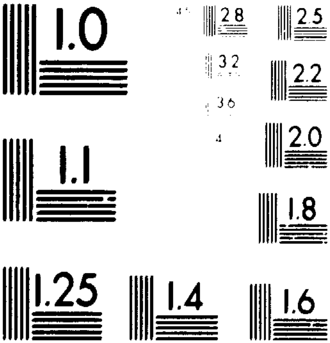

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INTERMEDIATE TECHNOLOGY CONSULTANTS LTD

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POTENTIALITIES AND PROSPECTS OF SMALLER SCALE PLANTS IN DEVELOPING COUNTRIES

Prepared by

IT Consultants Ltd

for

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PREFACE

This study of the role and potential of small-scale plants in developing countries has been prepared by IT Consultants Ltd, the consultancy service of the Intermediate Technology Development Group, for UNIDO under Contract No. 83/299, Intersectoral Research and Substantive Support.

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IT Consultants Ltd
30 June 1983

INTRODUCTION

The economies of scale have long been a significant theme of economists and engineers alike, leading to empirical rules of thumb such as the "six-tenths rule" which states that each doubling of capacity tends to require increases in investment of only about six-tenths. Largely as a result of this unquestioned belief, industry in both industrialised and developing countries has shown a strong tendency to concentration, and for some years there has been a distinct constituency in development studies which has exclusively favoured the development and extension of large-scale industry.[1)]

How firm are the foundations upon which this edifice has been constructed? In view of the importance of the topic, it is perhaps surprising that few objective studies of the impact of concentration and scale have been done, and those that there are provide an unsatisfactory basis for international comparison, owing to different statistical definitions of small, medium and large enterprises in different countries. Even so, the perspective began to change in the 1970's as a result of new thinking on the socio-economic impact of technology expressed by writers such as the late Fritz Schumacher in "Small in Beautiful"[2)], while the technological advantages of scale were beginning to be eroded by the breakthrough in micro-electronics.

The first step on the road to understanding is usually to ask the right questions, so we must start with the fundamental question of "What is scale?" The Oxford English Dictionary contents itself with "relative or proportionate size or extent" which is not particularly helpful in the present context. A much more useful definition is provided in a recent publication of the International Institute for Applied Systems Analysis on "Scale in Production Systems"[3)]:

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1) See, for example: EMMANUEL, A 1982, Appropriate or Undeveloped Technology?, Chichester, John Wiley.

2) SCHUMACHER, F. 1974 Small is Beautiful: Abacus (published by Sphere Books Ltd)

3) J.A. BUZACOTT ET AL, 1982. Scale in Production Systems, International Institute for Applied Systems Analysis, Pergamon.

- "scale is more than size: it is size with proportions and consequences. When proportions are no longer in harmony, or consequences are unanticipated, we have "problems of scale".

Thus increasing scale can give rise to problems as well as solutions, and the implication is that a simple minded reliance on automatic "economies of scale" is an inappropriate response. It is much more likely that large, intermediate and small-scale solutions all have their place, and the optimum scale of technology will vary from sector to sector and product to product, as well as being a function of the specific socio-economic environment and national policy for industrialisation.

In deciding whether a small-scale solution is appropriate in any particular case, it is important to separate the technical aspects of choice of scale from the value-laden aspects. However, objectivity does not require that the broader social and economic aspects should be ignored simply because they are difficult to evaluate. For example, the risk element implicit in reliance on a single large-scale plant could provide valid grounds for concern in a small country, and an inadequate or overstrained transportation and distribution network can lead to unforeseen shortages and price escalations in regions remote from the central plant. These difficulties may then be tackled by some form of price equalisation or rationing scheme, which will lead to further costs, delays and uncertainties. Heady optimism usually characterises the early days of most substantial project ideas, with the result that decisions on scale and level of technology are based on assumptions of smooth and speedy implementation followed by commissioning and the prompt achievement of 80 or 90 per cent capacity utilisation.

Iconoclasts in the area of project management are rare indeed, but they do exist. In a perceptive study entitled "How to learn from Project Disasters", Kharabanda and Stallworthy 1) comment that "Overruns in time and cost are customarily seen as a failure in project management and when extreme can well be a "disaster". Such overruns, unfortunately, are the norm rather than the exceptions that they ought to be." If it is true that cost and time overruns are in fact the norm on large projects, it is clear that some form of allowance for this risk should be made at the stage when

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1) KHARABANDA AND STALLWORTHY, 1983. How to learn from project disasters, The Gower Press.

project alternatives are being discussed. Yet this rarely happens in practice, and successive "disasters" are treated as one-off phenomena never to be repeated. These considerations would not be relevant if risk factors were directly proportional to size of project, although elementary probability theory suggests that a steadier overall output of any product can be expected from a series of smaller plants than from a single large plant when the susceptibility to breakdown is proportionately similar.

But there are indications that risk factors are in fact larger for large plants, and that these frequently eat into, and sometimes totally consume, anticipated economies of scale. Kharabanda and Stallworthy ask (rhetorically) "Why did anyone ever say that bigger plants were more economic than smaller plants?" They trace the conception (or misconception) to the popular formula which relates the capital cost of a process plant to capacity as:

$$\text{Cost} \propto (\text{Capacity})^n$$

They point out that "although this formula has been extremely helpful to process designers, cost engineers and the like, it has also been badly misunderstood and widely misused." The value of the exponent 'n' is of course crucial in the application of this formula. "Economies of scale" depend on 'n' being less than unity. It is very common for a value of '0.6' to be ascribed to 'n' and the formula is frequently described as the "six-tenths rule." If the "six-tenths rule" was in fact universally applicable the cost advantages for large-scale projects would be formidable, since it would imply that doubling the capacity of a plant would result in an increase in capital cost of no more than 50 per cent, so that the other half of the increased capacity would be effectively cost-free (assuming full demand and capacity utilisation).

Recent evidence suggests that the "six-tenths rule" is not a rule at all, and that the exponent 'n' is in fact a variable which increases with the level of plant capacity and can rise to or even exceed unity (implying a direct diseconomy of scale). Kharanbanda and Stallworthy quote a study of the variation of 'n' with capacity for ethylene plants (Table I.1), which demonstrates that for this process there is no further economy of scale above a capacity of 1200 tons per day (and indeed that direct diseconomies of scale can be anticipated).

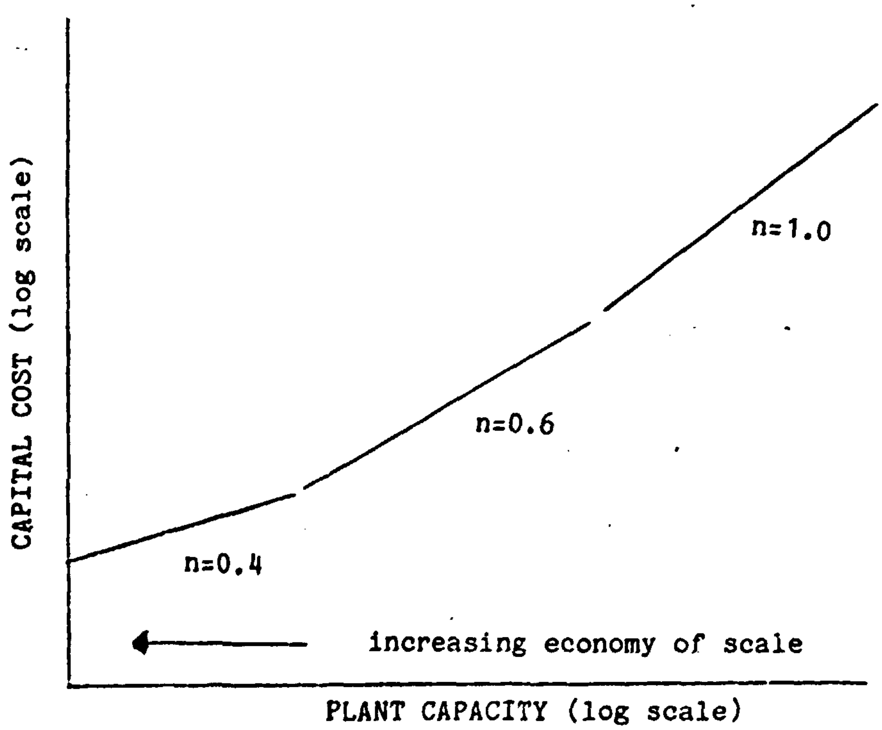
Table I.1 VARIATION ON 'N' WITH CAPACITY - ETHYLENE

Tons/day	Cost-capacity exponent 'n'
400	0.5
600	0.7
1200*	1.0
2000	1.1

* At this capacity heat exchangers have to be in multiple units and large towers must be field welded.

A study by Ball and Pearson [1] suggests that the phenomenon of the cost-capacity exponent 'n' increasing with plant capacity is a general relationship (Figure 1), with 'n' ranging from a value of about 0.4 for very small plants up to 1.0 or perhaps higher. It will be noted that 'n' is indeed approximately equal to 0.6 for an intermediate range of plants, which explains the discovery and popular acceptance of the "six-tenths rule".

Fig I.1 RELATIONSHIP BETWEEN CAPITAL COST AND PLANT CAPACITY



1) BALL D F and PEARSON A W. The Future Size of Process Plant. Long Range Planning. Vol 9, No. 4, August 1976.

At this stage is is sufficient to accept that the case for large-scale plants and industrial concentration is not universally overwhelming, since we can then go on to examine the multifarious socio-economic implications of choice of scale in various sectors and various environments. Whilst there is general acceptance that small plants and small-scale industry (SSI) is employment maximising, we will note that detailed observation in many cases suggests that small-scale plants also incorporate surplus-maximising techniques, so that their promotion can satisfy multiple development objectives. We begin with a discussion of the conceptual framework within which small-scale plants are to be viewed, and then proceed to an analysis of small-scale plants in ten different sectors. The broad conclusion is that there is scope for increased attention to the potentialities and prospects of small-scale plants and SSI and the concluding section suggests, for those countries which seek to pursue this course, various policies to promote and encourage the development of indigenous small-scale industries.

CHAPTER I. THE CONCEPTUAL FRAMEWORK

1.1 Typology

This paper concerns smaller-scale plants and small-scale industry (SSI), so our first need is agreement on the qualities that lead to the categorisation of a plant or an industry as "small". Unfortunately the concept of "smallness" has no absolute content and it is for this reason that the plant-size categorisation of "small-scale" varies so widely in statistical methodologies. In the UK, small-scale establishments involve the employment of less than 200 people; in Nigeria it excludes plants with less than 10 employees (considered to be part of the household sector), whilst in Kenya these very small plants are included in the "small-scale size categorisation. In India, it is not only the number of employees which is considered but also whether they have access to power[1].

Compounding the definitional confusion surrounding the number of employees which is used to characterise the size of establishments, is the tendency to use other types of criteria. Foremost amongst these are capital intensity (as reflected by concentration ratios), and even the degree of self-reliance[2], but a very wide range of additional criteria have also been used. In all of these cases, however, the conclusion reached by Staley and Morse[3] in their classic study of the SSI Sector, still stands, namely

> "It is wise to recognise at the outset that there can be no single best or correct way to classify industry units as small or large. *Different groups are appropriate for different purposes and at different places and times*".

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1) The National Sample Survey defines small-scale industries as those "establishments using power and employing less than 10 workers as well as those not using power and employing less than 20 workers". (National Sample Survey, Twenty-Third Round, July 1968-June 1969, Dept of Statistics, Ministry of Planning, N Delhi).

2) In Tanzania, the directive on small-scale industry defined it as "any unit whose control is within the capability of our people individually or collectively in terms of capital required or knowhow."

3) STALEY R and R MORSE, 1963, Modern Small Industry for Developing Countries, N Yor, McGraw Hill.

Nevertheless classifications, albeit imperfect, can be helpful and they did offer the following categories: (a) dispersed primary resource processors (b) market orientated (c) service industry (d) separable manufacturing activities (e) assembly, mixing and finishing (f) small total market. Over time the structure of the sector has changed in many developing countries, reflecting changes in the economy. Separable manufacturing (eg metal products producers) have tended to increase relative to for example traditional crafts in S.E. Asia. SSI can also be categorised in terms of traditional/modern, and in terms of level of organisation - household/rural enterprise/urban enterprise. An overlapping division is that of factory/non-factory production. The technical definition, for example in terms of employment, varies considerably from country to country, but may not be particularly helpful from the policy point of view. Downscaling of industry may involve on the one hand the promotion of mini-production units (eg handloom weaving with between 1 and 10 workers), and on the other hand mini-cement or mini-steel plants, which, at the minimum scale technically feasible, still employ hundreds of workers and require large amounts of capital funds (eg a minimum of around $150 million for a proposed 50,000 ton basic steel making plant in Nepal).

In this paper it will be necessary to make categorisation of SSI on functional, not technical, criteria, since the object is to identify promotional policy and strategy which may not be applicable to strictly technical classifications of smallness.

1.2 Generalising About SSI

As we shall see below there have been a number of recent attempts to draw together various cross-section studies on the role of SSI in various economies. On the basis of such studies, some observers (eg Anderson[1]) have proposed a schematic framework in which economies progress from low per capita income small-industry dominated structures to high levels of per capita product based on a dominant role played by large scale industry. But before we turn our attention

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1) ANDERSON D, 1982. Small Industry in Developing Countries: A discussion of Issues, World Development, Vol 10 No. 11 pp 913-948

to this data-base it is important to consider briefly a number of caveats, some of which will be discussed in greater detail below. First is the familiar problem of moving from cross-section analysis to forecasts over time: observing a cross-country pattern at any one point in time does not in itself legitimise predictive analysis[1]

Related to this is the changing pattern of economic and technological structure over time - how many American observers in the mid 1960's predicted the explosive growth of small new technology based firms (NTBF's) in the 1970's? So that even in individual economies, the role of SSI changes over time and not always in a direction which leads to its elimination. Third, since economies of scale in production are an important element in the growing predominance of large-scale industry, country-size will be an important determinant of the role played by SSI. The smaller the economy, the greater the proportion of small-scale plants is likely to be, despite the theoretical possibility that export-oriented enterprises can nevertheless take advantage of scale economies by serving the world market. Fourth, much of the empirical literature (eg Langden[2], Stewart[3], ILO[4]) points to the close links between choice of product and choice of technique. Development strategies[5] which are characterised by "openness" and/or an unequal distribution of income and which are dominated by the international demonstration effect in establishing consumption patterns are likely to involve product choices which favour the utilisation of large-scale, capital-intensive techniques. Fifth is the phenomenon of "X-inefficiency"[6], that is the actual operating

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1) Some observers, notably Anderson, consider both time-and cross-series data.
2) LANGDEN, 1978. Multinational Corporations in the Political Economy of Kenya, London, Macmillan.
3) STEWART, 1978. Technology and Underdevelopment, London, Macmillan.
4) ILO, 1972. Employment, Income and Equality: A Strategy for Increasing Productive Employment in Kenya, Geneva, ILO
5) These strategies do differ as a result of particular types of political systems. If they were to follow a predictable role, then the choice of product/choice of technique link would have little relevance to the role of SSI.
6) LIEBENSTEN, 1978. General X-Efficiency Theory and Economic Development, London and N York, Oxford University Press.

characteristics of techniques compared to their best-practice efficiency. Some observers have argued that labour-intensive (and small-scale) techniques tend to suffer from greater levels of X-inefficiency since the managerial function becomes crucially import in their operation. But clearly the degree of managerial inefficien is not just a function of labour-intensity and scale but also of factors such as motivation, experience and training. These latter factors clearly vary over time and economic space. A sixth factor suggesting caution in interpreting comparative information on SSI is familiar problem with the data-base - there is a notable tendency fo small-scale enterprises, particularly those of an 'informal' or seasonal nature, to be unrecorded; even more problematic is an estimation of their value-added, output and cost figures. And, finally, as Schmitz[1] observes, the analysis of the role played by small-scale industry is generally bedevilled by a failure to distinguish adequately between the external and internal factors constraining their growth.

In the light of these seven caveats it is appropriate to approach th literature on SSI with a good deal of caution. Probably the only common factor between SSI's in different environments and in differe periods of time is their size. And even then, as we have been, ther is enough ambiguity in the definition of size to lay even this commc tendency open to ambiguous interpretation.

1.3 Some Evidence on the Role of SSI

Notwithstanding the definitional ambiguity concerning size, and the problems involved with the quality of data, a number of attempts hav been made to draw together various sets of country-level data on the role played by small-scale industry. A recent survey by Anderson[2] utilises cross-sectional data on nine countries (table 1.1) and time series data on nine countries (table 1.2) to develop a schematic pat for the role of small-scale industry over time (fig 1.1). As can be seen it suggests that the "household and artisanal" sector (which

1) SCHMITZ H, 1982. Growth Constraints on Small-Scale Manufacturing in Developing Countries: A Critical Review. World Development Vol 10 No. pp 429-450

2) ANDERSON D, 1982. op cit.

includes a wide range of industries, namely "village industries - smiths, shoemakers, garment-makers, handicrafts, masons, carpenters, builders, various crop processing activities and so on - and the subsistence-level, off-farm activities of peasant households" p 918) declines over time, whilst the share of small-scale workshops and factories first stabilises and then falls; conversely the share of large scale plants expands uninteruptedly.

Table 1.1 EMPLOYMENT IN MANUFACTURING BY SCALE & TYPE OF ACTIVITY: SELECTED COUNTRIES

		% Distribution of Manufacturing employment				
			Establishments		GDP per	
			< 100	> 100	capita	% GDP from
Country	Year	Household	workers	workers	(in '77 prices)	agriculture
Tanzania	1967	55	8	37	170	44
Ghana	1970	78	7	15	310	44
Kenya	1969	49	10	41	228	37
Nigeria	1972	59	15	26	431	31
Indonesia	1975	76	12	12	283	34
India*	1973	60	18	22	146	44
Philippines	1975	53	21	26	428	29
Columbia	1973	48	22	30	690	30
Turkey	1970	32	36	32	799	29
S Korea*	1975	29	24	47	814	26
Taiwan	1971	n.a.	36	64	851	13
Japan	1973	17	44	39	5902	5
UK	1968	12	26	62	3875	3
Germany	1970	small	22	78	7271	3
US	1976	small	23	77	7404	3

* Data not strictly comparable.

Source: ANDERSON D, 1982. Small Industry in Developing Countries: A Discussion of Issues. World Development Vol 10 No. 11, pp 913-948

Table 1.2 CHANGES IN THE DISTRIBUTION OF MANUFACTURING EMPLOYMENT BY SCALE AND TYPE OF ACTIVITY: SELECTED COUNTRIES

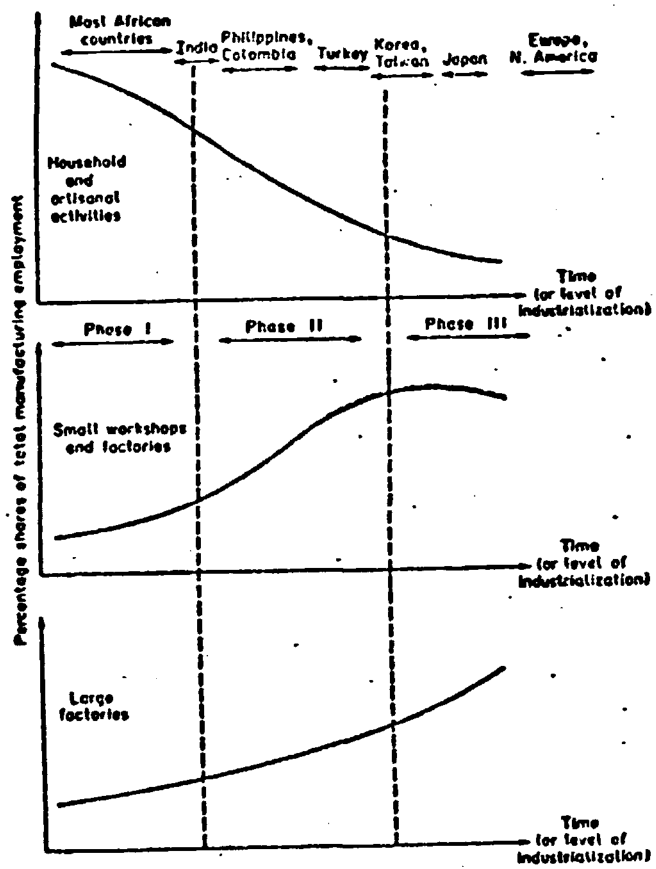
Country: scale and type of manufacturing activity	Year: % distribution of labour force in manufacturing and actual labour force in manufacturing 000's				% Annual growth of No. employed over the period indicated
Philippines	1967			1975	1967-1975
Household (%)	63			53	0.2
Establishments < 100 (%)	15			21	6.0
Establishments > 100 (%)	22			26	4.3
No of workers (000s)	1390			1651	2.2
Columbia	1953			1973	1953-1973
IIII and < 5 (%)	59			49	2.4
Establishments 5-49 (%)	19			16	2.5
Establishments > 50 (%)	22			35	5.9
No of workers (000s)	485			950	3.4
Turkey	1970			1977	1970-1977
IIII and < 5 (%)	55			50	2.6
Establishments 5-49(%)	13			14	5.2
Establishments > 50 (%)	32			36	5.9
No of workers (000s)	1240			1652	4.2
India: Uttar Pradesh	1961			1971	1961-1971
Single worker and < 10 (%)	57			60	9.7
Establishments 10-99 (%)	17			19	9.6
Establishments < 100 (%)	26			21	6.9
No of workers (000s)	772			1831	9.0
Taiwan	1920	1940	1954	1971	1920-1940
IIII and < 5 (%)	61	25	na	na	-3.0
Establishments 5-99 (%)			54	35	
Establishments > 100(%)	39	75	46	65	4.7
No of workers (000s)	131	172	-	-	1.4

Table 1.2 CHANGES IN THE DISTRIBUTION OF MANUFACTURING EMPLOYMENT BY SCALE AND TYPE OF ACTIVITY: SELECTED COUNTRIES (Cont/d)

Country: scale and type of manufacturing activity	Year: % distribution of labour force in manufacturing and actual labour force in manufacturing 000's				% Annual growth of No. employed over the period indicated
Korea		1958	1963	1975	1963-1975
(Excluding IIII employment)					
Establishments 5-99 (%)		67	57	26	4.0
Establishments > 100 (%)		33	43	74	16.2
No of workers (000s)		260	402	1420	11.1
Germany	1882	1925	1961	1970	1882-1925
IIII and < 5 (%)	55	22			-0.4
Establishments 5-49 (%)	18	23			2.4
Establishments > 50 (%)	27	55	75	78	4.5
No of workers (000s)	5934	12704	9363	9785	1.8
United States	1914	1937	1954	1967	1914-1937
Establishments < 100 (%)	35	27	26	23	0.0
Establishments > 100 (%)	65	73	74	77	1.7
No of workers (000s)	8210	10794	15645	18492	1.2

Source: ANDERSON D, 1982. Small Industry in Developing Countries: A Discussion of Issues. World Development Vol 10 No. 11 pp 913-948.

