and installation costs were estimated at 15 per cent of the f.o.b. cost of the equipment, without taking into account customs charges, which vary from country to country.

Set out below is the area, in square metres, of the mills in question, based on the number of machines. The estimated cost of a square metre is 25 dollars.

	Mill size (spindles)				
	1,000	2,000	5,000	9,500	13,500
Area in square metres	1,000	1,000	2,500	3,750	4,500

For the purpose of calculating interest, a period of two years was postulated for construction and installation of the various mills.3/

5. Determination of labour and raw material inputs

The labour force for the various size categories was based on workload per operative in European mills which have the same equipment as that postulated here, with reasonable productivity levels, i.e., workloads per operative of 30 cards, 12 drawing heads, 200 roving frames, 2,000 ring spindles and 40 cone winders, respectively. In practice, these levels are not attained under Latin American conditions, often for want of such equipment, but also even when it is available. The reasons for the existing low labour productivity have been analysed in other ECLA documents.4/

3/ In fact, this period would be somewhat shorter for smaller mills.

4/ See ECLA, La industria textil en América Latina. I. Chile (United Nations publication, Sales N° 63.II.G.5); II. Brazil (Sales N° 64.II.G.2); III. Colombia (Sales N° 64.2.G/Mim.2); IV. Uruguay (Sales N° 64.2.G/Mim.5); V. Peru (Sales N° 64.2.G/Mim.3); VI. Bolivia (Sales N° 64.2.G/Mim.4); and VII. Paraguay (Sales N° 65.2.G/Mim.6). All the above are in Spanish only, except N° II. Brazil, which is in English only.

/The workloads

The workloads for the different mill sizes studied, in terms of the number of machines handled directly by each operative, are as follows:

	Mill size (spindles)				
	1,000	2,000	5,000	9,500	13,000
	(Machines per operative)				
Cards	2	4	9	17	22
Drawing frames (heads	4	4	8	12	9
Roving frames (spindles)	66	66	116	109	150
Spinning frames (spindles)	1 000	2 000	1 670	1 900	1 857
Cone winders (spindles)	18	36	29	41	38

As mill size increases, labour utilization improves. An important point, however, is that while in the 13,000-spindle category the machinery is better used, the same is not true for labour, in such operations as drawing, spinning and cone winding.

The present study has two aims in view: to guide the industrialist in selecting the most economic range of mill sizes, and to provide him with a general estimate of the investment required for each size. But once the most economic size-range is established, it is the responsibility of the firm, either directly or through a consultant, to determine whether it would be more profitable to add extra units in order to utilize labour more rationally, or whether, in countries where labour is cheap, to refrain from doing so, in order to keep down the volume of investment, even where this means foregoing the maximum utilization of labour. Consequently the main aim should be to achieve a technical balance (a more efficient use of labour and a balanced operational flow).

This explains why the costs curve, as will be seen later, does not represent a straight line, but a series of steps, since in certain size levels the two requirements for technical balance are not met. Hence, in countries where manpower is cheap, a mill making good, even if not optimum, use of labour might well be more economical than a mill of the same size in other countries.

The following table shows the number of workers needed for each size, the number of operatives per 1,000 spindles, and the labour force required in each category as a percentage of the labour force required for the largest mill size.

	Mill size (spindles)				
	1 000	2 000	5 000	9 500	13 000
Number of workers	30	40	71	100	129
Workers per 1,000 spindle/shifts	10	6.7	4.74	3.5	3.3
Labour force of each category as a percentage of the labour force of the 13,000-spindle mill	23	31	55	78	100

Thus the labour force index increases from 23 in the smallest size to 100 in the largest, and conversely the number of operatives per 1,000 spindle/shifts shrinks from 10 in the smallest category to 3.3 in the largest.

The estimated average labour cost is equivalent to 35 dollar cents an hour for the first two shifts, and 33 per cent more for the third (night shift), i.e., 46.5 dollar cents an hour. These figures are based on

/textile industry

textile industry wages in several Latin American countries, plus the normally substantial social security contributions.

The following table on raw material production and inputs shows daily and annual output, production per man/day, and output as a percentage of that of the largest category. Three hundred working days a year have been taken as the generally accepted figure.

Output	Mill size (spindles)				
	1 000	2 000	5 000	9 500	13 000
Kg/day	515	1 030	2 575	4 893	6 700
Metric tons/year	154.4	309	770	1.470	2.010
Kg per man/day	17.2	25.8	36.3	48.93	52
Output of each category as a percentage of output of the 13,000-spindle category	7.7	15.4	38.5	73	100

It should be noted that in order to simplify the calculations no account has been taken of wastage in the various operations, particularly in opening, scutching and carding. Since the purpose of the study is to demonstrate a methodology, and it is based on comparisons, this simplification does not affect the basic conclusions.