Fig 1.1 COMPARISON OF SHARES OF LOCAL MANUFACTURING EMPLOYMENT



Source: ANDERSON D, 1982. Small Industry in Developing Countries: A Discussion of Issues. World Development Vol 10 No. 11 pp 913-948.

In general, argues Anderson, this change in share-distribution largely reflects changes in industrial structure; certain industries such as foods and garment manufacture are inherently small in scale, but their relative significance tends to fall-off over time (that is their relative income elasticity is low). The factors influencing the 'space' for these household, artisanal and small industries include

- the degree of perishability of final product (eg bread) or inputs (eg sugar cane)
- the cost of transporting goods from the site of production to the market, which is affected, inter alia, by the degree of weight-loss in processing (eg high in mineral processing) and the transport-to-value ratio (eg high in the case of cement, low in the case of electronics)
- the specificity of the final product (as in repair and maintenance, as well as in some types of capital good manufacture)
- the inherent scale economies in production.

We have already mentioned a number of caveats which ought to be borne in mind in interpreting this aggregated data. But before we proceed to discuss the policy implications for this projected role of small-scale industry, it is desirable to point to a major limitation of both these time-series and cross-section sets of data. In the case of the former set, the US observations end in 1967 and the German in 1970; in the cross-section data the surveys were undertaken in 1968 in the UK, 1970 in Germany, 1973 in Japan and 1976 in USA. In other words, the explosive growth of small-scale new-technology based firms (NTBFs) in the mid and late 1970's in the developed economies is largely overlooked leading Anderson in our view, to underestimate the role played by SSI in high-income economies. Rothwell[1)] draws attention to the significance of this phenomenon:

"The results of a recent study by the US Department of Commerce would appear to lend some support to this "new small firm" argument. The study looked at six "mature" corporations (including General Motors and Bethlehem Steel), five "innovative" companies (including Polaroid

1) ROTHWELL R, 1981. Technology, Structural Change and Manufacturing Employment. Omega, Vol 9 No. 3 pp 229-245.

and IBM) and five young "high technology" firms (such as Marion Labs and Digital Equipment). The mature firms which had combined annual sales of $36 billion, added only 25,000 workers between 1973 and 1978; the innovative companies, with combined annual sales of $21 billion added 106,000 workers; the high technology companies, with total sales of $857 million, created 35,000 new jobs. In terms of workers created/$million of turnover, this yields the figures: mature corporations 0.7, innovative companies 5, young high technology companies 41. In the 50's and 60's the semiconductor and computer hardware industries were generating a lot of new employment. In the 70's the main growth in employment has not derived from the hardware side, but from the software side, eg computer bureaux, information services, where small new firms have proliferated".

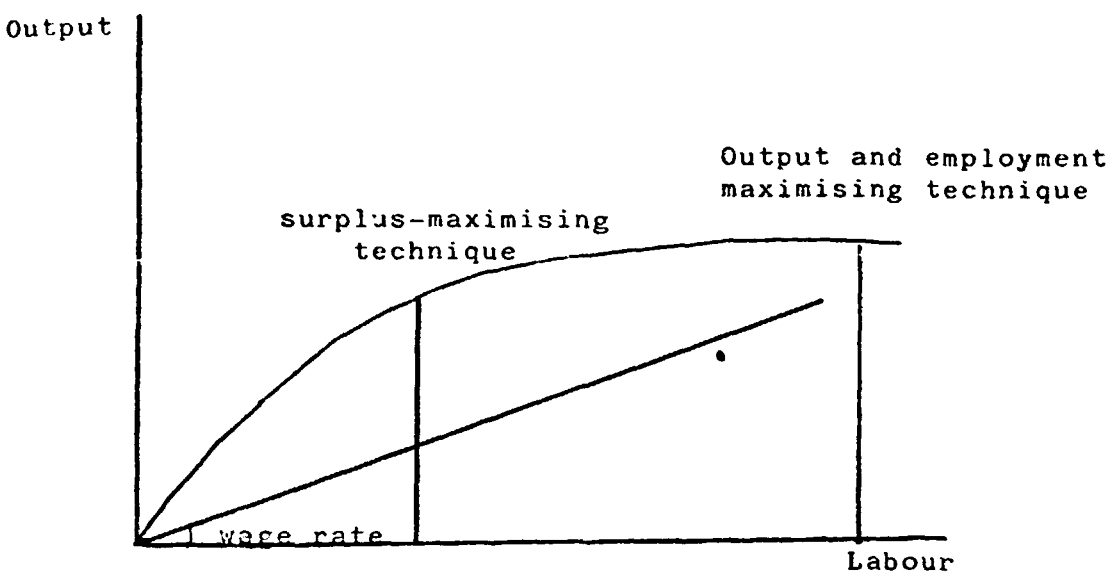
Moreover, as we shall see below, there are reasons to believe that the nature of emerging automation technology is fundamentally altering economies of scale in production, affecting both small and large-scale plants in developed countries. Both these developments add further caution to the development of schematic profiles which could lead policy makers to underestimate the potential offered by small-scale enterprise.

1.4 Do SSI in Developing Economies Necessitate a Trade Off Between Employment and Other Development Objectives?

Notwithstanding the changes inherent in generalising across time, economic space of sectors, it is instructive to consider the assertion that whilst there is general agreement that SSI maximise employment, this is at the cost of output growth and product quality. This view, recently restated by Emmanuel, in large part derives from Sen's classic study of the Choice of Techniques [1] in which the labour-intensive (usually small-scale) techniques also maximise output in the short-run, but not in the long-run given the surplus-maximising nature of the capital-intensive (and large-scale) counterparts - see figure 1.2

1) SEN A K, 1968 Choice of Techniques, 3rd Edition, Oxford, Blackwells.

Figure 1.2: The Choice of Output, Employment and Surplus Maximising Techniques



However, as Cooper[1)] points out it is often forgotten that this perspective on technical choice was based upon an assumption of a centrally-planned economy. In the operating conditions of most developing economies, in which factor, input and output prices vary <u>between</u> enterprises <u>within</u> sectors, the evidence does not always bear out the assertion that the small-scale labour intensive techniques are surplus minimising. In the case of sugar, for example[2)], given realistic selling prices for the output of large-scale mill-output, the small-scale plants are <u>both</u> employment and surplus maximising in the contrasting economic environments of Kenya and India. To produce the same quantity of sugar, the small-scale plants in India would not only provide greater re-investable surplus than the large-scale mills, but also create almost three times as many jobs at only 70 per cent of the capital cost. Moreover this would involve production in over 2,500 decentralised sites compared to 327 large scale mills. Nevertheless the small scale plants do not provide unambiguous benefits since they require more agricultural land, involve

1) COOPER C. Science Policy and Technological Change in Underdeveloped Economies. World Development Vol 2 No.3 March 1974 pp 55-64

2) KAPLINSKY R, 1983. Sugar processing; development of a 3rd World Technology. Intermediate Technology Publications Ltd

significantly worse working conditions and, in India at least are sometimes associated with socially-undesirable money-lending practices. A similar story can be told with regard to bread production in Kenya, where the small scale indigenous techniques are both employment and surplus maximising[1] (See later sub-sectoral study 2.10b)

The significant point of these and other sectoral studies is that there are many cases in which the share of small-scale plants in industry-output is much lower than their operating characteristics would warrant. Coming back to the examples cited above, the more "profitable"[2] small-scale sugar mills account for only around 10 per cent of cane consumption in India and less than 2 per cent in Kenya; in the Kenyan bakery industry the small scale indigenous brick-oven bakeries, whilst around three times as profitable as their large-scale imported counterparts, have a share of around 2 per cent of the market.

Thus in developing a suitable policy framework for SSI in developing countries, it is important to consider not only the problems involved in determining a schema of progress based upon the experience of other countries over time, but also the constraints which inhibit the role played by small-scale enterprises. It is to these latter issues which we now direct our attention.

1.5 An Outline of SSI Development Experience

Conventionally it has been assumed that the industrial sector in many countries has been dualistic, with an increasingly dominant medium to large-scale sector, and a fairly extensive craft sector maintaining a significant share of output, while the small-scale factory sector, at least in the earlier stages of industrialisation, has been eroded. This is supported by some evidence for example from Tanzania and the Philippines.

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1) KAPLINSKY R, 1981. Appropriate Technology in a Developing Country: The Bakery Industry in Kenya. D Phil Dissertation, University of Sussex.
2) That is, if the large-scale mills were to sell sugar at a realistic price - see below

In Tanzania the average size of plants in the organised industrial sector has increased rapidly, while the share of small factories in output and employment has correspondingly declined, as follows[1]:

Table 1.3 PLANT SIZE AND INDUSTRIAL CONCENTRATION IN TANZANIA

	1966	1968	1970	1971	1973	1974
Share of Employment						
Units of below 100 workers	34%	31%	24%	23%	20.5%	19%
Units of above 500 workers	16	30	37	38	40	43
Share of Output						
Units of below 100 workers	36%	44%	36%	29%	27%	27%
Units of above 500 workers	18	19	23	25	34	38

Source: Phillips D op cit. (Reproduced by permission of the author)

The above data for Tanzania demonstrate the erosion of small factories. The ILO mission findings for the Philippines also demonstrate clearly the extent of technological dualism in 1969-71, 70% of employment in manufacturing was at craft level, while 17.5% was in plants of over 200 workers. More recently such findings have been partly supported. Units of less than 10 workers showed the highest employment growth rate (6.5% per annum) between 1967 and 1975, although the growth rate of the large scale (200+) sector was relatively low (4.3%). The sector of 10-200 worker plants showed a growth rate of about 5%. However, the conclusions of recent research on Korea and Taiwan, show an ambiguous picture. Over time there is no doubt that the craft (non factory) sector in Taiwan has declined as an employer; between 1966 and 1971 the most rapid growth was in the 100+

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1) PHILLIPS D, 1981. Choice of Technology and Industrial Transformation - the Case of Tanzania. in Industry and Development Vol1 No. 5 1981 (UN)

worker group - ie medium/large-scale, while smaller factories share of employment tended to decline. The same applies to Korea. However, at the same time in both countries the growth rate of employment has accelerated in the small factory sector for the 20+ worker group. Only the smallest (craft) units of below 10 workers has the growth rate been both low and decreasing (contrary to the case of the Philippines). Over 1961-71 on Taiwan employment growth for the smallest craft units was negative, while the average for all industry was 19.7% per annum; units in the 50-99 worker group grew at 14.4%, and in the 100+ group around 15%.

The data are both of limited reliability and often ambiguous; however there appear to be two conflicting interpretations - (1) that dualism tends to deepen, at least at the earlier stages of industrialisation, reflecting the substitution of small by large (often externally financed) production units (2) that dualism does not occur, with steady decline of handicrafts, early growth of small plants, and later emergence of large plants as suggested by Anderson. Depending on which interpretation is accepted, different general policy conclusions follow. The first interpretation, which is consistent with dependency-type arguments, suggests that state intervention of a relatively strong variety is required, and that even then to reverse the trend is an uncertain prospect. The second interpretation suggests a linear development path towards increasing scale, and that small-scale industry would be expected to play a constructive, perhaps catalytic, role in the transition to an industrialised economy. Policy implication would be that scale promotion, rather than active intervention, is appropriate.

1.6 SSI Contributions to UK Industry

There may be some implications to be drawn out of the experience of Britain[1]. First of all, it is important to realise that small industry (defined officially as establishments of below 200 workers) still play a significant role. In 1978 in fact 50% of the UK

1) PHILLIPS D. The Role and Promotion of Small Enterprises in Britain. PDC discussion paper No. 83, 1982

manufacturing establishments still employed 10 or less workers, while 94% of establishments are in the 200 and below group. The contribution to employment and output over time has been as follows:

Table 1.4 SSI SHARE IN EMPLOYMENT AND OUTPUT - UK

	1924	1935	1948	1963	1972	1975	1978
% Employment	44	44	37	31	27	29	29.5
% Output	42	41	37	28	24	25	26.5

Source: Bolton report; Wilson Committee; UK Census of Production.

The above data show firstly steady decline up to 1972, and then a turnround such that in terms of both output and employment small industries have increased their share. The turnround is a phenomenon of the recession, when on balance small firms were able to respond more flexibly to declining market due partly to their lower overhead costs per unit. SSI shares have been maintained at above 30% of output in many other European countries, and in Japan. In the UK in 1978 SSI share of employment and output was above 50% in certain industries notably leather, fur, timber, furniture, metal goods n.e.s. Clothing and footwear output and employment is also relatively decentralised, with 44% SSI share. In terms of the Staley and Morse classification of industries susceptible to efficient small-scale production, the above rather aggregated groups would probably come within the following categories; assembly and finishing (metal products); differentiated products (clothing, footwear, leather and fur); the service industries do not fall within the above data. Within the service sector small-scale motor repair works and associated activities with up to £100,000 turnover in 1963 accounted for around 30% of net output and employment in the motor trade sector. The category miscellaneous service (excluding distribution construction and motor trade) showed 82% of employment and 68% of output within small units of up to £50,000 turnover[1]. Lowest small-scale share in UK manufacturing are in vehicles, electrical engineering, coal, petroleum and metal manufacturing.

1) Bolton Commission Report (HMSO 1971)

The implications of the UK experience are

a) that despite the long run trend of increasing scale and capital-intensity associated with scale economies in production, marketing and finance, the SSI share has been able to stabilise.

b) the types of industries which are likely to maintain a long term significant share of output at smaller scale are service oriented activities, differentiated products (with short production runs), market oriented assembly and finishing activities in some industries.

The importance of location in determining scale is reduced as infrastructure (especially transport) develops, and as population concentrates in major market centres. On the other hand as incomes rise diversification of consumer spending allows diversification of production into products with relatively small total markets.

1.7 Constraints on the Role Played by SSI in Developing Countries

There are a large number of factors which inhibit an expansion of the role played by small-scale enterprises in developing economies. Many of these are specific to particular locations (eg resource availability) and specific times (eg the availability of suitable technologies). But others are of a more general nature and are reflected in the experience of many countries. We focus our discussion on four of these more general factors, namely technological determinants of plant size, external and internal constraints on expansion, and indigenous technological capability.

i) Technological Determinants of Plant Size

It is customary to draw a major cleavage in the discussion of manufacturing industry, between those enterprises producing dimensional products (that is where the output is measured in terms of weight and volume) and those producing discrete products (that is, individual units)[1]. In general, as we shall see, the types of scale economies in production - the existence of which stand as a major obstacle to small-scale industry - varies significantly between these two types of industry.

It cannot be over-emphasized that a major, if not the major factor constraining an expansion of the small-scale sector within any industry is the existence of scale economies with production. The greater these are, the less the scope for small-scale plants. It is important therefore to unravel the factors which are involved in these economies of scale. Here we must distinguish between direct and indirect costs of production.

(a) Direct Production Costs

Different factors affect direct costs of production in the dimensional and discrete product industries. In the former case, direct cost tend to be affected by the "six-tenths rule"[2]. Although there has been recent evidence that the value of this exponent ultimately increases, so that all high levels of output economies of scale are eroded, there is no doubt that dimensional product industries are generally susceptible to scale-economies, making the very small-scale production of products such as chemicals and synthetic fibres economically unviable except in special circumstances.

In the discrete products industries, however, scale economies arise as a consequence of a different factor, namely the time and output lost as a consequence of resetting machinery to produce products of different specifications. Hence, for example, to adjust bottle-making machines from one specification to another involves two-hours of machine down-time whilst moulds are changed, and a further six hours

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1) The categorisation, first drawn by Woodward, 1965, is similar to the better known continuous vs batch distinction. However it is more accurate since much of the output of process industries is in fact produced on a batch basis.
(* Joan Woodland. Industrial Organisation: Theory and Practice, Oxford University Press, 1970 Edition)

2) See Introduction

of damaged production whilst machine settings are changed, iteratively to optimum levels. As a consequence of these changeover costs, wherever possible, production occurs in very long runs of a single bottle size and scale economies arise. Yet in the case of many products, limitations of demand do not allow for such scale economies to be realised - in the metalworking sectors of the major developed economies, for example, around 75 per cent of production is of a small-batch nature and hence much production, in the capital goods and machine tool sectors, still occurs in small batches and in small-scale plants using labour-intensive technologies.

(b) Indirect Production Costs

The above discussion of direct production costs addressed the issue of product and plant economies of scale. However, a further type of scale economy arises as a consequence of economies of scale in indirect product costs and involves firm economies of scale. These arise from firm-level activities such as Research and Development (which has become increasingly important over the years, particularly in the new technology sectors), purchasing and marketing. It is immediately evident that there need be no necessary conflict between the existence of small scale factories, where direct production costs involve few scale-economies, and large-scale firms, spreading fixed, indirect production costs over large runs of output.

(c) The impact of new technology on scale economies

Historically the period until the 1930's was one in which concentration occurred with respect to plants; thereafter these remained relatively muted until the mid 1970's, and the major growth in concentration occurred with respect to firms, rather than plants[1] (It was in this period, incidentally, that the studies cited by Anderson and others took place). However in recent years major changes have begun to occur in production technology which fundamentally alter this previous pattern of technological progress[2]

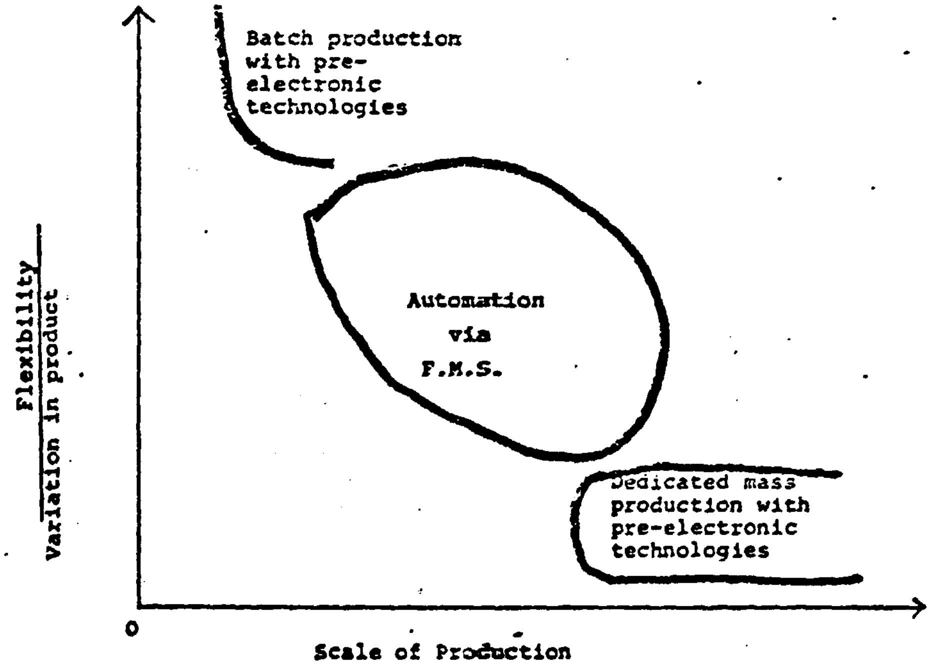
1) BRETT E A, 1983. International Money and Capitalised Crisis: The Anatomy of Global Disintegration. London, Heinemann

2) KAPLINSKY R, 1983a. Automation in a Crisis. London, Longmans

In particular the new micro-electronics based automation technologies, by allowing for greater flexibility in production, changes the optimum scale at which production occurs (figure 1.3). The effect is threefold.

Firstly it undermines plant economies of scale in mass-production industries, especially those in the discrete products industries. Thus, for example, the new Mazda automobile plant can adjust instantaneously to assemble three completely different types of car[1)] - previously three separate plants would have been required to reap economies of scale in production. Second, for the first time economies of scale are being introduced into small batch production so that, for example, small-scale machine-tool and mould making enterprises using pre-electronic technologies are experiencing increasing difficulty in coping with competition from enterprises introducing more capital-intensive numerically-controlled (NC) machine-tools. And, third, since the development of these NC machine tools requires substantial software engineering, and since they are more expensive to purchase, the tendency towards firm economies of scale is being enhanced.

Figure 1.3 The Effect of FMS on Automation and Product Composition



Source: Kaplinsky 1983a Op Cit (Reproduced by permission of the author)

1) Namely the 323 front-wheel drive small hatchback, the front-engined rear-wheel drive 626 medium saloon and the rotary-engined RX7 sports car.

We are therefore confronted by a series of radical changes in manufacturing technology which are likely to have a major influence on scale economies in production. In some cases (eg in mass production discrete products industries) these are reduced at the plant and product level, thereby providing greater potential for small-scale plants. In other cases (eg in small-batch production) its introduction is likely to erode the comparative advantage of small plants. Hence in considering the future role of SSI in developing economies, it is essential to bear in mind these changed technological relationships.

ii) External Constraints on the Expansion of the SS Sector

The external environment in which SSI operates is a key determinant of the extent to which this sector is allowed to realise its potential. As we noted above, in most economies the potential is systematically unrealised, a conclusion shared by two recent surveys written on the topic: Anderson [1] precedes his discussion of the external constraints by noting that "the implication [of these external constraints] is that the growth could be significantly greater than has been experienced so far" (p 932); Schmitz [2] concludes that "the issue is not whether small enterprises have growth and employment potential but under what conditions" (p 445)

A wide number of such constraints could be listed, reflecting in part the ideological perceptions of the analysts involved and in part the real difference in operating conditions over space and over time. Anderson, for example, focusses his attention on the SS sector's limited access to finance, its problems in obtaining extension services, misguided employment-maximising programmes of governments[3] and industrialisation-policies which disfavour agriculture and hence reduce the extent of demand for SSI's output. Schmitz focusses on the exploitation of the small-scale sector (which provides cheap wage goods for large scale industry), the continuing dependence of SS subcontracting, the problems faced by the sector in obtaining access

1) ANDERSON op cit.

2) SCHMITZ op cit.

3) Which by concentrating only on the employment objective, prejudices programmes of more general relevance to the sector.

to markets, raw materials and credit, and their discrimination by Governments. Whilst it is difficult to believe than any one approach is "correct" we concentrate our analysis on three major sets of external constraints, namely the demand patterns inherent in particular development strategies, the relationship between large (often multinational) and small-scale industry, and the nature of the state.

(a) The Structure of Demand

There was a time in the 1960's and early 1970's when the reaction against neo-classical economies was so pronounced that it was commonly believed that in most sectors there was no choice of technique. However as a consequence of a variety of empirical studies undertaken on the economies of technical choice it came to be recognised that if tight product specifications were relaxed, then the degree of technical choice increased. For example if the object was to produce ball-point pens of a specific proprietory kind, only one efficient large-scale technology was available and was owned by an American TNC; however if the product-specification was changed to "writing implements" the degree of technical choice was very large indeed. Although the extent of choice varies between Sectors, it came to be recognised that product and process choice was inextriably linked[1]. Thus in focussing our attention on the constraints faced by the small-scale sector it is important to address the determinants of the structure of demand.

Whilst demand structures are clearly affected by cultural traditions, the orientation of the overall development strategy is also of great significance. For example, it has been suggested that a common

1) See a) STEWART op cit.

b) MORAWETZ H, 1974. Employment Implications of Industrialisation in Developing Countries: A Survey. Economic Journal, vol 84.

c) BHALLA A S, 1975. Technology and Employment in Industry: A Case Study Approach. Geneva, ILO.

characteristic of development strategies has been to favour the growth of the (large-scale) industrial sector[1] by, inter alia, turning the terms of trade against the agricultural sector. The consequence has been a depressed rate of agricultural growth and internal migration to the cities, hence reducing the size of rural markets, and thus the demand for decentralised SSI products.

But in addition to the extent and location of markets, the type of demand also has an important bearing. In many developing economies, particularly the smaller and more open ones, the demand for need-satisfaction has been translated over the years into the demand for very particular products - thus the market seeks well-advertised branded pens rather than writing implements. These factors are almost inevitably exacerbated when income distribution structures are particularly unequal.

(b) Large versus Small Industry

Consider the following paradox: we expect that in market economies investable resources will be allocated so as to maximise profits, yet we have observed that there is a consistent tendency for underinvestment in more profitable SSI. The resolution of this paradox lies in the perspective held by the investors, the allocators of resources. The point is that conventional economic theory often mistakenly views this group as a homogeneous entity. More typically it is comprised of at least two distinct sub-strata - small-scale industrialists with their links in the agricultural sector or petty commodity production, and the large-scale industrialists who have close bonds with the state and foreign capital/technology. Movement between these two strata is by no means free. Thus whereas the potential profit available from a large number of dispersed plants may be greater than that from a single, large unit, the large-scale fraction of industrialists is generally unable to control these dispersed units and hence appropriate the theoretically large surplus.

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1) The World Bank, for example, attributes a large part of sub-Saharas current economic crisis to these policies.
See: IBRD, 1981. Accelerated Development in Sub-Saharan Africa: An Agen for Action. Washington, The World Bank.

Moreover in part the small-scale units are more profitable because they have access to lower labour costs and can evade state-regulation - the very entry of large-scale industrial capital into these small-scale activities is likely to erode these competitive advantages.

The natural response of the large-scale sector is to attempt to undermine the advantages of the SS sector. This may involve advertising to influence taste-patterns, denying the small-scale sector access to raw-materials or credit, cartelisation and a variety of other competition-reducing strategies. The particular forms this takes will inevitably vary over time and space, but remain as a significant constraint to the expansion of the SS industry.

(c) The Nature of the State

The debate on the nature of the state in the Third World is complex and contentious and is beyond the scope of this paper. However some elements of the discussion are relevant in defining the external environment in which the small-scale sector exists. There is now ample evidence from many developing economies that the large-scale sector benefits disproportionately from government policies[1], and in a variety of different ways. Take for example the previously-cited case of sugar: in both countries (India and Kenya) the case against the small-scale plants rests largely on its apparent lack of price-competitiveness. Yet the prices at which the large-scale mills sell sugar do not reflect the true (social) opportunity cost of resources because the depreciation rate implicit in price determination is based upon historic and not replacement costs[2]. In one large mill the depreciation costs of a 7,000 tcd (tonnes of cane crushed per day) plant are based on a historic cost of $50m, whereas the replacement cost of a plant of that size it more in the region of $210m. If the sugar selling price is unrealistic based on a recoupment of historic capital cost by the large plant, then the new small plants cannot compete. But at a more realistic depreciation rate based upon replacement investment costs (which are more like $325m) new small-scale plants are highly viable. This phenomenon - involving a

1) Some of this evidence is surveyed in Schmitz (1982) op cit.

2) In Kenya, an additional social costs (that is the scarcity of foreign exchange) is also involved, but is excluded from this discussion.

subsidised depreciation rate - is extremely common in the case of large scale projects, particularly those in which the state participates in equity; it acts as a constraint on potentially viable SSI and is merely one example of a common type of discrimination against the small-scale sector which is implicit in state policies.

The question is why this occurs and here there are at least three explanations. First, as we have argued above, in some respects the interests of small-and-large-scale capitalists diverge and in most documented cases the latter triumph in their access to the state. Second is the unfortunate tendency for investment decisions to reflect a subjective approach so that the investment decision becomes in Enos' terms[1] the "choice of beneficiary" rather than the choice of technique. If this the case; the bias will normally be in favour of large scale plants. And, finally although the state may ultimately reflect the interest of a particular class, it is characterised by relative autonomy and acts often as a class-for-itself. As Dobrska[2] points out, even in the centrally planned economies large scale plants reflect the desire for control rather than the logic of surplus of employment maximisation; a similar phenomenon occurs in developed market economies, as in the committment to large-scale nuclear power despite contrary evidence that it is a costly and dangerous alternative[3]

iii) Internal Constraints on the Expansion of the SS sector

Despite the clear significance of the external constraints on the small-scale sector, it is the internal constraints which have received more attention, both in the research literature and in actual government policies. Thus much of the weakness of this sector is attributed to its own internal failings. The key elements here are seen as comprising a mixture of motivation drive, skills and

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1) ENOS, 1982. Choice of Technique or Choice of Beneficiary. In Economics of New Technology in Developing Countries. Edited by Frances Stewart an Geoffrey James. Francis Pinter.

2) DOBRSKA Z, 1981. The Problem of Technological Choice, in D Seers (ed) Dependency Theory: A Critical Reassessment. London, Francis Pinter.

3) MACKERRON G S, 1982. Nuclear Power: The Economic Interests of Consumer Electricity Consumer Council. Research Paper No. 6, London.

experience - in all cases the small-scale sector is said to suffer disproportionately from the absence of these desired (albeit elusive) attributes. No doubt there is much validity in this view and in the consequent call for suitable government extension services (despite their frequent lack of cost - effectiveness in practice).[1]

Yet this does not add up to the weight given to these internal constraints, particularly since much of the evidence is open to reinterpretation. Kilby[2] for example, argues that skill did not always correlate positively with success in the Nigerian SS sector; similar observations are drawn by Harper[3] in Kenya. In fact, in comparison with the perceived "inefficiency" of SS entrepreneurs, the large-scale sector may if anything perform even worse, although in theoretical terms this is rationalised away as "satisficing", rather than profit-maximising managerial behaviour. Moreover there is much evidence of "control-loss" in large-scale plants which arises as a direct consequence of their size (see Caves' 1980 survey of industrial organisation)[4].

For all these and other reasons, we play down the relative importance of internal constraints on the expansion of the SS sector. This not however to deny their validity and we return to these problems in part III when we discuss appropriate policies for the small-scale sector.

iv) <u>Trade Policies and Indigenous Technological Capability</u>

So far, despite a discussion of the potential impact of the new automation technology on economies of scale and hence on the role to be played by the small-scale sector, we have tended to conflate the sector into a single category. However in discussing the link between indigenous technical capability (ITC) and SSI we neeed to

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1) LIVINGSTONE I, 1982. Rural Development, Employment and Incomes in Kenya, ILO/JASPA. Geneva.

2) KILBY P,1919. Industrialisation in an Open Economy: Nigeria 1945-66. London, Cambridge University Press.

3) HARPER M & T THIAM SOON, 1979. Small Industries in Developing Countries: Case studies and Conclusions. Intermediate Technology Publications Ltd.

4) CAVE, 1980. Industrial Organisation: Corporate Strategy and Structure. Journal of Economic Liberation. Vol XVIII, 1980 pp 64-92.

differentiate the concept in a manner similar to that used by Anderson and represented in his schema of industrial development (figure 1.1). Our own sub-categorisation distinguishes indigenous-small-scale industry from modern-small-scale industry (largely using imported technology) and both from small new-technology-based-firms (NTBFs), few of which have yet penetrated the Third World.

The relevance of this discussion only requires brief explanation. In the first two and a half post-war decades most developing economies concentrated on laying the basis for future economic growth by instituting import-substituting industrial programmes, developing their economic infrastructure, and in improving the quality of their human resources. It was a period of substantial economic and technological dependence and one in which transnational corporations (TNCs) played a significant role. The environment in which the TNCs and national firms operated was increasingly constrained by government efforts to regulate and control the transfer of technology[1]. Then in the 1970's two important trends began to emerge. First many of these import-substituting enterprises were characterised by significant degrees of inefficiency, giving birth to the concept of X-inefficiency discussed above. And, second, a limited number of newly-industrialising countries (NICs), some of whom provided an extremely liberal environment for TNCs, became increasingly competitive on the world market. The upshot of these events, coupled with the increasing power given to multi-lateral agencies as a consequence of the debt-problems of most developing countries has been a drive to root out "inefficiency" in developing economy enterprises. In some cases - as in the World Bank's policy document for sub-Saharan Africa[2] - the call is to root out X-inefficiency by recourse to reformed trade policy. In Balassa's terms if enterprises cannot cope with less than ten per cent protection after 8 years, then it is questionable whether their continued protection can be justified.[3]

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1) In some notable cases, this involved inter-governmental cooperation as in the Andean Pact.

2) IBRD op cit.

3) BALASSA B (and others), 1982. Development Strategies in Semi-industrial Economies. Baltimore, Johns Hopkins University Press.

How does this discussion relate to SSI? Here we need to distinguish the indigenous group from the modern, and NTBF small firms (whose impact upon developing economies is in general likely to be indirect in the immediate future). However some modern SSI - as exists in many SSI estates in Africa - must be seen in similar terms to large-scale enterprises. Their existence and survival without state support - either explicitly through subsidies or protection, or implicitly through favourable depreciation policies - is problematic. They often involve the production of low-quality, high-cost products, the consequence of which is to turn the domestic terms of trade against agriculture and to worsen the distribution of income. Their existnece is to be explained in terms of class formation (that is a protected/subsidised route to accumulation) and they can only be justified in social terms if they lead to significant external economies or benefit from learning-by-doing. In respect to learning-by-doing the eveidence is mixed[1] and largely negative; external economies are often a matter of belief rather than a fact of life.

Thus if the role played by these modern small-scale enterprises and their large-scale counterparts are limited, then it is possible that more space will be left for indigenous SSI, much of which cannot compete with the "quality" image and subsidised prices of their more "modern" counterparts. The question is whether they will be able to compete with imported products which are likely to flow in if trade regimes are liberalised in the proposed manner. This is something which can only be evaluated on a sectoral basis, and in addition is affected by the complementary policies for industry vis-a-vis agriculture policies together with the reformed trade-policies.

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1) BELL R M, 1982. Technical change in infant industries; a review of empirical evidence: Science Policy Research Unit (SPRU). University of Sussex, Brighton, Sussex.

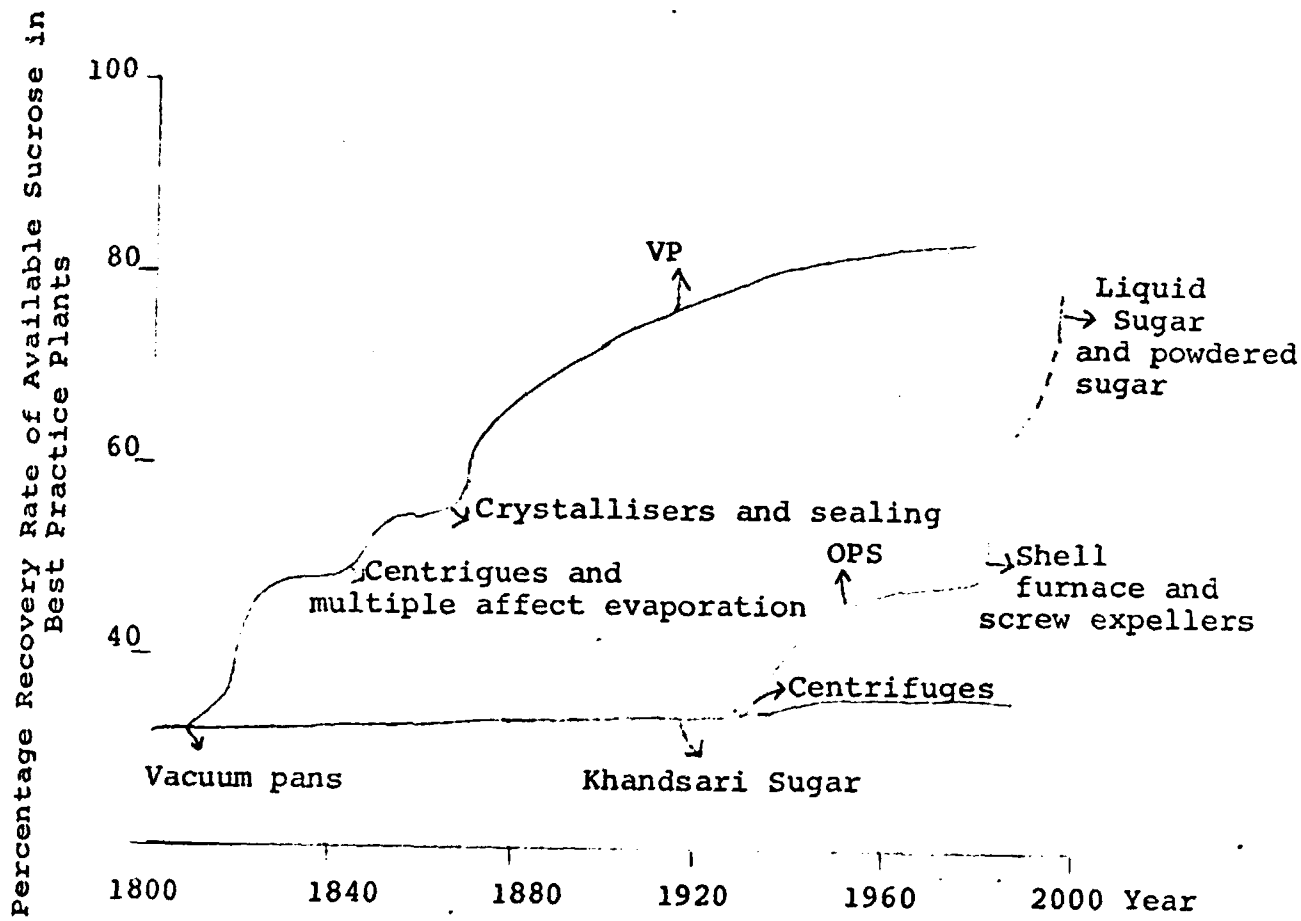
We are left, then, with the indigenous small scale sector. We should bear in mind that "small" is a relative concept and many of these enterprises may be small relative to their large-scale counterparts but nevertheless of significant size; small-scale glass container plants can cost over $1m, whilst investment in small-scale sugar mills can approach $10m. It is here that the fruits of many developing economies' investments in human resources are being felt and that indigenous technological capability (ITC) is being applied. The problem, however, is that the likely effect of the new trade policies will be highly deleterious. The ten per cent for eight years criteria <u>may</u> be a suitable way of rooting out X-inefficiency with imported technology, but it holds little relevance for developing indigenous technology. As Bell[1] points out, the <u>successful</u> cases of indigenous technical change display a long gestation period and this can be very clearly seen when we survey the development of both small and large-scale sugar technologies (Figure 1.4). In the case of the large scale, vacuum-pan, variant, the technology took at least 100 years to mature. In the case of the SS open-pan technology, by the mid 1970's - fifty years after the technology was first introduced - the technology could not compete with the large scale equivalents, leading various observers (Forsyth, 1977[2], Baron, 1975[3]) to conclude that it was suboptimal. Only in very recent years (circa 1981) has the input of ITC begun to bear fruit.

1) BELL R M, 1982. op cit.

2) FORSYTH D, 1977. Appropriate Technology in Sugar Manufacturing. World Development Vol 5 No. 3 pp 189-202.

3) BARON C G, 1975. Sugar Processing Techniques in India. In A S Bhalla (Ed) Technology and Employment in Industry. Geneva, ILO.

Figure 1.4 Development in VP and OPS Technology



Source: Kaplinsky 1983 op cit.

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1.8 SSI in the 1980s

From the above discussion it is possible to point to three major trends which appear to be emerging and which seem likely to play an important role in the development of SSI in the 1980's. They are an important backdrop to the later discussion (part III) on Promotion and Implementation strategies. First is the significance of the new automation technologies. For not only do they undermine the conclusions of cross-section analysis on the eventual decline of small-scale industry, but they appear to change the pattern of plant-scale economies in production; these are likely to be reduced in the case of mass production, discrete-products industries, and to be increased in small and medium batch-production sectors. In all cases this will probably have a signiificant impact upon the role played by small-scale plants, although not necessarily by small-scale firms. Second, with the increasing foreign-exchange and debt-problems of developing economies, reforms of trade-policies are likely to become more common. In some senses, notably by removing inefficient competitors, this may be to the benefit of indigenous SSI. But the effect of liberalised imports on this sector is still uncertain and is likely to vary, especially if reformed trade policies go hand-in-hand with domestic policies which lead to a relative expansion of the agricultural sector and domestic demand. Third, and finally, we have only seen the first fruit of ITC being applied to Third World technology. The potential is abundant and with a suitable mix of government policies it is possible that indigenous small-scale technology, which, because of its roots is likely to be less capital-intensive and smaller than its imported counterparts, will flourish in the coming decade.

A. SECTOR STUDIES

This chapter examines the prospects, potentialities and evidence of the experience with small plants in the following ten sectors within three broad industrial divisions:

Basic Investment Industries

1. Iron and Steel
2. Machine tools and workshop equipment
3. Agricultural equipment
4. Computer-aided design
5. Building materials

Process Industries

6. Petrochemicals and associated industries
7. Pulp and paper

Light Industries

8. Bicycle manufacture
9. Textiles
10. Food manufacturing (with sub-sectoral studies of cane sugar processing and bread making).

The sectors have been chosen partly on grounds of their intrinsic importance, but also with a view to illustrating the variety of constraints and considerations that affect the discussion of scale. Special emphasis has been given to technologies appropriate for developing countries, analysis of the costs and benefits of smaller-scale plants and the potential to go beyond currently-available alternatives.

2.1 IRON AND STEEL

2.1.1 Introduction

The general euphoria associated with the expansion of steel-making capacity in recent years has now been seen to be without economic justification, and there is now considerable overcapacity which is further compounded by rises in oil prices and the worldwide economic depression. The pace and extent of the world recovery is difficult to forecast, but it is clear that the inroads made into the traditional ferrous markets by plastics and concrete will exert a continuing influence. Confirmation of the balance between a contracting developed market and expansion in the developing countries has to be awaited, but a general restructuring of the steel production in industrialised countries may be expected to continue. At a national level, large capacities exist, but operating levels are lower as plants become obsolete and consequently uneconomic. As new capacity is established in developing countries, developed industries are forced to seek better competitiveness by introducing innovations such as continuous casting and mini-mills which make steel from scrap (and which now account for over one-fifth of steel made in the USA).[1)]

2.1.2 Minimum and Maximum Sizes of Plants

The basic steelworks operations can be separated into three discrete areas:

- iron making
- steel making
- rolling into profiles

There is no quality disadvantage in separating these operations by delivering prepared iron for conversion into steel, from which ingots are cast for subsequent rolling. Local conditions still significantly affect the economy of operation: in cases where rationalisation of an existing national steel industry is being considered, it is entirely feasible to isolate any of the three areas

1) "American Steel: Resurrection". The Economist. April 2 1983.

in order to improve utilisation of an established plant as a service to a projected new facility. Consequently economic factors can be sharply influenced by the relationship to established capacity.

2.1.3 Manufacturing Route in Iron Production

Urged by enhanced fuel costs, an increasingly large number of alternatives for metal reduction is emerging. Large integrated complexes use liquid iron from a blast furnace for conversion to steel by direct transfer to a form of converter, while the traditional shaft furnace, fuelled by coke to produce pig iron, is being progressively challenged by direct reduction plants. Meanwhile shaft furnaces established in developing countries successfully employ charcoal as a fuel in smaller-sized plants (up to 500 tons/day) and a feature is the low volume of slag produced, yielding potential advantages for countries with good forest resources and effective afforestation programmes.