The raw material postulated for the selected product, yarn count Ne 20, is the American strict-middling 1-1/16" cotton, priced at 75 dollar cents per kilogramme c.i.f. Liverpool.

In view of the shortage of available data on power and fuel inputs, and maintenance costs (which may be calculated as 6 per cent of the labour and raw material costs), and since this study relates to comparisons, these factors have not been taken into account.

6. Investment components

Two investment components are considered: fixed investment and working capital. The former includes the f.o.b. cost of equipment; transport and installation, estimated at 15 per cent of that cost; construction of premises, and interest on the above-listed investment items, estimated at 12 per cent of the total for a period of two years, which is the time postulated for the erection and installation of a plant.

Working capital is regarded as covering four month's consumption of raw material (three months in stock and one month in the processing stage), plus one month's operating costs (labour) - excluding power, fuel, maintenance and overheads, for the reasons stated above.

The overheads not covered by the study may be roughly estimated as 40.5 per cent of the total working capital.

Table 3 on investment gives four ratios. The first is the ratio of fixed investment to total investment, which declines from 85.8 per cent for the lowest size category to 77.2 per cent for the highest. The second is the ratio between the cost of the machinery and total fixed investment, and the third is the ratio between the cost of raw materials and total working capital, which rises from 94.8 for the lowest category to 98.3 for the two highest. This rather high percentage would, of course, be considerably lower if account were taken of the other operating costs, which have been deliberately omitted. Even so, raw materials would still represent the largest proportion of working capital.

The fourth ratio represents the total investment required in each case as a percentage of that required for the 13,000-spindle plant. The total investment for the 1,000-spindle plant represents only 12.4 per cent of the investment needed for the largest category of plant. The ratio increases, as might be expected, to 75 per cent for the 9,500-spindle plant. Nevertheless, the investment ratio is unfavorable for the small plants, since while in the largest plant the cost per spindle does not exceed $86.30, in the 1,000-spindle plant the cost is nearly $145, a difference of 68 per cent.

7. Cost determination

Only operational and financial costs have been taken into account as cost components; overheads and administrative costs have been excluded, since insufficient data are available and they can be regarded as amounting in general to about 30 per cent of the total cost.

Table 4 on costs shows that raw materials are the main component of the final cost, representing 58.60 per cent for the lowest size category and as much as 73.18 per cent for the highest. The ideal is for the cost of raw materials to constitute the highest possible percentage of the total cost, since as their use is essential and the price is the same for mills of all sizes, the higher the percentage it represents the lower the percentage of all the other elements that affect the final cost.

Labour represents 13 per cent in the smallest mills and naturally decreases as mill size increases, being only 5.54 per cent in the 13,000-spindle plant.

With respect to the financial costs, it has been assumed that, even though amortization varies from country to country, a rate of 10 per cent for the machinery and its installation and 5 per cent for buildings can be regarded as quite normal for Latin American conditions. Similarly, an interest rate of 12 per cent on the total capital invested corresponds to the average cost of capital in Latin America, and consequently capital charges have been assessed at 12 per cent of the total investment.

Amortization of fixed investment amounts to 11.60 per cent for the lowest size category, and declines to 8.16 per cent for the highest. Capital charges represent 16.80 per cent of the total investment for the lowest size category and declines to 13.12 per cent for the highest.

/Table 3

Table 3

INVESTMENT

Investment components	Size category (spindles)				
	1 000	2 000	5 000	9 500	13 000
Fixed investment					
Machinery (f.o.b.)	144 940	226 440	463 250	832 400	1 120 600
Transport and installation (15 per cent f.o.b.)	21 750	34 000	69 500	125 000	168 000
Construction	25 000	25 000	62 500	93 800	112 000
Interest on fixed investment (12 per cent over 2 years)	46 000	68 700	142 500	252 000	336 000
Total fixed investment	237 690	354 140	737 750	1 303 200	1 736 600
Working capital					
Raw materials (4 months) c.i.f. Liverpool	38 500	77 200	193 000	367 000	501 000
Labour (1 month, at 25 days per month)	2 130	2 820	5 050	7 160	9 500
Total working capital	40 630	80 020	198 050	374 160	510 500
Total investment	278 320	434 160	935 800	1 677 360	2 247 100
Ratios					
1. Fixed investment as percentage of total investment	85.5	81.5	78.7	77.8	77.2
2. Machinery as percentage of fixed investment	61.2	63.8	63	64	64.8
3. Raw material as percentage of working capital	94.8	96.6	97.5	98.3	98.3
4. Investment for each category as a percentage of investment for 13 000-spindle mill	12.4	19.4	41.7	75	100

/The over-all

The over-all unit cost declines from 1.2805 dollars per kg for the lowest size category to 1.0250 for the highest. This means that in a 13,000-spindle mill 1 kg of yarn can be sold at 25 per cent less than in a 1,000-spindle mill, as indicated in the last line of table 4.