An important challenge to the blast furnace is the now well-established direct reduction plant employing a gaseous or solid process without a liquid phase. Natural gas and non-cooking coal are satisfactory fuels, and thus open up scope for adoption in developing countries. Direct reduction iron has uniform chemical properties, and by reason of fewer metallic impurities than recycled scrap, improves the technical control possible in the later stages of steelmaking. An incidental advantage of sponge iron over scrap is easier mechanical handling which in turn promoted improved control.

2.1.4 Manufacturing Route in Steel Production

Review of steel making processes throughout the world shows great differences in the choice of technical route, particularly influenced by the national characteristics of the economy and internal linkages. Apart from direct steel production from blast furnace iron, other methods exist for steel liquid manufacture using cold iron charge with or without recycled steel scrap and mill returns. Traditional steel melting and treating furnaces continue to be utilised, but to decreasing extent as open-hearth and Thomas converter production has given way to electric melting and oxygen-based processes, of which Linz-Donawitz was an important development. There is a considerable variety of individual processes which offer extensive scope for utilisation of locally available fuels, including:

- Bottom-and side-blown converter, Stora - Kaldo,
  Linz-Donawitz Oxygen Bottom Maxhutta,
  Submerged Injection, Creusot-Loire etc (LWS);

- Numerous continuous processes including the spray process.
  Electric processes ie resistance, direct arc, electro-slag.

The following table indicates the low specific investment for small-scale steel producing facilities and the dis-economy of scale for large annual output. Energy considerations do not feature predominantly in final cost analysis but more so in the form of energy supply.

Table 2.1 COMPARATIVE CAPITAL COSTS

FOR RAW STEEL PRODUCING FACILITIES

Facilities	Annual Capacity tons	Investment Cost $/ton
Electric furnace	50,000	240
Continuous casting		
Hot mill	100,000	230
Direct reduction	500,000	320
Electric furnace		
Continuous casting		
Merchant mill	1,000,000	606
Open-hearth furnace		
Continuous casting		
Merchant mill	500,000	610
Electric furnace		
Continuous casting		
Hot mill	500,000	340
Merchant mill		
Electric furnace		
Continuous casting		
Hot mill	1,000,000	346
Electric furnace		
Ignot casting		
Hot mill	1,000,000	390
Blast furnace		
Basic oxygen furnace		
Continuous casting		
Hot mill	2,000,000	477
Direction reduction		
Electric furnace		
Continuous casting		
Hot mill	2,000,000	482

Source: Data supplied by Geoffrey Lamb (Consultants) Ltd., Birmingham, UK.

2.1.7 Plant Complexity and Operating Prospects

It is difficult to evaluate performance of plants of varying degre of complexity due to the lack of common standards for comparison, coupled with the practical consideration that the basic profitabil of a given works may be wholly tied to manufacturing performance s that statistics are not published. A further factor to consider likely level of external infrastructural support. Installations i industrial countries can rely upon the full support of local and national technological infrastructure (independently of scale), w in the less well-supported environment of a developing country functional complexity is likely to be a positive disadvantage, gi rise to serious problems of operation and maintenance.

Across the range of machinery involved in steelworks production, broad processes can be identified:

- mainly metallurgical iron reduction
- jointly mechanised and metallurgical steel production
- mechanical rolling.

In general mechanical skills can be transferred most readily beca the operation can be directly seen and assessed, whereas the metallurgical elements require instrumentation and lengthy experi The mechanical functions of furnace and ancillary plant are readi measured, but elements such as refractory condition need experien observation to avoid the two expensive extremes of:

- overcautious replacement which exaggerated down-time, production loss and increased repair materials consumptior

- driving the equipment beyond the point of prudent repair, with disastrous results where metal burst-out occurs.

Concern for design for minimum maintenance is a sensible priority this should not be an overwhelming factor, and it is essential to differentiate between design for easy maintenance and choice of obsolete technology. In any event, technology transfer packages for developing countries should always include simple routing production and maintenance procedures coupled with provisions to ensure a safe working environment.

2.1.8 Choice of Scale

Over the past 10 years small, efficient and flexible mini-steel plants have been taking business away from the larger integrated steel producers and, in Europe, it is clear that countries employing a high proportion of mini-steel mills have weathered the recession more easily than those committed to very large integrated steel plants. In Italy alone there are currently 120 mini-mills and, since 1976, 15 million tons of crude steel capacity has been installed in the form of small-scale and mini-mill plants, while a further 25 million tons is envisaged by 1990.

Table 2.2 MINI-STEEL PRODUCTION 1980 - PER CENT OF OVERALL OUTPUT

Italy	55%
Spain	46%
UK	32%
Korea	29%
USA	27%
Japan	23%

Source: Data supplied by Geoffrey Lamb (Consultants) Ltd

One merit in employing separate melting and rolling facilities is the possibility of employing under-utilised foundry melting capacity for ingot manufacture to level the peaks of demand. A further point to note is that strong links exist between the mini-mill and its melting method. The electric arc furnace is currently predominant, but some interest is developing in electro-slag.

Raw materials for electric melting may be

- direct reduced (sponge) iron
- recycled steel and iron scrap
- pig iron

In any given plant projection the availability of steel scrap is most important, and country reserves and recycling levels must be carefully evaluated. Sponge iron will become available from increasingly diverse sources in future years, but the overall expansion in the decade from 1980 is only foreseen as 20/25 million tons, representing about 1% of the world installed steelmaking capacity. Even so its importance to the developing world is likely to be significant. The impact of world resources and distribution of scrap metals on future melting trends could be crucial, because increased electric arc furnace capacity will favour scrap as a raw material on cost grounds in some medium scale plants. Indeed export controls may become a factor in the availability of steel and iron scrap in the foreseeable future.

Rolling mills are the largest item of capital investment in mini-steel plants. Equipment specifications depend upon the accuracy of market forecast, since specialist facilities are more economical at high operating rates, while the introduction of flexibility into rolling programmes usually leads to reduced utilisation.

For a 150,000 tons per year plant, a typical investment cost breakdown is: (1)

Melting	12%
Casting	14%
Rolling	52%
Building	12%
Services	10%

(1) Source: Data supplied by Geoffrey Lamb (Consultants) Ltd

A wide variety of alternatives is available, ranging from common roughing and finishing stands to sophisticated high-speed plant, with intermediate stands and controlled cooling. Often rod mills are the first step for developing country investment, due to the wide-spread demand for reinforcement bars. Sometimes the capacity of plant is restricted to simple sections such as flats and angles within the power available for an initial programme of rebar production.

2.1.9 Beyond Current Alternatives

Since the steel making process related to forming of raw materials, it is an obvious improvement to delete any part of the chain. It is reasonable to project that refinements of the production sequence will continue to develop, while wider use of continuous casting, direct casting of flat slab of larger area and less thickness can also be foreseen, couple with improvements in performing pipes and tubes.

Energy considerations must always feature significantly in metallurgical processes, so that the application of atomic energy is a long-term possibility. It is probable that reactor heat may be used to obtain hydrogen from water which could be used for direct reduction of iron ore; alternatively heat from a high temperature gas-cooled reactor may be harnessed to reform hydro carbon gas for direct reduction. Researchers in many countries are known to be working along these lines but it may not be possible to see effective industrial operation until the next decade.

Another novel route, also claiming significant energy reductions, would be to remove most of the gangue material from an iron ore in its cold form - ie by mineral separation techniques, rather than by slagging in a blast furnace. Only applicable to certain ores, a 99%+ Fe content "super concentrate" would be formed. This would then be reduced to sponge iron in a conventional direct reduction process. The Swansea University version[1] of this process, claimed to be particularly suitable for developing countries applications, goes on to feed the sponge iron directly into a rolling mill, without an intermediate steel

1) AHIER S J and SINGER A R E. Direct Rolling of Sponge Iron Pellets. Iron and Steel International Dec 1979.

... has properties comparable to conventional mild steel, and popular thin sections (such as angle and rebar) can easily be formed.

More prosaic, but equally important developments will concern skills, health and safety, and the improvement of working conditions, since almost all steelworks plant involves hostile operating conditions and heavy forces. In industrialised countries many of the traditional operating skills are currently being replaced by high-speed monitoring equipment, which means that skills are increasingly related to maintenance and calibration of the instruments.

Apart from better working conditions for direct production workers, the instrument interface facilitates off-the-job training in use and servicing. The trend towards mini-mills with smaller staffs will lead to less formal management styles, with fewer layers of management and more operational responsibility being devolved for foremen and supervisors. In general, there will be a growing trend for product quality and plant performance skills to become managament and technologist skills as distinct from craft skills, and staff recruitment and training will have to be re-orientated accordingly.

Overall the trend towards mini-mills appears to be firmly established, thereby offering an attractive option to those developing countries with limited markets and capital resources, but who wish to build up indigenous capacity in this still-important basic industry.

2.2 MACHINE TOOLS AND WORKSHOP EQUIPMENT

2.2.1 Introduction

Before examining the impact of recent developments including numerical control (NC) and robotics on machining operations, it is helpful to review simpler mechanical forms of automation which enable the manufacture of a particular component or part to be repeated:

Jigs: The simplest method is by use of jigs or templates which the operator of a drill or lathe can follow.

Form cutting: The cutting or grinding tool is preformed so that it cuts the part to shape by moving the tool into the part at a preset depth.

Straight line cutting: Line milling and the turning of stepped shapes by manually setting a series of mechanical stops which provide a preset sequence of tool moves.

Copy milling: More complex mechanical automation can be achieved by making a three-dimensional model of, say, a die surface and then copy milling the model to form the complex die shape. This is most often applied to small batch manufacture of complex shapes.

Cam automatics: Where relatively simple shapes have to be produced in large batch sizes a series of cams can be made for a specific part, and used to cause a machine tool to cut that part.

A disadvantage of all these methods is that they require the pre-manufacture of a mechanical part, which is itself time-consuming and expensive (obviously less so for simple jigs and templates), and the costs of storage and maintenance are also significant. Numerical control offers the great advantage of flexibility, in that the movements of the machine tool are controlled by numerically-written instruction which are read automatically as numbers by the NC system which controls the machine tool.[1)]

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1) A management guide to numerical control machine tools. The Institution of Production Engineers, London. 1978.

2.2.2 Scale and Changing Technology

Machine tool manufacture provides an interesting example of the impact of new technologies on the economies of scale. Prior to the introduction of NC, many machine tools were relatively standard items and markets could be won by price and cost reductions resulting from large-scale production. As the new technologies began to be developed, however, the value added per item became significantly greater so that smaller scale production could be profitable. On the other hand research and development costs rose rapidly yielding scale economies of a different kind to those businesses which could spread their overheads over larger production runs.

Flexibility is also important in view of the pace of technological change, and in order to compete firms have to learn new electronic skills to supplement their traditional mechanical engineering expertise. There have been major advances in precision grinders through the application of sensors and microprocessor-based controls, while multi-purpose turning and machining centres, which are capable of changing tools automatically, are a further significant development. Other interesting innovations are adaptive controls that automatically compensate for tool wear, active magnetic bearings that permit ultra high spindel speeds, adoption of new hydraulic fluids compatible with coolants and lubricants and the replacement of gears with continuously variable drives. One effect of the higher speeds and metal removal rates made possible by NC techniques has been the need for stiffer machine structures to withstand higher stresses, leading to increased interest in the use of concrete for machine tool structures so as to dampen structural vibration and give a high dynamic stiffness to relatively small structures.[1)]

With automatic workpiece loading, most machine tool downtime comes from adjusting the position of cutting tools to compensate for wear, and those stoppages of 15 minutes or so occur at least seven times over the life of a tool in the case of lathes and boring mills. Thus there is a considerable saving in incorporating adaptive controls which adjust the tool position automatically after each workpiece is

1) DANN Richard T. Machine Tools on the Move. Machine Design. March 12 1981.

cut, and thereby keep finished parts continuously within tolerance limits. For example, the Samsomatic control produced by Genicon Inc. can adjust tools with a reproducible resolution of 0.0001 cm., which is considerably better than most production line tolerances.

2.2.3 Robotics

A particularly interesting and controversial sub-sector is the manufacture of robots, defined by the Robot Institute of America as:

"a reprogrammable multifunction manipulator designed to move materials, parts, tools, or specialised devices through variable programmed motions for the performance of a variety of tasks."

Robots are of particular interest to companies in high-wage industrialised countries, such as the USA, where it has been forecast that robot shipments will rise from 2,100 in 1981 to 31,350 in 1990 (22.6% in the automotive industry, 39.5% in light manufacturing, 9% in heavy manufacturing, 13.6% in the electrical electronics sector, 11.3% in the foundry industry and 4% in aerospace).[1) However, Japan is the world leader in both the production and use of industrials robots, with sales forecast to rise from 3,200 in 1980 to 57,450 in 1990[2), partly due to the less suspicious attitude to automation by Japanese employees in view of the advanced provisions for retraining of displaced workers, the common guarantee of lifetime employment in large enterprises and the substantial bonus element in remuneration packages which is geared to company profitability.

At present the robotics market is characterised by a compact group of large customers, such as the major motor manufacturers, served by a rather large number of robot manufacturers or would-be manufacturers (although two manufacturers hold over half the market share between them in the USA). At present there are about 140 firms in Japan which manufacture robots of various kinds, distributed over the whole

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1) Source: Bache Halsey Stuart Shields Inc. 1981.

2) OWEN A E. Chips in Industry. EIU Special Report No. 135. Economist Intelligence Unit, 1983.

business scales from small firms to giant corporations.[1] This is typical of new, fast-growing and tempting markets, with near certain growth prospects. However, it is also likely that economies of scale will eventually dictate a phase of concentration, particularly in view of the high cost of research and development as advanced technologies continue to develop. Indeed the phase of concentration may come about more quickly if the explosive growth in demand that has been forecast does not come about. The risks currently are high, and it has been stated that "the industry probably cannot support half the enthusiasm and resources that have been committed."[1] It is clear that high levels of skill and innovatory qualities plus substantial amounts of risk capital will be required for success. Thus only a few developing countries will be in a position to compete successfully in the manufacture of NC machine tools and robotics, although it will be necessary to come to terms with their labour-saving potential in applications. Computer-aided design (CAD), the subject of a following study, is a development of considerable significance and can achieve as much as a 400% increase in the productivity of industrial designers, as well as yielding an engineering data base which could lead on to computer aided manufacturing (CAM). As the CAD study indicates, the development of CAD-type technologies requires strong backward and forward linkages which are often difficult to achieve in the operational environment of a developing country. Nevertheless, it will be beneficial for developing countries to build up their technological capabilities through education and training, strategic use of public purchases and strenthening the capabilities for selection and acquisition of technology.[2]

2.2.5 Backward and Forward Linkages

Meanwhile the arguments for encouraging synergy through backward and forward linkages contain a lesson for the many millions thoughout the world who will continue to live in scattered rural villages and whose

1) THACKRAY J. America's Robotic Rising. Management Today, February 1983.
2) Micro-electronics and Developing Countries: Towards an Action-Oriented Approach. Note by UNIDO Secretariat to Expert Meeting Preparatory to International Forum on Technology Advances and Development, Moscow Nov-Dec 1982. ID/WD.384/5/Rev.1 Feb 1983.

lives will not be touched directly by developments in the fields of micro-electronics, NC machine tools and robots. By encouraging the local development of simple tools and workshop equipment, it is feasible to encourage industrial decentralisation programmes which provide a route into the industrial sector without urban migration and encourage self-sufficiency. It is therefore upon the recent and potential developments in the area of local production of basic workshop equipment that the remainder of this sectoral study will focus.

2.2.6 Workshop Equipment

Whilst the technologically-exciting developments in numerically-controlled machine tools and robotics catch the limelight, these are irrelevant to the many millions throughout the rural areas of the developing countries who are struggling to take the first steps towards the benefits of industrialisation. For these people the need is for a new range of simple wood and metal working tools and equipment that could be brought together in rural workshops to enable local communities to be self-reliant in the small-scale production of basic equipment. The equipment should be simple, robust, capable of easy repair and maintenance and preferably should be susceptible to local manufacture with a minimum (preferably zero) imported materials and components.

One of the few organisations that is attempting to meet this need is Intermediate Technology Industrial Services (IT-IS), a part of the Intermediate Technology Development Group Ltd., which has embarked on a "comprehensive project to identify design and develop a range of equipment for rural workshops in developing countries" in order to:[1)]

1. permit a wider range of projects to be made available;
2. introduce production/repair facilities not normally enjoyed by rural consummers;
3. raise quality standards in rural workshops;
4. reduce rural communities dependance on often remote producers;
5. enhance the status and influence of rural artisans.

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1) ITIS Project Outline: Rural Workshop Equipment (unpublished)

operational without electrical power. Each design will involve production of a prototype, field testing and the printing of a detailed manual on manufacture and assembly. The step-by-step instructions of these manuals will assume availability of only the most basic tools and welding equipment.

The first design produced in this series was for a simple, but versatile machine for working sheet metal to produce items such as ducting, steel boxes, trays, baking pans, chimney flues, funnels and agricultural equipment such as seed-hoppers, troughs, water and fuel tanks as well as components for vehicle building and repair. The design was originally proposed by ApT Design and Development, Cumbria, UK., who produced a full scale prototype in collaboration with IT-IS. A draft manual was then prepared and sent to several institutions who had expressed interest in the design. Amongst these were the Appropriate Technology Development Centre, Coimbatore, India, and the Makgonatsotlhe Production Unit, Mochudi, Botswana, which eventually produced and tested the device. After the participating workshops came back to ITIS with suggested improvements, a final version of the manual, including adaptations, was produced. A feature of the manual is the inclusion of numerous clear and detailed illustrations and step-by-step building instructions, so that the machine could be made by a typical rural workshop from readily-available channel, angle and hollow steel sections using basic welding and fabrication techniques. The only equipment essential to its construction is a drilling machine, an electronic welder, G clamps and basic hand tools.[1)]

The enthusiastic response to this initial item of equipment has encouraged IT-IS to proceed with the development of a tube bender, a sheet rolling machine, a bench shear, a workshop drill and a treadle lathe; while future items are expected to include an angle bender, a log splitter, wood-lathe attachments, a jigsaw and bench presses (toggle and hydraulic).

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1) HITCHINGS R, 1981. How to Make a Folding Machine for Sheet Metal Work. Intermediate Technology Publications Ltd.

All the future manuals will follow the same basic outline. Complete manufacturing instructions will included materials lists, templates, drawings of components, solutions to potential difficulties, etc., while there will also be a section on how to adapt the tool for specialised jobs.

2.3 AGRICULTURAL EQUIPMENT

2.3.1 Introduction

Agricultural equipment has been described in a recent UNIDO study as a "basic sector at the interface between agriculture and industry."[1) Whilst that study was specific to Africa, it remains generally true that "without efficient local production and use of the right kind of agricultural and rural equipment, food self-sufficiency will be delayed, job and higher incomes will not materialize in rural areas and the urban drift will not be halted. "The study suggested that a strong indigenous agricultural machinery industry facilitates progress on three fronts. The contribution to agricultural production, food supplies and food self-sufficiency is direct. If the industry's output is broadly defined to include basic rural equipment such as vehicles and first-stage food processing machinery (such as depulpers, grinders, sheller and oil presses) there can also be a dramatic impact on employment, rural incomes and the quality of rural life. Furthermore, as part of industry and as a purchaser of industrial materials, semi-finished goods and components, the agricultural machinery sector can become the seed for developing industry where there is none and a stimulus for related industrial activities where they have already been established. Yet some simple types of hand tool are already in substantial demand. Another UNIDO study suggest that an African rural family of five people purchase one hoe per year[2), whilst in Tanzania the average annual demand for

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1) Agricultural Machinery and Rural Equipment in Africa: A New Approach to a Growing Crisis. UNIDO Sectoral Studies Series No. 1, Vienna 1983. (UNIDO/IS.377)

2) The Development of African Capacities for the Design and Manufacture of Basic Agricultural Equipment. UNIDO Sectoral Working Paper Series No. 2 Vienna, 1982.

hoes for the period 1980-84 has been estimated to be 1.5 -1.8 million units for a population of about 17 million.[1)]

Indeed the hoe, known by a variety of local names in different parts of the world (jambe, pawrah, etc...) remains the most important agricultural implement for many millions of farming households in Africa and Asia where hand tools remain the most important method of cultivation in the small-scale agricultural sector. A second reason why this tool has been chosen as the focus of this sectoral study is that hoes are currently manufactured in developing countries over a very wide range of scales of production, from traditional village blacksmiths to large-scale national industries, and are also imported in large numbers from Chinese, Indian, Taiwanese, European and American sources. Thus the scope for scale, product and process comparison is much richer than for other types of agricultural equipment.

2.3.2 Types of hoe

The hoe is variously used as a digging, cultivating, weeding, levelling and scraping tool. It consists of a metal blade, the hoe head, fitted at an acute angle to a wooden handle. It is the standard practice for the hoe head to be supplied separately from the handle which is often made by the farmer himself from local wood. This paper therefore concentrates on the production of hoe heads.

A wide variety of types of hoe are used in different parts of the world. These variations are consequence of differences in uses, soil conditions, crops grown and working techniques, and of local customs and preferences. The variations include:

i) the angle between head and handle which varies from about 45° to nearly 90°;
ii) the curvature of the blade;
iii) the shape of the blade - pointed end, square end and tapered;
iv) the size of the blade.

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1) NANYAMA L. Production of Agricultural Tools and Animal-drawn Implements in Tanzania. International Conference on Mechanisation at the Small-Scale Farm Level in the Humid Tropics of West and Central Africa. Cameroun, 1980.

An additional variation is the use of a forked hoe which is effective in certain soil conditions. The hoe normally has a circular or oval eye into which the handle is fitted. However, in some places, hoes are used which have a spike, rather than an eye. This spike is pushed through the wooden handle and secured.

Hoe heads can be categorised into two basic types which relate to the methods used for their manufacture:

i) single-piece hoe heads, in which a single piece of metal is forged or press-formed to produce the required blade shape and hollow-eye (or spike) for attachment of the handle.

ii) two-piece hoe heads, in which the blade is rivetted to a forged eye or welded to an eye formed from steel tube.

2.3.3 Existing Scales of Hoe Production

The following different scales of hoe production are found in developing countries at present:

Village Blacksmiths

In certain countries the traditional skills of blacksmithing are long-established at village-level. In some places these skills extend to iron smelting, but generally this is no longer economic because of the time consuming nature of the traditional process and its high consumption of wood. Traditional village blacksmiths now work predominantly with scrap materials, making and repairing a range of implements of which the hoe is usually the most important. A variety of scrap materials are used, including discarded motor vehicle, railway stock and agricultural equipment parts, and ship plate. Traditional blacksmiths work with a charcoal hearth, bellows, anvil and hand tools, and have the skills to hand forge spiked hoe heads from a single piece of material. The quality of the final product depends on the skill of the blacksmith in identifying the characteristics of the raw material and in forging.

is the "modern" blacksmith. He provides the same type of services as the traditional blacksmith but lacks his skills in forging and his understanding of materials. The "modern" blacksmith generally produces hoe heads in two parts and may have welding facilities for attaching the blade to the eye. Like the traditional blacksmith, he uses predominantly scrap materials. The scale of production of these village-level industries is small, catering to the needs of one or a few villages.

Small/medium Scale Industries

In several countries there are small and medium scale urban-based industries producing hoe heads. Most of these industries produce two-part hoe heads by hand forging, drop-hammer forging or press forming. Some industries make single piece heads from steel sheet either by using a spike-fitting, or by forming the fixing hole for the handle by a series of pressing operations. Industries at this scale are characterised by the use of electrically powered equipment and by a transition from use of scrap materials to mild steel. These industries generally produce a range of other products in addition to hoes.

Large-scale Industries

There are two types of large-scale hoe manufacturing industry in developing countries.

The first type makes two-piece heads with the blade hot press-formed from medium carbon steel sheet, and the eye cut from a length of steel tube and welded to the blade. A taper is sometimes formed in the eye by a pressing operation. Generally the head is not heat treated after forming. Examples of industries of this type are found in Ethiopia and Mozambique, the latter having an output of one million hoes per annum. Both industries also produce a range of other hand tools.

The second type of large scale industry produces single-piece hoe heads by die forging and rolling. The raw material is medium carbon steel and the heads are normally heat treated after processing. This is the most capital intensive manufacturing technology for hoe production, the minimum level of investment in equipment and tooling being about US$1.2 million. Utilisation of this plant on a one-shift basis gives an output of 250,000 hoes per annum, which is about the minimum level at which the technology is economic. This type of industry would normally produce other forged hand tools - hammers, pick-axes etc., as well as hoes. It is this level of manufacturing technology that is normally used in industrialised countries.

2.3.4 Characteristics of Different Scales of Production

The different levels of hoe production often co-exist in a particular country, sometimes in competition with imported products. It is therefore useful to compare the characteristics of the different levels of production.

Raw Materials Supply

The major problems of supply of raw materials occur at the smallest and largest scales of production. The village blacksmith is dependent upon obtaining a regular supply of suitable scrap materials. He may have to obtain these himself or arrange deliveries from urban areas where most of scrap is generated. In terms of access to supplies, he is at a disadvantage compared to small urban industries processing scrap material. Mild steel, which is also used by small urban industries is a general purpose material and is usually easily available.

Large-scale industries process medium carbon steels which have to be imported into most developing countries. They therefore face the problems of obtaining foreign exchange and import licences to ensure regular supply of materials. They also need systematic testing procedures to check the specification of the materials supplied.

Ordering and Distribution

Village blacksmiths typically manufacture hoes to order, or in limited batches for sale in local markets. They receive payments in cash, and their distribution costs are minimal. Because their products are hand made they can produce hoes to meet the specific requirements, in terms of size, shape and weight, of a particular user. Therefore, unlike large-scale manufacturers they are responsive to local demands for tools and suit soil and crop conditions and customer preference.

- -- particular specifications of hoe in order to utilise their manufacturing equipment efficiently and to amortize the considerable investment in tooling. Large manufacturers normally produce hoes in a limited range of sizes, each of which requires its own set of tooling. There is evidence (eg in Tanzania) of village blacksmiths modifying hoes supplied by large industries to suit the requirements of local customers.

Large-scale industries normally supply their hoes in large batches to agricultural extension services, other government departments (eg public works department) and commercial trading houses.

Quality and Cost

The best quality hoes are those made in a single piece, with a hollow eye, by die forging and rolling using medium carbon steel which is heat treated in temperature and atmosphere controlled furnaces after farming. This method of manufacture produces a hoe which increases in thickness towards the eye end to provide adequate bending strength, has a well shaped eye to provide a secure fit of the handle, and has the correct material properties to give high bending and impact strength and low wear rate. The quality of the products of a particular manufacturer depends upon the material specification, the quality of the forging and rolling dies and the condition in which they are maintained, and the control of the heat treatment process. Hoes of this type can only be manufactured on a large scale.

Next bet in quality are the spiked hoes made by the traditional blacksmiths[1)]. The use of hand forging allows the desirable variation in material thickness defined above to be obtained and, if the blacksmith is skilled, adequate material properties can be achieved. The latter is critically dependent upon the skill of the blacksmith in judging the characteristics of a piece of scrap material, and heat treating it appropriately over an open flame. However, this cannot

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1. This statement needs qualification. Although the hoe blade is of good quality, unless the spike is fitted carefully to the handle it will cause the wood to split and break. Where this type of hoe is traditional, techniques have been evolved locally for fitting the spike securely to the handle.

achieve the consistent quality of controlled furnace treatment. These traditional skills are only acquired over long years of practice working as an assistant to a blacksmith, and are normally handed down from generation to generation.

The quality of two piece hoes is limited by the inherent weakness of the joint between the blade and the eye. Rivetted joints inevitably work loose even if they do not break, and welded joints are prone to failure. Blades made from steel sheet, rather than by forging, lack the desirable increase in material thickness towards the eye. This steel has relatively poor strength and wear properties, and this is also likely to be the case with scrap materials unless they are worked by a highly-skilled blacksmith.

The cost of manufacturing a hoe is directly related to its quality. In particular single-piece forged hoes cost more than two-piece designs, and hoes made from medium carbon steel are more expensive than those made from mild steel or scrap. Evidence from countries in Africa and Asia shoes that large scale local manufacture of forged hoes is economically efficient in cost terms compared with importing. However, its viability is crucially dependent on the willingness of the farmer to buy a higher quality product for a higher price. The number of countries with traditional blacksmiths is fairly small. In other countries the choice for the farmer is between buying a locally made two-piece hoe, or a more expensive forged hoe which is either imported or made by a large national industry. The advantages of the latter are longer life, since the wear rate and likelihood of breakage are lower, and higher working efficiency. However, since for many small farmers shortage of funds is a major constraint, they may well choose to buy a low quality tool which has to be replaced more frequently, because of its lower initial cost. This relationship is obviously affected by subsidised purchase of tools which occurs on some agricultural development programmes.

Employment

Village blacksmiths is inherently labour-intensive and the value added is close to 100% since scrap materials are used and most of the manufacturing equipment is self-made. Village blacksmithing provides employment in rural areas, and makes available to local communities a village blacksmith can be developed through formal training courses, but those of the traditional blacksmith, particularly in working scrap materials, are not amenable to this process.

The small-scale urban industry remains fairly labour intensive though it is characterised by a transition to the use of powered machinery and of new rather than scrap materials. The skills can be acquired through informal apprenticeship and formal training.

Large-scale manufacture is capital-intensive, and relies on imported manufacturing equipment and materials. Machine operation is by semi-skilled labour. However, skilled tool-makers are required for the manufacture and refurbishing of dies.

2.3.5 Discussion

High quality hoes can currently only be produced on a large scale. The total demand for hoes in many countries is sufficient to make this level of manufacture economically efficient and it would normally be combined with the production of other forged tools. However, its viability is dependent upon the willingness of small farmers to purchase a high quality tool at a relatively high price, or alternatively, on measures to promote the use of better quality tools through agricultural development programmes.

Village blacksmiths offer the advantages of creating employment in rural areas, and providing a service which is responsive to local requirements. However, except where "traditional" skills exist they generally make relatively poor quality implements and have a very limited financial base which limits their capacity for development. To upgrade this sector in terms of quality and scale of production assistance would be required along the lines defined in a recent UNIDO document[1]:

- supply of raw materials of consistent quality;
- training (in hand forging and open-flame heat treatment).

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1) Background document for first consultation meeting on the agricultural machinery industry 1979.

It is estimated that a village production unit could be established, employing four people, with an output of 4,000 tools per annum which would serve a group of villages.

In recent years, considerable effort has been devoted to the application of efficient labour-intensive methods in the road construction and forestry sectors. To achieve high productivity using labour based methods, good quality tools are essential. They are subjected to intensive use and any shortcomings in quality rapidly become apparent. This has led to a number of initiatives to produce good quality tools on the relative small-scale required for these programmes. Substantial progress has been made in this direction on a variety of tool heads and handles, including shovels, rakes and machetes. The hoe head remains one of the most difficult to make to high quality on a small-scale because, as noted earlier single-piece forging of hoe and eye is inherently a large-scale operation. However, some progress has been made on a forestry project in the Philippines [1] by:

i) use of a single type of scrap material with the required properties - in this case discarded disc harrows;

ii) modification of the head design. A two part head is used, but the eye is fabricated and bolted to the blade which gives a stronger joint than welding or rivetting;

iii) use of centralised controlled furnace heat treatment facilities - in this case at the Metal Industries Research and Development Centre.

The small-scale manufacturer involved in this project is now successfully producing efficient high quality hoes for forestry work. The example illustrates the kind of approach which is required to "scale-down" the production of high quality hoes.

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1) Implementation of appropriate technology in Philippines forestry. ILO, Manila 1982 (draft).

2.4 COMPUTER AIDED DESIGN (CAD)

This sector and its technology provides an interesting example of the balance between small-scale and large-scale production, and how this has changed over time. Its relevance is particularly acute in the light of our earlier discussion on new technology based firms. Moreover in focussing on this sector we are not only able to obtain insights into the small-large balance at both the production and consuming ends of the sector's output, but also to observe the crucial transition from traditional technology to the knowledge-intensive electronic era.

2.4.1 The Technology

Traditional designing technology involved the drawing board, drawing instruments and some form of primitive calculating device such as a slide rule. Even today design offices using the traditional technology seldom involve an investment per worker of more than $1,000. Then in the late 1950's the American requirements for an early-warning missile system led to the development of the light-pen linked to the computer screen. Whilst General Motors Automobile Company pioneered the commercial development of this new technology it was in the aerospace industry that the technology first matured (in the 1960's). Then in the early 1970's the electronics industry saw its further refinement, and in particular the move from batch-processing to interactive use. Finally after the mid 1970's the technology diffused at an extraordinarily rapid rate to the manufacturing sector. The sector grew at an annual rate of over 70 per cent in this period with a turnover exceeding $1b by 1980. There is every sign that high growth rates will continue over the 1980's and that the technology's use will become mandatory if firms are to survive international competition.

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1) As is common in the industry we refer here to graphics-based interactive CAD, rather than the more general use of computers in design, which often occurs as a batch processing basis.

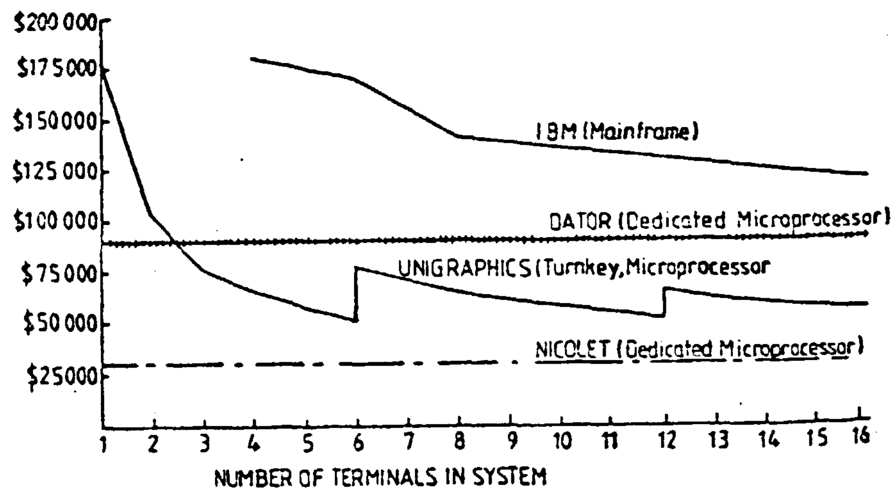
Basically three sets of technology are available. The first uses micro-computers, is cheap (around $25,000 per terminal) and has limited applications to draughting and a few design tasks[1]. The second currently involves mini-computers, although as computing power expands there is likely to be a move towards micro-computers. Each system can support about 4-6 terminals and design-processing capabilities are wide and growing[2]; unit terminal costs are currently around $90,000. Finally there are mainframe systems in which CAD is merely one component of a firm-wide data processing capability. These often cost over $200,000 per terminal. As can be seen from Figure 2.1 there are significant scale economies to users - however, as we have seen the three types of system often serve different functions. The micro-computer based systems are ideal for small, single-product users; the mini-computer based systems satisfy medium-sized and design-intensive firms, and the mainframe systems serve the needs of very large corporations or medium-sized firms taking a comprehensive approach to automation. Whatever these differences, though, a stark constrast exists between them and the drawing board based traditional technologies.

See for Example:

ARNOLD E and SENKER P, 1982. Designing the Future: The Implications of CAD Interactive Graphics for Employment and Skills in the British Engineering Industry. Occasional Paper No. 9, Watford Engineering Industries Training Board.

1) For example, printed circuit board layout for the electronic sector.

2) For example, they include electronics-programmes eg: PCB layout and auto-routing mechnical-design applications(eg finite element analysis and 3-D modelling) and CAD-CAM links (eg parts programming).



Source: Kaplinsky R, 1982. Computer Aided Design: Electronics, Comparative Advantage and Development. London, Francis Pinter. (Reproduced by permission of the author)

2.4.2 Capabilities

At one level the capital-intensive, and therefore inherently large-scale, CAD technologies are viable as a pure choice of technique. Given their generously high productivity (see later) compared to traditional systems, their use is justified when gross annual wage costs exceed $9,000. However in many sectors even these cost-advantages are outweighed by the other benefits the technology provides to successful users. By shortening product lead-time, optimising the design of products[1] and being essential for other products[2], CAD technology is rapidly becoming a mandatory component of production technology.

1) For example in the automobile industry, where increasing fuel-efficiency is important, the use of CAD is crucial in reducing the weight of cars and the drag-coefficients.

2) For example in the electronics and aerospace industries.

However as a consequence of these knowledge-intensive capabilities, CAD technology has an important impact upon the nature of work. Whilst designers often find that their design-skills are enhanced, the more numerous craft-based draughting skills are undermined. Allied to the fact that the machine-based technology requires multiple-shift utilisation to take advantage of scale economies, that it implies an individual rather than social working environment and that it paces the worker,[(1)] many design workers find that the quality of their working lives has been significantly reduced by the introduction of CAD technology.

2.4.3 Skill implications

Four sets of skills are involved in the production and utilisation of the new technology. First is the issue of operator skills and here, in common with much of the new automation technology, the skill threshold appears to be reduced. Second is the managerial component which is crucial since many of the commercial benefits are reaped in non-design spheres. This tends to imply a change in the type of managerial skills involved (incorporating a perspective on systemic organisation) as much as the extent of training. Third is the back-up skill required to service and repair the new equipment. In the past this has been an important constraint on diffusion, but in recent years the development of modular designs, "self-diagnosing" machinery[(2)] and "self-healing"[(3)] systems have undercut a great deal of the skill required to service and repair the equipment. Finally there are the software skills required to design CAD systems. Here, despite the introduction of structured-programming systems and the target of "automated software", these skills are a major constraint on the development and extension of CAD technology.[(4)]

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(1) With what the industry calls "user friendly" systems!
(2) Machines which inform the "Technician" which printed-circuit board or integrated circuit to replace
(3) This involves building redundant, duplicating systems into the machinery which automatically come into play
(4) when a sub-system fails
(4) One major supplier's system incorporates over 7 million lines of machine code involving over 1,000 person years of s/war

2.4.4 Linkages

A variety of linkages are involved in the development and utilisation of CAD technology. With regard to the production of the technology itself, both backward and forward linkages are involved. In the former case proximity and access to the electronics and computer-peripheral industries are important despite the fact that CAD-technology has seldom pioneered the utilisation of hardware technology. Perhaps more important is the fact that the industry developed largely due to the spin-off of highly qualified designers from the electronics industry. With regard to foreward linkages the immaturity of much of the applications software has meant that suppliers need to interact closely with users in order to debug new applications packages. Similarly the utilisation of the technology also involves linkages whose importance is not so much one of stimulating the development of supportive industry, but rather to take advantage of synergies with complementary activities Here, in addition to the aforementioned user-supplier link, there is an important role played by user-groups in developing the technology and putting pressure on suppliers to up-date and refine their immature applications software.

2.4.5 Employment implications

There can be little doubt that the machine-based CAD technology is inherently employment-displacing.[1]

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(1) We refer, here, to employment in design and draughting. Even though the overall effect of successfully utilising the technilogy may lead to greater levels of employment within particular firms, at the industry-level the technology (especially when linked to other CAD-CAM technologies) is also employment displacing.

Table 2.3 PRODUCTIVITY OF CAD SYSTEMS

Sector of activity	Location	Primary use of CAD	Average productivity ratio	Range of PR between different types of drawings
Integrated circuits	US	Design	2:1 after 6 months	NI
Automobile components	UK	Design	3:1 after 12 months	NI
Plant design	UK	Draughting	3:1	1:1 – 20:1
Process plant	UK	Design	NI	1:1 – 50:1
Electric motors	UK	Draughting	6.6:1	NI
Printing machinery	UK	Design/draughting	>2:1	NI
Architecture	UK	Design	3.5:1	NI
Automobiles	UK	Design	3:1	NI
Computers – pcb's	UK	Design/draughting	>5:1	NI
Process plant	UK	Design/draughting	4:1	NI
Petroleum exploration	UK	Design	2:1	NI
Automobiles	UK	Design/draughting	2.78:1 after 6 months	NI
Aircraft	US	Design	2.5:1 in 1979 3.32:1 in 1980	NI NI
Instruments – pcb's	UK	Design/draughting	>3:1	NI
Public utility	US	Draughting	>3:1	

NI = No information.
Source: Interviews with users.

Source: Kaplinski 1982 op cit. (Reproduced by permission of the author)

As can be seen from table 1, the general experience of user firms in the US and the UK is that average productivity gains are in the region of 3:1.

2.4.6 Overall implications for the size of firms

As we have seen the CAD industry, which par excellence represents the emergence of NTBFs,has scale implications at both the user and supplier level. With regard to users, we must distinguish between firms using manual and machine-based design technologies. SS firms which do not use the new technology may find it difficult to survive the increasingly competitive environment. However for firms who utilise CAD systems, the development of distributed processing systems has the effect of reducing plant economies of scale (by allowing networked terminals to be linked to a centralised data-base) and increasing firm economies of scale.

In relation to the production of CAD technology, there is a significant difference between traditional engineering technology and the new knowledge-based electronic systems. The very heavy level of software investment in the new technology has meant that the difference between marginal and average costs of production are even more pronounced than in pre-electronic industries. At the same time some of the mature applications programs are individual-specific, and this has meant that a significant proportion of production now occurs in new small firms offering small, cheap limited-capability microprocessor-based terminals. This development has few parrallels in pre-electronic industries such as automobiles, chemicals or draughting equipment.

Of all the many potential implications for developing countries, two stand out in significance. First, despite the low skill-barriers to entry noted above, is the importance of synergistic linkages in the development and utilisation of the technology. Although there are some signs of utilisation of CAD technology in the NIC's, outside of India (where diffusion is very clearly constrained by the absence of synergistic users), there is no evidence of LDCs producing this type of technology which makes extensive use of applications-software. And second is the threat to LDCs implicit in the development of CAD-type technologies. To the extent to which it is possible to anticipate the diffusion of the technology it appears to be going precisely into those sectors in which LDCs made such remarkable progress in the 1970's. (Table 2.4). If this pattern is sustained and repeated in other sectors there will be a real threat to continued industrial growth, so the rapid development of appropriate synergistic linkages is a prerequisite to the diffusion of these new technologies to the Third World.

Table 2.4 DC IMPORTS OF MANUFACTURES FROM LDC IN RELATION TO DESIGN AND DRAUGHTING INTENSITY

Table 2 . DC imports of manufactures from LDCs in relation to design and draughting intensity

	Value $ million 1970	Value $ million 1978	Growth 1978/1970	Rankings (N=15) Value (1978)	Rankings (N=15) Growth	Rankings (N=15) Draughting intensity	Rankings (N=15) Design intensity
Traditional manufactures							
Semi-finished textiles	1,815	9,610	5.3	1	15	11	11
Leather	183	950	5.2	9	14	13	12
Clothing	1,181	9,502	8.1	2	10	12	14
Shoes	151	2,035	13.5	7	6	14	13
Higher-technology manufactures							
Chemicals	588	2,282	3.9	5	15	9	6
Metals and metal products	319	2,223	7	6	12	10	9
Machinery except electrical and business	81	1,136	14	8	5	4	3
(Farm machinery)	2	29	14.5	15	4	7	7
Electrical machinery	372	4,463	12	3	7	1	1
Business machines	31	560	7.4	12	11	2	5
Scientific instruments	24	359	15	13	3	3	4
Motor vehicles	23	603	26.2	11	2	8	10
Aircraft	18	737	40.9	10	1	6	2
Shipbuilding	40	355	8.9	14	9	5	8
Consumer electronics	214	2,391	11.2	4	8	*	*
Total manufactures	5,493	40,195	7.3				
Total traditional manufactures	3,330	22,095	6.6				
Total higher technology manufactures	2,163	18,100	8.4				

* Datedness of 1960 data (see Tables 7.1 and 7.2) does not allow for meaningful figures. In general design is high in this sector and so is draughting.
Source: Calculated from United States Department of Labour (1979) which provides information on ISIC sectors, and United States Central Intelligence Agency (1980), which provides information on Standard International Trade Classification (SITC) sectors.