8. Variation of costs with mill size

The following table gives the indexes of output, labour force, investment and costs for the various size categories with the 13,000-spindle mill as the base.

Index	Size category (spindles)				
	1,000	2,000	5,000	9,500	13,000
Output	7.7	15.4	38.5	73	100
Labour force	23	31	55	78	100
Investment	12.4	19.4	41.7	75	100
Costs	125	112	104.5	100.5	100
Employment per unit of output	299	201	143	107	100
Investment per unit of output	161	126	108	103	100
Cost per unit of output	125	112	104.5	100.5	100

If output is assumed to be proportional to the size of the mill, the above figures reveal that employment per unit of output in the smallest size is nearly three times that of the largest, total investment per unit 61 per cent higher and production cost per unit 25 per cent higher than in the most economic mill. It is also shown that these unfavourable ratios become rapidly smaller as the size increases and at the 5,000-spindle level investment and costs are only 8 and 4.5 per cent above that of the 13,000-spindle mill, although the labour force is still 43 per cent higher.

The 9,500-spindle is a striking example, since with a total investment that is only 75 per cent of that required for the 13,000-spindle mill, production costs are almost identical. In general, where capital resources are scarce and markets small, the former size would seem to offer certain advantages from the standpoing of number employed, investment and costs. However, in countries where labour costs are higher than those considered in this example, it may prove more economic to seek a balance at a level of 13,000 spindles or more, if the increase in the investment required is offset by a further lowering of production costs.

/Table 4

Table 4

COSTS

Cost components	Size category (spindles)									
	1 000		2 000		5 000		9 500		13 000	
	Dollars per kg	Percentage of total cost	Dollars per kg	Percentage of total cost	Dollars per kg	Percentage of total cost	Dollars per kg	Percentage of total cost	Dollars per kg	Percentage of total cost
Operational costs										
Raw materials (c.i.f. Liverpool)	0.7500	58.60	0.7500	65.80	0.7500	70.20	0.7500	72.70	0.7500	73.18
Labour (direct and indirect)	0.1660	13.00	0.1100	9.60	0.0785	7.30	0.0588	5.70	0.0568	5.54
Total	0.9160	71.60	0.8600	75.40	0.8285	77.58	0.8088	78.40	0.8068	78.72
Financial costs										
Amortization of fixed assets (for machinery, installation and interest at 10 per cent, for construction at 5 per cent)	0.1485	11.60	0.1120	9.80	0.0918	8.62	0.0853	8.30	0.0837	8.16
Interest on capital (12 per cent of total investment)	0.2160	16.80	0.1690	14.80	0.1470	13.80	0.1370	13.30	0.1345	13.12
Total	0.3645	28.40	0.2810	24.60	0.2388	22.42	0.2223	21.60	0.2182	21.28
Total cost	1.2805	100.00	1.1410	100.00	1.0673	100.00	1.0311	100.00	1.0250	100.00
Costs for each category as percentage of cost for 13 000-spindle mill	125		112		104.5		100.5		100	