Source: Kaplinski 1982 op cit. (Reproduced by permission of the author)

2.5.1 Introduction

The range of materials used in construction is very wide, and the only valid generalisation is that most are heavy and bulky so that transport costs (both from raw materials source to manufacturing unit and from manufacturing unit to site) are usually significant contributors to overall cost. The high cost of transport is a crucial factor in the many developing countries with inadequate communications facilities, and frequently more than offsets any anticipated economies of scale through centralised production. Thus the statement still holds true that:[1)]

"Few building materials are manufactured on a large-scale; many are produced efficiently on a relatively small-scale. The industry is usually characterised by a large number of small producers."

Despite the impact of transport cost, large plants predominate in such materials as plate glass and steel, including rolling mills and pipe-forming plants. On the other hand timber processing and joinery manufacture are both frequently carried out in small-scale plants, the main disadvantage being that larger sawmills are able to install kilns for seasoning. Where a choice of technology is available, the "X-inefficiency factor" introduced in Chapter I must be considered since the construction industry is notorious for sharp fluctuations in demand depending on the general level of economic activity. Thus capital-intensive large plants, such as modern brickworks, may well yield apparent financial advantages if run steadily at high levels of output, but run into serious losses as output drops due to the impact of inescapable fixed costs. Meanwhile small labour-intensive plants, which can adapt readily to changing circumstances, may in fact yield a higher aggregated financial surplus as well as reducing the call upon imported items and scarce foreign exchange (although dispersed surpluses are sometimes hard to capture and therefore unpopular - see study 10b: Bread baking). In view of the heterogenous nature of the industry, this study focusses upon cement which - besides being a key material - illustrates

1) Building Materials Industry. UNIDO Monograph on Industrial Development No. 3, 1977. (77-1069)

the theme of the need for a critical examination of the established trend to increasing concentration and larger plants.

2.5.2 Background to Cement

Cement is an essential and ubiquitous construction material. Its function of binding materials together is fundamental to building, and few, if any, projects can today do without it. Absence or shortage of cement is frequently the root cause of delays and price escalation in construction projects and programmes in developing countries, and substitution of alternatives such as timber or steel is rarely feasible due to inadequate local supplies. Thus most construction needs cementitious materials and much capital formation requires construction, so cement (and/or its substitutes) are a prerequisite to capital formation.

In virtually every developing country, the establishment and expansion of indigenous cement-making capacity has been a priority in industrial development, during the decade 1970-1979 cement production in the developing regions of Africa, Asia and South and Central America each increased at a rate exceeding 7.0 per cent per annum[1)] (UN 1980), much more rapidly than the rate of increase of GNP. These regions, in 1979, produced about 300 million tonnes, over one third of the world's total production. This rapid expansion has exacted a significant cost burden. For example, during the sixth Indian five-year plan period (1978-83) investment in cement plants alone is planned to be 8.42 billion Rs (approximately US$1 billion) for a capacity expansion of 13 million tons of cement per year. The prospect appears to be one of continuing expansion and, according to one European company's forecast, could rise by about 50% by 1990, to around 1,300 million tonnes, with developing countries accounting for as much as nine tenths of the increase[2)]. As expansion continues rapidly, the question of appropriate scales of production has began to command increasing attention. Furthermore, the traditional attachment to high quality portland cement is being questioned in view of the potential cost advantages of producing alternative cements on a small-scale for non specialist users.

2.5.3 Minimum and Maximum Sizes of Plants

There is no theorical upper limit to the size of cement plants.

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1) United Nations Statistical Yearbook, 1980

2) "Cement: Quietly Glamorous" The Economist May 17, 1980.

Throughout this century, the trend has been one of a steadily increasing scale of production. The average size of kiln being installed today by one firm is 2,500 tonnes per day (tpd),[3] while a number of kilns with capacities over 4000 tpd are already in production. It seems unlikely that the maximum size has yet been reached.

At the other end of the scale, plants producing cement of the same quality at a scale of only 20 tpd are now beginning to come on stream.

Indeed cementing materials can even be produced at a cottage-industry scale. Mehta[2] has experimented with the production of cement from lime mixed with the ash from rice husks used as fuel in a domestic stove; by this method, 30kg per month would be produced, a scale of production four million times smaller than todays largest.

The difference between these two extremes is not just one of scale of production; the properties and uses of the materials made are widely different, as is the technology involved. But it is significant that there is active development work being carried out today at both ends of the scale, as well as at many intermediate points. It is becoming increasingly clear that there is not one single best or appropriate technology for the production of cement; and that a national policy for cement production would make best use of available resources if (just like a national energy policy) use was made of both large scale and small-scale contributions to the overall demand.

One million tonnes of cement per year, for example (which is enough cement to provide 50kg/capita for a population of 20 million people) could be produced either in a single large plant, or in 200 mini plants each producing 10 tpd or even using the output of 3 million rice-husk burning stoves. It is now becoming possible to choose appropriate scales of production not, as has been the case in the past, solely by the criteria of efficiency set by the cement plant

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(1) ITDG, 1983

(2) "Appropriate Technology" 1983

(3) World Cement Technology, 1981

equipment manufacturers, but as a response to each country's overall and regional needs - taking into account the pattern of demand for different types of cementitious materials, available raw materials and fuel resources, and technological, managerial and financial capability.

2.5.4 Economies and diseconomies of scale

Apparent economies of scale in cement production are substantial, as examplified in the unit cost indices in the following table:

Table 2.5 CEMENT PRODUCTIVITY: CAPITAL AND UNIT COST INDICES

Capacity (Tonnes per day Cement)	Index of Capital Cost of Plant	Index of Unit Cost
500	44	220
1000	57	142
2500	100	100

Source: Based on data in Oliver Jensen, "Cost of New Cement Plants and Conversions", Paper presented at the Interregional Seminar on Cement Technology, Beijing, China 9-24 Oct 1980. UNIDO , ID/WG.326/12, Nov 12 1980

In practice these apparently attractive economies of scale are unlikely to be realised in developing countries, and the actual performance of large plants frequently fails to match forecasts and projections continued in feasibility studies. For example, a recent study of the construction industry in the Sudan reported that, of two major plants, production at Atbara for 1979/80 was 130,000 tons compared to a rated capacity of 200,000 tons per annum, while the other plant at Rabak produced 43,000 tons compared to a rated capacity of 100,000 tons per annum.(1) Actual outputs of around 50% of rated capacity are by no means atypical, and total financial investment, plant operation sophistication (implying a heavy demand for scarce technical and managerial skills) and increased construction time all increase with

(1) Democratic Republic of the Sudan: The Domestic Construction Industry - A Survey and Project Identification Report. World Bank/UNIDO Co-operative Programme Report No 10. December 1981.

increasing plant size. The scope for labour-intensive operation to reduce unit capital costs is also generally greater for smaller plants. But perhaps the most important consideration is the cost of transporting the finished product, which can in fact be greater than the ex-works cost for remote projects (together with the likely deterioration in quality during transit). This factor will be discussed further in a later sub-section.

2.5.5 Costs and benefits of smaller-scale plants

Production in a small number of small plants could offer direct savings in transport cost coupled with increased assurance of supply through a multiplicity of suppliers. Of course dispersed production in small scale plants would be possible only if the raw materials (mainly limestone and gypsum) are generally available. Fortunately these materials are widely available in most countries, and a further advantage of small plants is that they can usefully exploit small outcrops of these materials. Another advantage of dispersed cement production associated with production in smaller plants is that easier availability of cheaper cement in rural areas is likely to promote construction of rural infrastructure and spread the benefits of development more evenly and fairly.

Many developing countries with their low density of cement demand may have comissioned larger unit sizes because only such plants are supplied by developed country manufacturers and/or transport cost are subsidized, thereby distorting economic analysis in favour of conventional large-scale solutions. The following sub-section attempts a dispassionate analysis of the four levels of production technology that constitute the currently available alternatives.

2.5.6 Analysis of available alternatives

Although cements can be produced at any scale, it is possible to identify four distinct scales of production (Table 2) based on level of technology and types of material produced:

1. Medium and Large-scale plants producing 500 tpd or more (sometimes very large plants more than 2500 tpd are identified as a separate group)

2. Small-scale plants, producing between 100 and 500 tpd.

3. Mini plants, producing 20-100 tpd.

4. Village-scale plants, producing less than 20 tpd.

The two largest scales of production both produce a range of cements, the most important of which are Portland cement (PC), Portland pozzolana cement (PPC) and Portland slag cement (PSC). The raw materials are limestone, a siliceous or aluminous material such as clay or blast-furnace slag, with gypsum and sometimes a pozzolan as an additive. These cements satisfy internationally accepted (ISO) standards, and can therefore be used in virtually any type of building project, or sold readily on the world market.

Table 2.6 CEMENT TECHNOLOGICAL PROFILE

Scale of Production	Kiln	Materials Produced	Quality Index (a) (Q)	Technology Availability (b)	Other Technological Considerations
1 Medium/Large 500-3000 TPD	RK	PC PBC PPC	1.0 1.0 0.9-1.0	Import (Some local mfr)	
2 Small 100-500 TPD	PK (300+ VSK	PC PBC PPC	1.0 1.0 0.9-1.0	Import (more local mfr)	
3 Mini 25-100 TPD	VSK	PC	0.8-1.0	In-country manufacture	May not meet full standard for strength
4 Micro 25 TPD	VSK	Low-grade cements (c)	0.6 Max	In-country design and rural mfr	Standards not univerallly available

Notes:
(a) Implies that quantity required to replace 1.0 tonne PC.
(b) Import or local depends on technology capability: this refers to less developed LDCs.
(c) Substitutable for Portland cement only in low-strength applications, mortars, plasters, soil-stabilisation, blockmaking, etc

Large-scale plants are based on rotary kilns which are, as previously discussed, subject to marked apparent economies of scale. For the small-scale plants (100-500 tpd) there are two distinct technologies available. Most existing plants of this size use rotary kilns; but there is an alternative technology based on the vertical shaft kiln (VSK). This technology has for a long time been less favoured than rotary kiln technology, because there is an upper size limit, and there are some control problems. But VSK plants tend to have good fuel efficiency, and with recent developments in discharge and draught control, this has again become a viable technology where availability of raw materials or market size limits production.

The majority of the world's mini plants (20-100 tpd) are in China, where national industrial development policy in the 1960's and 1970's, (described as 'walking on two legs') promoted the production of cement at county and commune level for local use. The technology is based on Portland cement, using shaft kilns, but it seems clear that the strength of the cement produced is often below that required in international standards for Portland cement. Unlike other countries, however, China has a range of standards for 'siliceous cements', specifying different strengths applicable to different production levels and appropriate to different end-uses. In India, on the other hand, where a single national standard prevails, development efforts over 20 years to develop mini-plants producing cement satisfying those standards are only now reaching fruition. The principal arguments in favour of such plants are that mini-scale production can use much smaller raw materials sources and save on transportation costs, while the capital required can be found from local investment, and they can quickly be brought into production.

Village-scale cement production is different in nature to the other three levels of technology. The materials produced are hydraulic limes and lime-pozzolana mixtures and may best be described as low-grade cements. A whole range of raw materials may be used; limestones which would be quite unsuitable for cement production at any other scale, volcanic tuffs, ground brick waste, and the ash from burning agricultural wastes. The cements are slower setting and of much lower strength than Portland cement, but can nevertheless be used for purposes in which high strength is not required (and for which their other properties may make them more suitable than Portland cement). For such specific purposes it is quite feasible to formulate mixtures which meet relevant performance standards. The production of such low-grade cements is considerable in some developing countries; they are mainly used for rural building, and their production flourishes when there is a shortage of manufactured Portland cement.

Table 2 summarises the most significant characteristics of the four levels of technology defined above. But there are other factors which should be considered in industrial base. Not only will the bulk of the equipment for both large-and-small-scale plants have to be imported, but they may also have to be operated under the guidance of the plant manufacturer and downtime for repairs and maintenance may be drastically higher than expected. Indeed there is evidence that in the larger plants recently installed in developing countries, over sophisticated control systems have resulted in much lower than anticipated output.[6] Plants providing lower levels of production, on the other hand, require very little-if-any-import of manufactured equipment or expertise, and repairs and maintenance should be executed more promptly and easily by local people using local materials and components.

Cement quality is frequently regarded as a constant, while there could be real economic advantages in accepting that cements or cementitious materials of lower strength than standard Portland cement would be technically satisfactory but significantly cheaper. It is true that there would have to be safeguards against the use of lower strength cements for structural purposes, such as reinforced concrete beams, columns or slabs, but close inspection of materials is already necessary (and provided for) on projects of that kind. The potential savings are attractive. Since, although

(6) World Cement Technology. 1981

no definitive figures are available, it is estimated that only 20% of worldwide consumption of cement requires the full strength of international Portland cement standards is needed. Approximately another 40% is used for structural purposes where a somewhat lower strength would be adequate if it was well-controlled; while the remaining 40% has uses (such as mortars and plasters, foundation concretes, concrete blocks, soil stabilisation) for which low-grade cements would be perfectly adquate. Thus, for about 80% of all cementing materials needed, there is a potential for a real choice of technology, which could be made on the basis of local considerations. Two important factors influencing that choice will be transportation and energy.

2.5.7 Transportation

Cement is material with a very low manufacturing cost per unit weight, which means that the transport cost forms a significant proportion of the price which the consumer pays. In India, where most cement is delivered by rail, there is an average freight charge of about 28% of the production cost, but there are many parts of developing countries distant from existing cement plants, where the transport cost even exceeds the production cost. The choice of appropriate scale of production should be based on the total cost at the intended points of use, rather than the cost of production alone. A dispersed pattern of small-scale plants, situated at a distance from existing or planned large plants, may therefore show an economic advantage even if the unit cost of production in somewhat higher than in a single large plant.

National pricing policies which equates the price of cement to all consumers, wherever situated, by freight pooling arrangements, eliminate the transportation cost advantage to the local producer and thus create a bias in favour of large centralised plants, thereby encouraging a wasteful use of scarce transportation resources. In such cases overload of existing railways or lack of trucks can seriously inhibit cement distribution. India, which has operated such a policy since 1956, has now begun to change it, and to provide additional incentives for small plants. Packaging is further consideration since cement must be bagged or moved in closed wagons if it is to be transported over long distances. However, re-usable sacks can be used for local distribution from a mini-plant, further reducing transport costs. An intermediate alternative to integrated local small-scale cement plants is the split-location plant, in which cement clinker is moved from the large-scale central factory, where the kiln is located, to a number of smaller local grinding and bagging plants. Clinker can be transported more cheaply than bagged cement, and without loss.

A useful measure of the likely applicability of small-scale plants is the cement consumption density (CCD) of a country or region ($kg/km^2/yr$). Where this is low, transportation costs from large plants will be high, especially if road transport must be used. By this criterion mini or small plants are much more likely to be viable in a country like Tanzania (CCD=0.3) than one like Turkey (CCD=16).

2.5.8 Energy and fuels

Cement is an energy-intensive industry, and electricity and fuels constitute the largest part of the production cost. The bulk of the fuel is used in the kiln, where a temperature of 1450^{o}C must be reached; the theoretical heat requirement for burning clinker is slightly over 400Kcal/kg, and most kilns operate at thermal efficiencies between 25% and 55%.

Among rotary kilns there are clearly established economies of scale in energy consumption. The increase in the scale of the kiln along with the introduction of more energy efficient kiln technologies, dry-process plants, preheaters and precalciners have all led to increased efficiency, and today's large plants have a kiln energy consumption of only about 750Kcal/kg, or about 65% of the theoretical efficiency.

Shaft kilns, because of their compact configuration, have smaller heat losses, and even small plants can compete with the most efficient rotary kilns on energy grounds. A recent survey[1] revealed that the old small VSK plants had lower specific energy consumption than recent RK plants, but no figures are available for recent small VSK plants outside China. From China specific energy consumptions between 800 and 1000 Kcal/kg are reported for various shaft kilns with outputs from 100-200 tpd. Smaller shaft kiln imply greater energy losses, and mini plants can be expected to use 20-25% more fuel than small VSK plants.

There is considerable scope for energy savings by increased use of fly-ash or slag in cement, since these are industrial waste products which can be introduced at the grinding stage, considerably reducing kiln energy per unit weight of cement. Blended cements can be produced in any scale of plant. The use of low-grade cements can result in overall energy savings. Though the kiln processes for burning limestone are relatively inefficient at a small scale, these cements contain a high proportion of naturally occurring or waste products which need no calcining. Thus economies in energy consumption over conventional cement production can be achieved either by scaling up, or by scaling down, or by producing cements of a different type.

2.5.9 Beyond current alternatives

Spurred by steadily increasing worldwide demand for cement and cement-based materials on the one hand, and by high energy costs on the other, the cement industry has been experiencing an active phase of technological development. The primary objectives have been to reduce energy costs through greater thermal efficiencies and using alternative fuels, and to reduce unit capital costs; but there has also been an impressive recent tread to devote research and development effort to the achievement of efficient output at

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(6) NATO, 1976

smaller scales of production. In a capital intensive industry, innovations are slow to impact on practice, and the near future will therefore see a continuation of present trends and large plants will continue to provide for the bulk of the expansion of capacity. But, as the technologies become established, there is also likely to be a rapid rise in the number of small and mini plants located mainly in areas away from existing large plants, and lower-grade cements produced at a very small scale will increasingly be used in the rural areas. Thus industrial development plans will in future have to consider and balance the contribution of production at all technological levels to make best use of resources.

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2.6.1 Introduction

The chemical industry has been described as "huge, bafflingly technical and hard to pin down"[1]. It is also ubiquitous, since "petrochemical products and their derivatives run into many hundreds ranging from fertilizers, solvents, plastics, fibres, synthetic rubbers, detergents, dyestuffs, explosives, drugs, proteins, speciality chemicals, to many derivatives which find application in various parts of industry and everyday life.[2]" The industry is generally perceived as heavy, commodity-based and capital-intensive as a result of its dependence on high technology and high added-value products, and therefore an industry in which the arguments for economies of scale are overwhelming. This impression is broadly correct for the production of basic petrochemicals, although "as one moves further downstream to end products, the economic capacity becomes smaller and smaller[3]". Indeed for dispersed markets and specialist applications, smaller entrepreneurial businesses (whether producing simple plastic cups or a sophisticated fluorescent solution to identify faults in compressor blades) are more likely to possess the agility and flair that are required to satisfy their chosen market.

2.6.2 Growth, Technology and Scale

The original inorganic chemical industry in developed countries was a relatively low technology business using raw materials such as animal fats, salt, limestone, pyrites and phosphate to produce intermediate products such as dyes and bleaches for the textile industry and simple phosphate fertilisers for agriculture. The startling growth in size and complexity came with the development of organic chemicals made from oil and gas after World War Two. For example, ethylene and propylene as major basic petrochemicals had a growth rate of 17 per cent per year between 1950 and 1973. Over the 20 year period from 1950 the world

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1) "Chemicals: A Survey". The Economist. April 7 1979

2) Opportunities for Co-operation among the Developing Countries for the Establishment of the Petrochemical Industry. UNIDO Sectoral Working Series No. 1. UNIDO/15.376. March 1983

3) Ibid

consumption of synthetic fibres increased by 68 times and that of plastics and synthetic rubbers by 18 and 9 times respectively. The consumption of low-density polyethylene (LDPE) in Western Europe increased from just under 100,000 tons per year in 1955 to just over 3 million tons per year in 1973[1].

The most obvious outcome of this helter-skelter growth was a blurring of the industry's boundaries. Even the split between organic and inorganic products ceased to hold good. For example PVC (poly vinyl chloride) is derived as to 60 per cent from inorganic chlorine and 40 per cent from ethylene. Definition of the industry itself became more difficult. It could be suggested that the chemical industry manupulates the molecules of carbon and various other elements, but this definition could be applied to food manufacturing units, steel plants and oil refineries. Indeed it may be that this blurring of the industry's boundaries has been a factor in the encroachment on the industry by businesses originating in other sectors. The major oil multinationals led the way in the 1960's, as they grasped the opportunity to participate in the sustained growth of petro-chemical demand. They had ample funds to finance the investment in ever-bigger, capital-intensive plants as new technologies were developed - from compressors and valves to chemical catalysts - that could yield productivity gains of 6-10 per cent a year[2]. Not only was the market growing rapidly, the feedstock was (apparently) in cheap and ample supply, and the surge in new technological advances yielded quick profits to investors in new, large plants as the new plants reduced unit costs and enabled the manufacturers to build market share through the replacement of traditional products. The avalanche of new plant building led inevitably to temporary surpluses of capacity, but the rapid growth of consumption made the ever larger plants ever more financially-enticing.

2.6.3 A Changing Cost Mix

With the adjustment of oil prices since 1973 the picture began to change. However, the oil companies had a new incentive to invest since their traditional profit centres were squeezed by acute supply problems.

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1) Ibid

2) The Economist April 7 1979. Op cit.

Thus they were encouraged to expand downstream in order to regain control over their pricing system. Even so, petrochemicals manufacture rapidly became a much more risky business as the raw materials component became a significant cost factor. For example, in the case of ethylene production, the cost of naphtha feedstock in 1972 was in fact covered by the credit value of by-products, whereas by 1983 it contributed more than half of production cost[1]. This changing cost mix began to undermine the almost automatic advantage enjoyed by investors in - "bigger and better" - plants which, with high break-even points, needed a steady and massive throughput to produce an acceptable financial performance. Meanwhile the major oil companies were finding that chemical technology and oil refinery technology were not so compatible as they might have appeared, since chemical processes are usually more intensive leading to more rapid depreciation of the plant. Anticipated benefits from controlling the whole chain of production proved elusive, as multinational oil companies experience enormous losses due to their inability to foresee and cope with a violently fluctuating demand. British Petroleum (BP) alone, having invested no less than £550 millions in the chemicals sector between 1976 and 1981, suffered losses of more than £180 millions during the last two years of that period. These losses persisted, and during 1982 BP ceased PVC manufacture in a swap arrangement with Imperial Chemical Industries (ICI), which was estimated to result in an extraordinary write-off of a further £110 millions.

The pattern is clear. Enticing growth rates, new technologies apparently favouring newer and larger plants, the influx of wealthy investors with a massive cash flow from their primary activities and a confident belief in the advantages to be derived from controlling the entire chain of production. Unfortunately for many of them, the confidence proved misplaced and they learned the hard way that - as stated in the opening paragraph of this section - "as one moves further downstream to end products, the economic capacity becomes smaller and smaller." Yet large plants still have real advantages for the manufacture of bulk products, and the most popular plant size for ethylene production appears to be of the order of 300,00 tons per year, with oil-producing countries as well as oil multinationals the most prominent investors. What these two groups have in common is the belief that, by moving downstream into petrochemicals, they will achieve a

1) UNIDO/15.376. Op cit.

higher added value to enhance the return on their basic product. This raises the important question of transfer value of the feedstock. If the transfer price for a plant at the well-head in an oil-producing country is set below market value (perhaps as low as cost), the plant can appear to be profitable. But the financial position can only be realistically assessed on the basis of realistic opportunity cost, which may alter the calculation dramatically. (The work "realistic" should be stressed, since in the case of gas which would otherwise be flared the opportunity cost is effectively zero!).

2.6.4 Costs and Benefits of Smaller-scale Plants

It is certainly true that "in planning the development of the petrochemical industry in developing countries, it will not always be practical or correct to use the same technical and economic considerations with regard to selecting the type and size of plants as is currently applied in the developed countries. On the contrary, developing countries may have to protect the young local industry in order to enable it to take root and grow to become competitive"[1]. However, an infant industry is only worthy of protection if the resulting benefits are real, whether they be tangible, intangible or a mixture of the two. Thus, if an oil-rich developing country is considering investment in a downstream facility that will manufacture products far in excess of domestic demand, the costs and benefits should be dispassionately evaluated. A series of small, relatively simple plants might be expected to yield a good spread of social, employment and training benefits, while being susceptible to local participation in repair and maintenance. These considerations may well offset the apparently better technical efficiency and target financial performance of larger plants built and operated in other circumstances and environments. There is evidence that even the sheer investment attractions of building large plants in oil-producing countries are being eroded, and it is reported that the cost of building such a plant in the Middle East is now up to two-thirds more than for an identical plant in Europe because of logistic problems (as against a differential of about one-fifth in 1974). Thus a comparison of capital investment costs for a steam cracker, using some 1.7 million tons/year of naphtha and producing 500,000 tons/year of propylene or its equivalent suggested

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1) Ibid

a figure of about $3,700 million if built in the Middle East as against about $2,600 million if built in Europe[1]. (Although admittedly such complicated plants as naphtha crackers are unlikely to be built in oil-producing countries with ample surplus natural gas.)

2.6.5 Analysis of Alternatives

Although the capital cost of large petrochemical complexes in developing countries is distinctly higher than in developed countries, it is also true that fixed costs are now a less significant element in overall costs. For ethylene, the leading base petrochemical, the index of production cost rose from 100 to 861 over the period 1972-80, while depreciation (related directly to capital cost) rose only from 100 to 215. Meanwhile the feedstock index rose massively from 100 to 1465.[2]. The fundamental dilemma remains; the need to evaluate the countervailing attractions to siting plants close to fuel and feedstock sources, or close to the market. All the signs point to a continuing heavy weighting of demand towards the developed countries (Table 2.6).

Table 2.6 FORECAST PER CAPITA CONSUMPTION OF MAJOR PETROCHEMICAL PRODUCTS (kg per capita)

	World		Developed Countries		Developing Countries	
	1981	1990	1981	1990	1981	1990
Ethylene	7.9	13.5	25.7	46.7	0.9	3.5
Thermoplastic	9.4	15.4	24.7	48.0	2.2	5.5
Synthetic fibres	2.7	2.9	7.6	8.2	0.8	1.3
Synthetic rubber	1.9	1.9	6.1	6.6	0.3	0.5
Methanol*	3.5	5.3	9.7	19.8	0.4	0.9
Ammonia*	21.8	20.1	38.4	47.5	13.6	11.7

* Figure relate to 1979, not 1981.

Source: The Second World Wide Study: Process of Restructuring UNIDO ID/WG.336/3 and UNIDO ID/336/3/Add. 1, 19 May 1981.

1) KHARABARDA O P and STALLWORTHY E A. How to Learn from Project Disasters. Gower Publishing Co Ltd, 1983. p 163.

2) Second World Wide Study Op Cit.

Thus large plants are unlikely to secure a strong local market, so their financial viability will depend upon their ability to offer competitive products to remote customers, which is only likely to be possible in bulk chemicals. This is a real possibility for oil-producing countries, which are likely to play an important role in industrial restructuring providing they concentrate on bulk products where their favourable overall cost structure should permit them to receive and regain substantial export markets. Specialty chemicals, which are likely to represent an increasing share of the total market, depend much more on identification and interaction with specific groups of customers and are thus less susceptible to manufacture in developing countries which rely substantially upon export markets. For example, it is now recognised that there are serious ecological (and economic) costs in the indiscriminate spraying of crops with pesticides and herbicides, so that it will be necessary for new technologies to be developed to produce specific agrichemicals for specific crops in specific geographical areas. This implies close and flexible response to increasingly segmented markets.

Increasing market segmentation may provide the impetus to develop technologies to enable smaller plants to operate more economically by making use of locally favourable conditions (lower financial requirements, shorter construction period, use of local materials, manpower and other resources) and designed to suit local markets. A UNIDO-sponsored seminar on the fertilizer industry held in Lahore, Pakistan (15-20 November 1982) confirmed the feasibility of this approach in respect of ammonia production, where "even a 100-ton/day ammonia plant becomes in certain circumstances feasible and attractive"[1].

The increasing cost, and financial risks arising from higher break-even points in a fluctuating rather than a steadily-growing market, have led to a more balanced research and development effort and a recent UNIDO document[2)] notes that "attention is being paid to develop smaller economic size units to suit the developing countries, and it is expected that by 1990 there will be greater flexibility in selecting and designing plant capacities." One example is the "higee" distillation unit developed by ICI, a compact 30,000 tonne per year plant, which

1) UNIDO/PC.61 Report, December 8, 1982.

2) UNIDO/15.376. Op cit.

is both compact enough to be transported on the back of a truck and more adaptable than conventional plants (closing down or starting up in about 2 hours rather than around 2 days)[1]. Although the demonstration plant costs nearly US$1.7 million, it is estimated that capital costs will come down to roughly half those of a conventional distillation plant. The Chemical sector, with its fragmented and dispersed markets appears to offer substantial scope for economic co-operation among developing countries (ECDC). For example, individual countries within a market region could agree to allocate the production of various products between themselves. One country might, for example, produce a plastics intermediate, another a synthetic fibres intermediate and another fertilizers for the specified joint market. Naturally the success of such an arrangement would depend upon a prior definition of arrangements that would secure equitable and mutual benefit to the partners.

2.6.6 Beyond current alternatives

Oil is a non-renewable and limited resource and, despite recent over supplies and dip in prices, forecasts that production will peak at some stage during the 1990's remain valid. Thus research is already focussing on alternative fuels and feedstocks. One possibility is a return to making organic chemicals from coal, which was only replaced by oil and gas because processes based on the latter are both easier and more economic (at current prices). Gasification, liquefaction and pyrolysis are the main alternatives, although none are economical with the current ratio of coal to oil prices. Another possibility is to manufacture fuels or chemical feedstock from vegetable matter or "biomass". Brazil has an established fermentation industry manufacturing ethanol from sugar, although it has been estimated that it would need to boost its crop yields of sugar and manioc by a factor of ten to have a viable chemical industry based on them[2]. Technologies based on coal or vegetable matter thus remain tentative, and their economic viability will depend upon future rises in the real price of oil and gas (which will in turn be affected by demand, future discoveries and the exploitation of alternative fuel sources such as nuclear power). Thus it is premature to forecast the effect of these

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1) The Guts of a Chemical P[illegible] Now Fit on a Lorry. The Economist November 13, 1982.

2) The Economist. April 7, 197[illegible] op cit.

alternatives on the scale argument although it can be stated that, in an increasingly uncertain operational and economic environment, simple bulk chemical plants with a low breakeven point may well turn out to be less risky than large conventional plants and therefore particularly attractive for non oil-producing developing countries with limited markets and a scarcity of financial resources.

2.7 PULP AND PAPER

2.7.1 Introduction

For the past 50 years or so paper manufacturing in the industrialised world has pushed steadily at the frontiers of scale, in terms of size and speed. Initially, the reasons for this were obvious; a production-orientated market, particularly after the second world war, and a vigorous machine manufacturing industry, kept busy during the war years on munitions and keen to satisfy its enlarged potential in the expanding paper market. The boom continued until about twenty years ago when the first signs of recession began to appear. Since then the industry has declined and polarised and under the current recession it is amongst the the most affected of the major industries. Many of the older, smaller mills have closed down, which could be taken as an argument for scale but there have been casualties amongst the larger mills also, less perhaps in the form of closures than in take-overs so that the largest have become larger, but not necessarily more profitable. Over the whole period activity was concentrated on the industrialised world, chiefly in the countries with softwood resources. Only a very small proportion of the total new production found its way to the third world. As developing countries are increasingly considering ways of entering the sector, it is opportune to review those factors that are relevant to decisions on appropriate scale. The special nature of the sector has led to treatment in a somewhat different format to that adopted in other sections of this chapter, including a major division between pulp mills and paper-making machines.

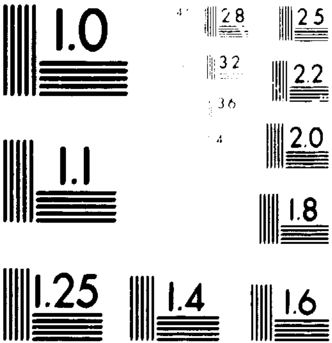
2.7.2 Wood-based pulp mills

Where adequate wood supplies of the quality required are available the advantages of scale are formidable. Production costs are lower because the same crew services greater capacity and capital costs are lower per unit of production. The paper machine can be likened to a bridge with rotating members, costing more as the span increases. The pulp mill is more like a container whose unit cost decreases as volume increases. Pulp quality is more uniform with greater volume, steam and power consumptions lower, and chemical recovery more efficient, often yielding also valuable bye-products. Capacity seems to have levelled out at around 1,[illegible] tonnes per day (tpd) as brown stock, the limit being set by the size of the washers where the bridge analogy applies again. It does not follow that an associated paper machine should have equal capacity, and except for some liner board machines it does not. Pulp mills of this capacity normally serve more than one machine or have an export pulp market. Whilst the technical advantages of large-scale wood-based pulp mills are clear, they are practical only where sufficient wood is available in the right species at the right price. Furthermore, if the cost of forest maintenance, felling, roads and transport equipment are taken into account, the apparent direct economic advantages may often also be offset. Smaller plants using predominantly waste wood for pulp may require minimal additional infrastructure investment, and thereby prove a useful addition to rural development schemes with a forestry component.

2.7.3 Non-Wood pulp mills

Pulp mills for non-wood fibres have several limitations to scale. With the exception of bamboo, which can be chipped and acts like wood, the materials most used are agricultural residues such as straw and bagasse or grasses, reeds etc. These materials will not flow naturally through the continous pulper designed for wood and they cannot be properly loaded or emptied as cooked pulp from standard stationary digesters. In continuous cookers they must be impelled by screws through the cooking zone; batch digestion can be achieved in small-capacity spherical digesters with large loading and emptying lids or in open vessels.

Continuous pulpers are limited in scale by the screw operation because straw or bagasse have relatively short cooking times and the pulp strength



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS
STANDARD REFERENCE MATERIAL 1010a
(ANSI and ISO TEST CHART No. 2)

and yield are adversely affected by over-cooking. The cooked pulp is also much less free than wood-pulp so far a given area of washer surface the throughput is reduced. The washer for 1,000 tpd of long-fibre wood-pulp is only capable of handling around 150 tpd of bagasse pulp and this represents the upper limit of capacity for a single line. The lower limit for continous pulping is now as small as 15 tpd, since mills of this size have become viable over the past five years as a result of development in controlled continous cooking and efficient chemical recovery, while even smaller levels of production can be achieved by using batch-type spherical digesters (around 4 tpd) or pulper-cookers.

However, the physical limitations to scale are matched by the limitations imposed by the availability and collection of the raw material. If the collection zone is greater than around 50 miles the cost of delivery can seriously affect viability. If this is accepted as a limit and only surplus straw or bagasse is available the mill is unlikely to be capable of approaching the maximum scale and 20/50 tpd is more normal. The scale can reach maximum where all the bagasse from a large sugar mill can be obtained, because substitute fuel is economically available or where by organisation all surplus straw is collected. However, mills as small as 10 tpd can be viable in remote areas with no other source of supply.

Capital costs for small-scale non-wood mills are not significantly higher per unit of production than those for wood-based mills particularly if bleached pulp is required, because 3-stage bleaching is sufficient whereas the wood-based pulp requires 5-stage bleaching.

2.7.4 Paper-making machines

In view of the variety of factors that impinge on choice of scale in paper-making plant, these will be examined under eight headings:-

a. Quality
b. Speed
c. Instrumentation and Control
d. Stock preparation plant

e. Efficiency of production

f. Production costs

g. Capital costs

h. Market

a. Quality: The conventional large-capacity paper machine, which is both wide and fast, has no intrinsic quality advantage over narrower machines of the same speed or slower. Indeed the opposite could be argued, since the very highest quality papers, such as bank-note paper or formica inlay, can only be made on slow, narrow machines (admittedly these are speciallity papers with a limited market). However, this consideration also applies to more commercial papers, such as sack-kraft. One of the most important characteristics required in the achievement of good quality paper is cross-machine directional stretch, which is distinctly easier to obtain on a narrow machine. Width also creates problems of level, drying (ie uniformity of thickness, moisture across the sheet width) and finish, which are vital for all grades of paper, particularly where high speed is concerned. Although these technical problems affecting large machines have gradually been solved by technological development (such as special flow-box and slice design, self-cambering "swimming" rolls for presses and calenders and double steam and condensate nozzles for drying cylinders), these developments have added to both cost and sophistication. Automatic substance, moisture and level controllers have also significantly raised quality stndards for wide machines as has computerised control but again, at a cost.

Generally, it should be recognised that quality, with the exception of speciality papers, is subject to price and the emergence of the large capacity machine has almost eliminated some of the paper grades which at one time were bought on quality alone. Alough cost is more important than quality for most customers, it is clear that in terms of quality scale has no inherent advantages and needs sophistication to meet standards which are readily attainable on smaller machines.

b. Speed: The critical speed of paper machine is an inverse function of of the deflection of the rolls which is in turn a function of width, not proportionately but to the third power. For a wide machine therefore the rolls have to be disproportionately larger to run at the same speed and for some of the widest machines material of a higher modulus of elasticity must be used, such as stainless steel whereas protected mild steel (standard tubes) or bronze is suitable for the narrow machine. Parity can only be achieved by additional cost.

The cost of speed in terms of energy should also be considered, since a high price has to be paid for the increased vacuum requirements to support high operational speed. Time is required for water removal and the higher the speed the less the time available. Furthermore, special expensive synthetic felts are necessary to support high operational speeds, and they have an insatiable appetite for vacuum. Experience and the indications from studies suggest that minimum energy per unit of production is obtained at speeds around 200 metres/minute, and a heavy price is paid for scale achieved by speeds up to 1,000 metres/minute, the current maximum.

c. Instrumentation and Control: Here the large capacity machine has a decided advantage, on the assumption that all machines need similar controls. With one exception the "hardware" costs the same for a machine of, say 100,000 tonnes per annum (tpd) capacity as would be the case for a machine of 10,000 tpa. The exception is the substance and moisture gauge where the cost, a significant element of the total cost, is disproportionate to width (and will remain so), whereas the other elements tend to decrease with miniaturisation. However, the assumption can be challenged. Sophisticated control is essential for the wide, fast machine; it is not necessary for the narrower, slower unit.

d. Stock Preparation Plant: For the purposes of this discussion stock preparation plant is included with the paper machine because a pulp mill is not an inevitable adjunct to a paper mill and even when it is additional stock preparation equipment will be required. However, there would seem to be no particular advantage or disadvantage for either large or small scale in this respect. Pulpers, refiners etc have been standardised over quite a wide capacity range and are normally used as multiples to achieve a given result. The cost or performance difference in terms of capital or energy is insignificant in the overall scale.

e. Effiency of Production: Given equal standards of operators and maintenance, practical experience suggests that the balance is decidely in favour of the smaller unit due to easier and quicker repairs and maintenance. For example, a press roll can be changed on a small machine (say 3 metres width) in less than two hours and a calender roll in about the same time, whereas for a large machine (up to 7 metres width) 4 and up to 12 hours respectively is required. The incidence of breakdown can, of course be minimised (by costly sophistication which is now a feature for some of the latest machines) but accidents still occur. Another lesser factor is the time taken to clear a machine after a short break, which is generally much less for a small machine.

f. Production Cost: In terms of material utilisation, fibre recovery, steam or power consumption per unit of production there are no appreciable scale advantages, and economies of scale stem essentially from savings in labour costs as crew sizes for small and large machine are comparable (although fewer maintenance and materials handling staff are required in small mills). A broad indication is that a mill with one large machine (say 100,000 tpa capacity) would employ about one-third of the number needed for ten mills with 100,000 tpa capacity, but it does not follow that unit labour costs for the small mills, will be three times as great. Large sophisticated paper mills depend heavily on highly skilled and motivated (and highly paid) operator and maintenance staff.

Economies of scale through labour saving are much harder to attain in developing countries, where a large-scale mill will almost certainly require expensive expatriate support. Indeed labour costs for the large Canadian mills are actually higher than the labour costs for the small mills producing similar grades in India because the rates of pay are more than five times as high. On socio-economic grounds it can also be argued that it is better to employ three men than one if labour costs are not prohibitive and that it is even better to have ten mills in ten districts than one mill at a single site.

g. Capital costs: The trend towards ever larger and more complicated machines has reached a stage where the risk/reward ratio of such investment is daunting, and payback periods are extended. Unfortunately, most of the established machine manufacturers, having tooled up expensively to produce large machines, are no longer capable of producing smaller machines economically. Lathes, planing machines and grinders capable of machining heavy rolls and components 400" long are expensive and seldom used for more than one shift per day. Unfortunately, for manufacturers possessing these resources this cost is also reflected in their price for smaller machines, making them less competitive than would be the case for a manufacturer set up only for machines of moderate size. The capital cost difference would be more in favour of the small machine but for this situation, as it is in India where simple and unsophisticated machines with a capacity of about 10,000 tpa are highly competitive. The quality of paper produced on these simple machines does not always match that of the large plant but this is mainly due to an almost complete absence of instrumentation and control which could be added to a sufficient degree without significant addition to capital costs.

h. Market: The effect of scale on the market so far as the industrialised world is concerned has been to polarise it so that paper production concentrates more and more on countries with natural wood resources. There has also been a trend towards integration with conversion to assure the market which has led to the largest companies becoming larger and the smaller companies dropping out. In countries without sufficient timber resources, manufacture has turned to waste recycling or specialised grades. In a saturated market the impact of new giant plants has been one factor in holding prices down to unprofitable levels, not so much because the new machine is intrinsically more profitable but because the higher break-even points have forced manufacturers to pursue market share at the expense of margins in order to cover the additional overheads.

For developing countries market considerations positively favour small scale because the total market is likely to be too small to accept the impact of large scale. In many of these countries also, distribution from a central plant may entail excessive transportation costs (as for cement). This is certainly the case for India where the small mill, serving a local area, can usually compete advantageously with the paper produced by the large mill many miles away. A possible exception to this general rule is newsprint where the consumption may justify a large mill and the market is concentrated among a few major publishers sited in the large towns (the limitations for this product are adequacy of fibre resources and water supplies).

2.7.5 Potential to go beyond currently-available alternatives

An (unpublished) study of the impact of scale economies and diseconomies by ITDG pulp and paper consultant Arthur Western aiming to determine the width representing minimum cost indicated that the least weight per tonne of product was for machines between 2.2 and 4 metres with little difference between. The weight of metal is, however, although a reasonable index, not conclusive. The type of metal and machining costs are also factors and the smaller machines have advantages here. Special metals are less necessary and standard tubes can cover a greater proportion. The same is true for components such as bearings. The exercise stipulated equal speeds and control equipment at the highest practical levels, for large and small machines. Subsequent work has indicated that the lower unit cost for the small machines would be lowered further at reduced speed, and speed should be around 200 metres/min for minimum energy. Several feasibility studies were subsequently made in which the output of a group of two or three small machines was compared to that of one large machine. In each case the smaller machines were most viable but, not sufficiently so to recover the cost of development on a single project. One interesting factor emerged; there was a significant reduction in cost, around 25% for two identical machines against one because of the elimination of design for the second machine and the repetitive tooling. In other words, if machines could be standardised, costs would be lower. Apart from the advantages in terms of cost and energy there would be economies in maintenance and cost of spares, simplicity in operation and training would be facilitated. The conclusion of this study is that standardisation of equipment is logical and must be beneficial. It is inconceivable that it should be based on the current large scale and the addition to scale has postponed the emergence of standardisation.

An interesting approach to standardisation is the "Monopulp Concept" offered by a Swedish consortium sponsored by the National Swedish Board for Technical Development, the Swedish International Development Authority and the Swedish Export Council. This offers a complete, integrated 30,000 tpa facility to produce newsprint, writing and printing papers from hardwood chemimechanical pulp, using component standardization and package design and using local fuels. There is certainly a case for those developing countries with ample timber resources and, a substantial local or potential export market examining the case for large-scale production, but the growing availability of choice across the full spectrum of scale offers the option of gradual entry into the market so that the investment risk may prove less daunting.