/Figure I

Figure I
COST VARIATION WITH MILL SIZE

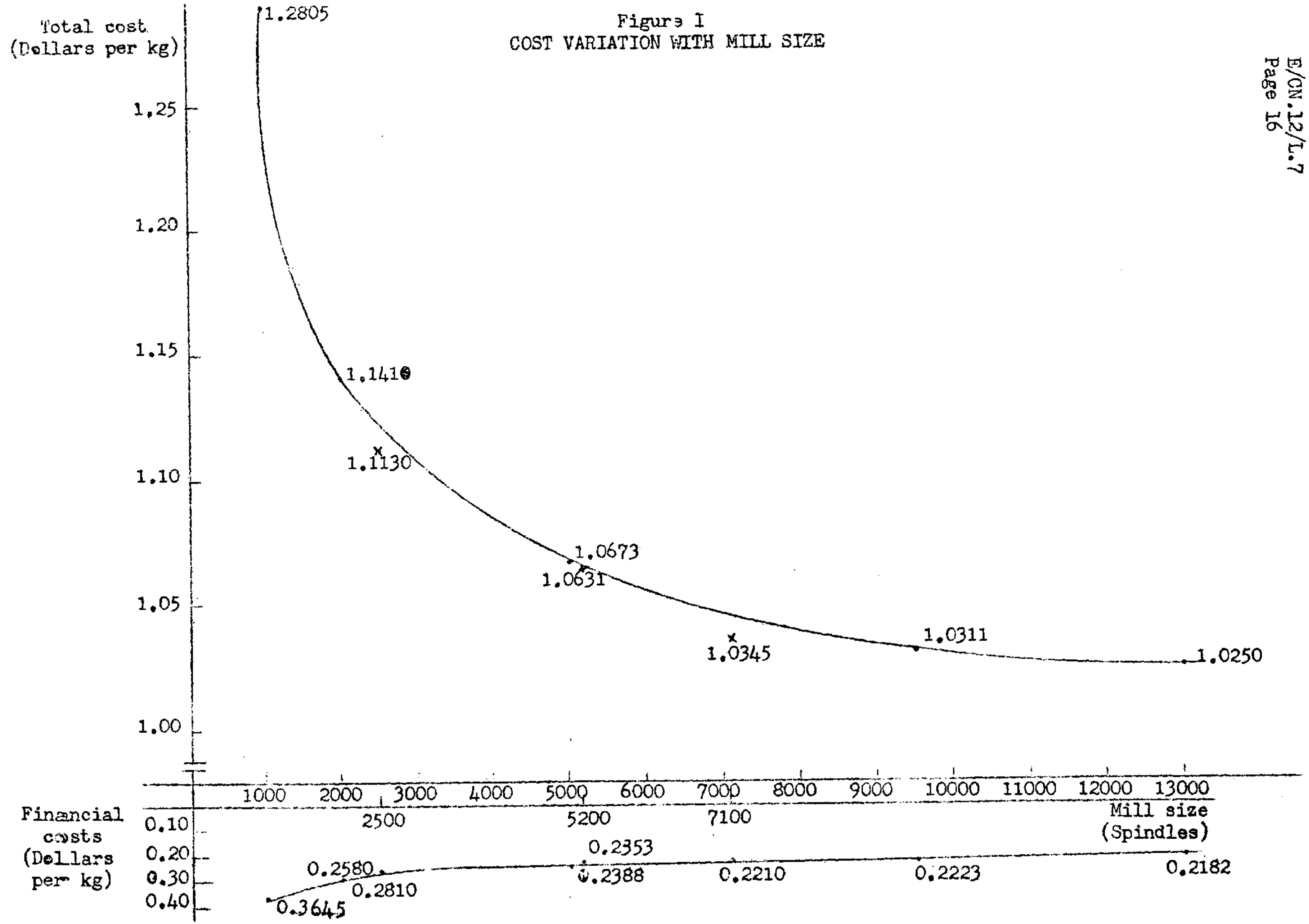

Figure I,[5] indicating the method of determining the most economic size, consists of two curves with a common axis of abscissae. For the upper curve the axis of co-ordinates shows the over-all unit costs in ascending order of magnitude from the axis of abscissae upwards, and for the lower curve it shows the financial costs in ascending order of magnitude from that axis downwards. The horizontal axis shows the different size categories of factories, for both curves. It can be seen that as mill-size increases both curves flatten out and become almost asymptotic; the approach becomes more pronounced at around 9,000 spindles and continues without becoming much closer from there on.

In section 9 three hypotheses for scutcher operation were considered, and the costs were calculated for each one. These costs have been marked on the cost curve, and it can be seen that the three sizes (2,500, 5,200 and 7,100 spindles) corresponding to the three hypotheses are below the curve drawn. The point is dealt with again in the section concerned. As indicated in the section on cost determination, the component that most affects the final cost is raw materials, which represents percentages ranging from 58.6 for the lowest size category to 73.18 for the highest. This accounts for the small economy of scale achieved as mill size increases, since that percentage of the total cost on which economies can be achieved shrinks progressively. Thus for the larger mills only slightly over 25 per cent of the total cost remains for reduction by economies of scale.

5/ See explanatory note in Annex.

ANNEX

Note on cost graph

It is important to note that these curves are not continuous, as shown in the figure, but descend in a series of sawtooth steps. This is because the utilization of machinery and labour in two mills fairly close on the size scale will not fall within the same small range, and consequently lead to significant gaps between the figures. For example, if for a given size thirty cards are needed, 31 or 32 will be needed for the next size category, which means a higher investment and the employment of another operative, and the existing operative and the new operative together will work at slightly over 50 per cent of the efficiency of the single operative in the smaller mill. Similarly, it should be noted that the line of the curve represents the minimum points of the sawteeth.

9. Estimated costs of scutching on a 1, 2 and 3-shift basis

It was decided to make three working hypotheses for scutching in this study, and to estimate the labour input, investment and costs for each one. They are put forward on the grounds that the unit where the bales are opened and the cotton scutched has the highest unit output and unit cost of the whole process, and should therefore achieve the highest unit yield.

Mill size is postulated in terms of spindle numbers as 2,500, 5,200 and 7,100 respectively, and it is assumed that the third shift would be only 6.5 hours. In all three hypotheses, the total unit cost is below the cost curve (see figure I) as might be expected, since the utilization rate of the opening and scutching unit is comparatively high in each case. When a scutcher is worked for two shifts (in the 5,200 spindle size) there is very little difference from the 5,000 category, in which the scutcher is worked for over fifteen hours, or only slightly less than two shifts. For 7,100 spindles, the distance from the curve is greater, since the opening and scutching unit is being used to the full.

This shows that the intermediate mill sizes that are closest to the three considered above should be avoided, since although the costs are not particularly high the volume of investment would be greater. More details of the cost structure for the three hypotheses are given in table 5.

/Table 5

Table 5

COSTS POSTULATED BY THREE WORKING HYPOTHESES FOR SCUTCHING

Cost components	Mill size (spindles)					
	2 500 (1 shift)		5 200 (2 shifts)		7 100 (3 shifts)	
	Dollars per kg	Percentage of total cost	Dollars per kg	Percentage of total cost	Dollars per kg	Percentage of total cost
Operational costs						
Raw materials (c.i.f. Liverpool)	0.7500	67.30	0.7500	70.60	0.7500	72.45
Labour (direct and indirect)	0.1050	9.50	0.0778	7.30	0.0635	6.15
Total	0.8550	76.80	0.8278	77.90	0.8135	78.60
Financial costs						
Amortization of fixed assets (for machinery, equipment and interest at 10 per cent, for building at 5 per cent)	0.1010	9.10	0.0905	8.50	0.0845	8.20
Interest on capital (12 per cent of total investment)	0.1570	14.10	0.1448	13.60	0.1365	13.20
Total	0.2580	23.20	0.2353	22.10	0.2210	21.40
Total cost	1.1130	100.00	1.0631	100.00	1.0345	100.00
Cost for each category as percentage of cost for 13 000-spindle mill	108		104		101	

/II. CONCLUSIONS

II. CONCLUSIONS

The following conclusions may be drawn:

1. The building of new small-scale mills is uneconomic, because production costs would be much higher than those of medium-sized but well-balanced mills.

2. The smallest economical range is between 7,100 and 9,500 spindles on the basis of an average production of yarn count Ne 20. If yarns with a finer count have to be spun, the most economic size of mill would be above that range, whereas for coarser counts it would be below.

3. Of the mill sizes in the economic range, (i.e. the range where costs and investment per unit of output are close to those for the larger and most economic mill sizes), the 9,500-spindle size seems to be the most suitable for producing yarn count Ne 20 in the basic conditions adopted for the example given here, since it is the best balanced as regards production, labour and investment, and costs are almost as low as the minimum level attained in the 13,000-spindle mill.

4. Except for the workers operating the cards and roving frames, labour utilization is also best in this mill size under all the hypotheses put forward.

5. Its productivity, although lower than in the 13,000-spindle category (nearly 49 kg per man-day or 6.125 per man-hour, against 52 kg per man-day or 6.500 per man-hour) shows a difference of only 6 per cent, whereas the total volume of investment required for the larger mill is 35 per cent more (although investment per unit of output is 3 per cent lower).

6. Economies of scale in cotton spinning and weaving, or in any other branch of the textile industry, are very different from those in highly mechanized industries because of the complexity of the processes, the large number of operations involved in the processing of the fibres, the labour-intensive nature of the work, the different production capacities of the units making up the operational process, and the variety of goods that can be manufactured.

7. As the raw material costs represent a high proportion of the production costs, and cannot be cut down, the savings that can be made through the adoption of fairly large mill sizes beyond the point where a well-balanced production flow is achieved, are necessarily limited to a small percentage of the production costs.

Accordingly, this study does not attempt to give any specific solution to the problem of the economies of a textile mill but it should be regarded as a methodological example. Any difference in the basic factors will lead to modifications that make it necessary to recalculate the technical and economic balance of the mill concerned.