With increasing use of pulp and their wider distribution, due not only to better transport but also because of the growing number of small paper making and converting equipment scattered throughout the developing world, Intermediate Technology Development Group in 1969/70 started development of a small scale pulp moulding process to manufacture from locally available waste paper and other pulp products, egg, fruit and food packages that would improve food distribution, better people's diet and reduce imports of packages.(1)

1) MARSHALL K. Package Deals, Intermediate Technology Publications Ltd 1983.

At that time the current moulding technology took the form of large machines producing many thousands of egg packages each hour, whereas what was needed was small equipment making a few hundred packages in every hour economically. This small scale development was successful, there are now 40 paper pulp moulding systems of different sizes installed in 20 countries from Cyprus to Zambia producing a variety of packages using local waste paper at rates of 200 to 4000 each hour.

2.8 BICYCLE MANUFACTURE

2.8.1 Introduction

The bicycle is the most common wheeled vehicle in the world with a large market in both developed and developing countries. In developing countries is is essentially a utility vehicle, widely used in both urban and rural areas for personal transport and for the movement of goods, and the demand is predominantly for the traditional heavy duty roadster model, usually fitted with rod brakes. The study suggests that bicycle manufacture can be efficient over a wide range of outputs, and there is scope for gradual industrialisation through frame manufacture followed by later introduction of component manufacture as demand rises. Cycle repair and maintenance operations also offer an important avenue for the encouragement of skills relevant to rural industrialisation.

2.8.2 World Bicycle Production

A comprehensive breakdown of world bicycle production is not available but Table 1 gives estimated output in 1981 using data from a variety of sources. The Table shows that manufacture is concentrated in Japan, USA, USSR, Europe, the newly industrialised countries of Taiwan and Brazil, and two large developing countries, China and India. There is considerable international trading in complete bicycles and cycle components. Bulk transport costs are low in relation to product value and international trade is stimulated by:

i) the low unit cost of many Asian and East European products;

ii) The reputation for product quality of certain developed country manufacturers.

2.8.3 Minimum and Maximum Scales of Production

Several manufacturers in the USA, Europe, India, Japan and China have outputs close to or exceeding 1 million units per annum. The two largest manufacturers are in China and the USA and have outputs of 2½%-3 million units per annum. However, while the USA output is made up of a wide range of different models and components, the Chinese manufacturer's range is much more limited and hence on a disaggregated basis, its scale of production is higher.

At the other extreme there are examples of small bicycle businesses operating successfully in both developed and developing countries at outputs of less than 200 units per annum. However they achieve this by either:

i) making specialist products which do not compete in the mainstream market; or

ii) restricting their activity to final assembly of bicycles purchased in component and sub-assembly form. However this adds only 2-4% to the value of the bicycle and, for the purposes of this paper, is not considered to be "manufacturing".

Table 2.7 WORLD BICYCLE PRODUCTION 1981

Country	Output (millions)
China	12.0
USA	6.9
Japan	6.3
USSR	6.0
India	5.3
West Germany	3.0
France	2.35
Italy	2.2
Taiwan	2.0
Brazil	1.8[a]
UK	1.5
Holland	1.0[a]
Others (less than 1 million units each)	18.0[b]
Total	68 [b]

a 1980 figures

b approximate

Source: Data supplied by Intermediate Technology Transport Ltd

The lowest level of output at which manufacturers are able to compete effectively in the mainstream bicycle market is about 3-5,000 units per annum. In both developing and developed countries there are manufacturers operating at all levels of output between this minimum and the maximum defined above. This implies that bicycle manufacture is efficient over a wide range of outputs and at different wage rates. To analyse this further it is necessary to distinguish between frame and component manufacture.

Frame Manufacture

The simplest elements of bicycle production, and those which are economic at the smallest scale are related to the manufacture of frames, forks and handlebars, which together account for 50-60% of total production cost. They involve the following common operations:

- press forming of lugs;
- cutting, profiling and bending of tube;
- joining of components by brazing;
- painting or, for the handlebars, plating.

Below an output of 15-20,000 units per annum, production of lugs and plating of handlebars is not economic and the smallest manufacturers normally buy in these components. The most difficult component of the frame to make, because of its shape, is the bottom bracket shell. It is made by casting or by a complex sequence of press forming operations, followed by a series of machining stages. The minimum economic level of output is about 100,000 units per annum, and it is therefore bought-in item for smaller manufacturers.

Component Manufacture

A characteristic of the bicycle is that the manufacture of the wheel, transmission and brake components requires a substantially higher level of output to be economic than the production of frames, forks and handlebars. The minimum levels of economic output range between 50,000 and 150,000 units[1] per annum. Consequently:

i) smaller cycle industries are essentially frame, fork and handlebar makers, all the remaining parts being bought-in.

ii) in general, the proportion of the bicycle manufactured "in-house" increases with level of production;[2]

iii) the number of countries with cycle component industries is much smaller than those making bicycles;

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1) Units of bicycles not components, ie 1 bicycle requires 2 wheel rims, 144 spokes etc...

2) However, some large manufacturers in industrialised countries are now beginning to utilise low-cost imported components

iv) specialist component manufacturers form an important element of the total cycle industry.

Certain components - tyres, tubes, fasteners and chains are almost universally supplied by specialist manufacturers. They involve capital intensive production technologies and manufacturers supply a range of markets of which the bicycle industry is one. The remaining cycle components require specialised manufacturing processes with relatively expensive equipment (e.g. rolling of wheel rims) and a range of special steels which in some cases are heat treated after processing. Certain components involve a range of non-complimentary processes (e.g. pedal manufacture involves forging, machining, pressforming, rubber moulding, heat treatment and plating). Consequently, minimum economic production level is much higher than for frames.

2.8.4 Issues of Scale

Bicycle manufacture, at whatever scale, remains relatively labour-intensive, with a lower level of automation than is found in, for example, the motor industry. For the various elements of frame production there are a range of manufacturing options, from manual through to semi-automatic, which can be used according to scale. For example frame-brazing can be done by hand, dip, and manually or automatically controlled "unit" brazing.[1] For cycle components the range is from operator controlled machine tools through to fully automatic processes. For certain components semi-automatic processes are the lowest level that is economically feasible with present technology. There are developments in the industrialised countries to "scale-up" manufacturing processes, by introducing a greater degree of automation. For example automatic equipment is now available for wheel truing, which until recently was a labour-intensive operation, even in large plants. This innovation has be possible by the availability of micro-processor technology. Methods have now been developed of moulding[2] joints around frame tubes which greatly reduces the labour-intensity of manufacture. These recent innovations require fairly large-scale production to justify the capital investment.

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1) In "unit brazing", measured amounts of brass and flux are located at the joints prior to applying heat.

2) By die-casting or injection moulding

In technical terms increasing the scale of manufacture beyond the present maximum offers little benefit since at this output all production equipment is replicated. The prospect of innovations which are only economic at outputs above 2½-3 million is small. The major diseconomies of scale appear to be the problems of management of very large-scale plants, and slow response to market demands. The bicycle industry is characteristically conservative with product innovation occurring only slowly. The major innovations of the last thirty years - small wheeled bicycles in the 1960s, and 'BMX' juvenile bicycle in the 1970s - have come from small manufacturers and subsequently been adopted by large industries.

As far as developing countries are concerned, the major factor which determines maximum scale of production is the market for the products. As noted earlier there are only two developing countries with large-scale bicycle industries, India and China and both are significant exporters. They are characterised by:

- very large home market;

- indigenous industry able to supply the range of steels required to manufacture a bicycle;

- low wage rate.

Very few other developing countries have the potential to become significant exporters to the industrialised world since, lacking the above combination of characteristics they would not compete on price and quality. Thus for most developing countries the market is limited to domestic consumption plus possible exports to neighbouring countries. In several parts of the world neighbouring markets are constrained by both tariff barriers and cultural factors. Apart from a very small number of highly populated countries, no developing country has a home market exceeding 200,000-250,000 units per annum. Market size relates to population, level of economic development, geographic conditions and social attitudes, and fluctuates with short-term variations in economic circumstances.

A further constraint on scale of production in developing countries is the ability of local industries to compete with imports of bicycles and components from China and India. Because of the nature of their home industries, and the need to generate foreign exchange bicycles exported from India and China are very cheap. The evidence suggests that most developing countries cannot compete on price in their home markets, in the supply of components or bicycles, without some form of protection through tariff or volume restrictions on imports. However, there are examples of local industries with links to developed country manufacturers competing on the basis of quality. In these countries the products of certain European manufacturers have a long-standing reputation for durability and reliability.

Thus for most developing countries, issues of scale of production using existing technologies are primarily concerned with:

i) scale of production of bicycle frames;

ii) whether local manufacture of cycle components is economic, and how this should be related to frame production;

2.8.5 Beyond Current Alternatives

There is potential for "scaling down" bicycle manufacture by increasing the value that can be added efficiently and improving quality in small-scale developing country plants.

For frame manufacture, one promising approach is to modify frame designs to incorporate lugless welded joints rather than the lugged brazed joints which predominate on developing country models at present. This type of frame design is widely used on "new-generation" bicycles such as MBX models in the industrialised world. it eliminates the need for pressformed lugs and replaces the complex bottom bracket shell by a relatively simple threaded tube. The use of MIG welding techniques and suitable jigs and fixtures would allow semi-skilled labour to produce complete frames efficiently and to high quality at levels of about 5,000 units/annum. The technique is already practiced in industrialised countries by small-scale manufacturers of certain types of bicycle, often in conjunction with electrostatic coating techniques using epoxy powder paints, which give a high quality finish.

The Oxtrike[1)] load-carrying tricycle takes this concept one stage further by using a frame formed mainly from square-section tube. The use of square section eliminates the need to profile the ends of the frame tubes. This type of frame can be produced economically in developing countries at a rate of 500 units per annum. At this level of output, the value added by the production unit is about 50% of the total manufactured cost.

The "scaling-down" of cycle component manufacture requires attention to:

i) development of efficient, smaller scale manufacturing techniques; and/or

ii) adaptation of component designs to suit smaller-scale manufacture.

The thrust of research and development efforts in bicycle manufacture have been directed towards increasing automation. The innovations that result tend to increase the minimum economic scale of production, thus limiting their applicability to developing countries. There has been no comparable effort to develop more efficient small-scale manufacturing techniques suited to developing country conditons. Because of the close link between design and manufacturing process, such an approach is likely to be most effective if it included re-design of components and sub-assemblies. There appears to be potential for scaling down production in this way without affecting the utility of the final product.

This concept can be taken a stage further. The bicycle in developing countries is a basic means of transport, subjected to arduous use to carry people and substantial loads, often over rough tracks and roads. The traditional roadster model remains popular because of its robustness. However little or no serious effort has been applied to the design of bicycles to suit the condition of use and manufacture in developing countries.

2.8.7 Ancillary Industries

Final assembly of bicycles often takes place at dealer level. Most countries have an extensive network of cycle dealers. Carrying out final assembly at this stage reduces distribution costs and appears to be economically effective. There is evidence to indicate that the various settings and adjustments made during final assembly are better carried out by dealers rather than manufacturers.

Because of the widespread use of bicycles it is common to find an extensive network of cycle repair and maintenance operations, often one man businesses. There are certain countries where it is close to the literal truth to say that "there is a bicycle repair man in very village". The work of these businesses sometimes extends to the fabrication of accessories such as carriers and parking stands.

2.8.8 Conclusions

Bicycle manufacture is efficient over a wide range of outputs under both developed and developing country conditions, since the product consists of a variety of sub-assemblies. In developing countries the minimum scale at which component manufacture is efficient is a least an order of magnitude higher than for frame manufacture. The maximum scale of cycle production in developing countries is constrained by the size of the home market and the ability to compete, on price or quality, with low-cost imports.

Frame manufacture is viable in many developing countries. There is evidence that small-scale operations offer greater employment potential and cheaper products, but of lower quality. The viability of component manufacture is dependent on market size and price competition, and will usually be on a small-scale. There is potential to "scale-down" current alternatives through development of new design and manufacturing technologies, and by improved production technology.

2.9 TEXTILES

2.9.1 Introduction

Textile manufacture comprises three basic processes:

1. Spinning - making fibres into a thread, generally referred to as ya
2. Fabric production - principally weaving and knitting.
3. Finishing - bleaching, dyeing, printing etc.

In relation to scale of production these three basic processes have lit in common. With the classical methods of production employed world-wid prior to 1750, between 10 and 20 spinners were needed to keep one weave supplied with yarn and the finishing of all the cloth produced by a weaver in one week could very easily be dealt with in half a day by one dyer. Mechanisation has largely removed the imbalance between spinning and weaving, subject to the employment of a greatly increased scale of operation in spinning, and it is these two processes which will be examined in greater detail in the remainder of this section.

2.9.2 Minimum and maximum sizes of plants

Spinning

The basic sub-processes involved in spinning staple fibres such as cotton, wool and man-made staples are:-

- i Opening and cleaning
- ii Carding
- iii Drawing
- iv Attenuation
- v Spinning proper

For many centuries the spinner carried out processes iii, iv and v simultaneously, producing only one thread at a time. The great breakthrough in the mechanisation of spinning, which came in the mid-18th century, was gained as a result of limiting the spinner's task substantially to process v and providing separate ancillary machines for processes iii and iv. By this means one spinner was able to spin more than one thread at a time. At first content with twelve to sixteen spindles, the number was gradually increased until, by the end of the 19th century spinning mules were being built with 1500 spindles and one spinner, with two juvenile assistants was able to tend a pair of mules - a total of 3000 spindles operated by one man and a boy. By this time, and still today, the total labour requirement for the operation of processes i to iv was of the same order as that required for spinning proper.

An important determinant of the minimum economic size of a spinning plant is the consideration that none of the major machines installed for the carrying-out of the various sub processes should be grossly under-utilized. In this consideration the sequence of machines which constitute the opening and cleaning 'line' is almost always the decisive element. Typical modern opening and cleaning lines have a productive capacity in the range 500 to 1000 Kg per hour and it would entail serious, if not gross, under-utilization if a mill were planned to have a throughput of less than 400 Kg per hour.

Hourly capacity however does not uniquely determine plant size. Although the fineness of the yarn to be spun has only a marginal effect on the productive capacity of the opening line it has an increasingly striking effect on successive machines in the processing. The magnitude of this effect is shown in Table 1 which gives the numbers of spindles and approximate costs of all machinery for mills able to utilize fully one opening and cleaning line with a productive capacity of 500 Kg of fibre per hour. It is not practicable, for a number of very good reasons, to spin yarns over the whole range of fineness on one set of machinery. The count ranges (English cotton system) used in this table are as wide as is commercially and technically practicable. The costs are based on the use of fairly up-to-date ring spinning machinery and on prices obtaining in 1983.

Table 2.7 SIZES AND COSTS OF MILLS

Based on a single opening and cleaning line of 500 Kg/hour capacity.

Counts range	8 - 16	12 - 24	20 - 40	30 - 60	40 - 80
Average count	10	15	25	40	55
Number of spindles (Thousands)	7.1	12.5	25	55	78
Cost of machinery (Million US$)	4.2	6.5	10.0	17.5	22.5

An enterprise wishing to produce a wider range of counts would set-up a mill with more than one opening and cleaning line. To cover the rang 8s to 40s it would have three lines, a total of 44,600 spindles and would cost about 20 million dollars.

Weaving

There are no overriding technical considerations which dictate a minimu plant size. The preparation of warps is the only preparatory operation involving appreciable capital outlay and in most countries this may be avoided by purchasing warp yarn already prepared on weavers beams. Many spinners are able to supply yarn on beams and in addition there are, commission beamers who will prepare warps on their customer's behal

Nor are there any serious operational reasons dictating a minimum plant size. Although large scale weavers generally have in-house facilities for maintenance, overall and repair this is only a marginal advantage. In most areas in which textile manufacture is established there are adequate supporting facilities for the provision of these services and units as small as 5 looms can be profitably operated although most weaving is done in units with numbers of looms within the range 50 to 250.

2.9.3 Economies and dis-economies of scale

Spinning

No significant economies of scale result from the use of plant sizes greater than the minima given in the above table. Nevertheless, because of the great weight of trade, roughly two thirds of the weight of all cotton spun, in the count range 8 - 24 the spinners of these coarser yarns commonly have mills several times larger than the minimum. A typical modern mill spinning counts in the range 8 - 24 has five lines, a total of around 45,000 spindles and produces approximately 16,000 tonnes of yarn per year. At the other end of the scale there is a much smaller weight of trade as only about 3% of all cotton spun is in the count range 40 - 80. Consequently mills in this section of the industry are often smaller than the strictly economic minimum size. A typical mill spinning in the range 40 - 80 has only one opening line and that is by no means heavily used. Such a mill has a total of around 60,000 spindles and produces about 2,400 tonnes per year.

Multi-line coarse-to-medium count mills enjoy no economies of scale in regard to manufacturing costs although they may gain some advantage in the market place - both in the buying of raw materials and in the selling of the yarn they have spun. Against this there are some dis-economies of scale to be contended with. Of these perhaps the most important are those connected with the logistics of textile manufacture. The movement of scutcher laps, cans of silver and bobbins of roving through the various processes requires careful planning and meticulous monitoring if the right intermediate-product is to be always at the right place, at the right time and in the right quantity. For technically efficient working a mill covering the count range 8 - 24 will need to use roving of at least five different hank numbers and probably four or more different blends of raw materials. Not only is the organization of this expensive, in addition there is a high risk of mistakes being made. In a recent study of customer complaints to UK spinners it was found that by far the most common complaint was 'mixed' yarn - arising almost always from mistakes in handling between processes. The largest mills suffered most from this trouble, as smaller enterprises with shorter chains of command are able to exercise more effective control.

The most serious dis-economy of scale encountered in practice is not strictly and necessarily a dis-economy of scale. It would, theoretically at least, be possible to confine even the largest mill to the making of only one, single standardised yarn but this is rarely feasible in practice. The effect of undue variety on the cost of manufacture is extremely significant and this important topic is discussed specifically in the following sub-section.

Weaving

Potential dis-economies of scale arise from logistic requirements in weaving but they are very much less severe than in spinning. The importance of production planning has long been appreciated and simple manual procedures are capable of keeping even the largest mills operating as efficiently as the smallest. It could be argued that the use of computer based planning methods will give the larger mills an advantage, but this will be offset as the capability of cheap mini-computers continues to grow.

Substantial economies of scale have been gained in high-labour-cost countries by the use of automatic, computerbased loom-performance monitoring, recording and analysis systems. The use of these systems gives a lower fault rate in the cloth, increased machine availability and a quite surprising increase in the number of looms which one weaver can tend. In mills producing standard fabrics of simple construction this development enables one weaver to tend up to 120 high speed looms. In so far as the effect on the cost-competiveness of mills in low-wage-cost countries is concerned this development cannot be entirely dis-regarded but its effect on cloth quality is even more important. This is because successful employment of these systems demands the use of meticulously prepared, high quality yarns and a very high standard of maintenance of the mechanical condition of the looms. These two factors combine to virtually eliminate both yarn and weaving faults and as a result the cloth is in great demand by mass-production garment makers.

2.9.4 Costs and benefits of smaller-scale plants

Using commercially available machinery there is no direct cost advantage in the setting-up and operation of small scale plants. In spinning the capital cost per unit of productive capacity is substantially independent of plant size for all sizes greater than the minima indicated above. In weaving it is completely independent of plant size from a single loom upwards.

In some situations in both spinning and weaving, savings in capital cost can be made by buying older types of machinery but, generally, this will carry a penalty in terms of increased operating costs and reduced durability and product quality. The harsh fact is that, in regard to both capital cost and operating cost, the cheapest way of producing textiles of internationally marketable quality, in any country, is in a full scale mill equipped with first class modern machinery. Not only is this the cheapest way of producing textiles; it is also the only way in which textiles of the highest quality (in terms of freedom from defects) can be produced. Where textiles are being made for local consumption through small scale marketing channels this latter factor may not be important, but for export and mass marketing it can be of greatest importance.

One of the few benefits conferred by small scale operation is the facility which it offers for intensive product specialization. It has already been noted above, under 'Economies and dis-economies of scale', that the effect of undue variety on cost of manufacture is very great indeed. This is true in spinning, weaving and finishing. This matter has been studied and it has been established beyond doubt that the actual cost of increased variety is always many times greater than the directly identifiable cost attributable to such factors as machine down-time, terminal losses etc. The reason for this appears to be that intensive specialization leads to far fuller optimization of all relevant variables than is pcssible when the variety of products being made is greater. The high cost of variety was at first thought to be a 'length of run' effect but closer investigation revealed that it is, in fact a 'fewness of sorts' effect and the fewer the number of different products made in one plant the lower will be the cost. As examples, the reduction of the number of yarns made by a well run spinning mill of 30,000 spindles from twelve sorts to five sorts reduced manufacturing costs by 40% and reduction in the number of different fabrics made in a300 loom mill from thirty to six reduced manufacturing costs by 55%. This factor could be of the greatest value to small plants equipped with standard machinery and engaged in the manufacture of speciality textiles for export.

2.9.5 Analysis of available alternatives

Spinning

Many alternatives exist and are in use but none is truly viable. Most require to be subsidised in one way or another and the earnings of individual spinners is minimal.

Single-spindle spinning is practised in many parts of the world but, except for the coarsest wollen yarns, the productive capacity is so low that it can only be economic if wage levels are desperately low or a 'hand-made' product commands a substantial premium in the market place.

Many forms of pedal or hand driven multi-spindle devices are in use in rural India. The earliest of these 'charkas', introduced about 30 years ago, had four spindles and was hand driven. From this was developed a six spindle hand driven model and a six spindle pedal driven one. Based on these machines, a widespread Khadi (home-spun) industry has been established with state aid and supervision. About one million spinners are engaged in this industry and they provide the yarn needed by about 100,000 hand loom weavers. Scale of the products is aided by substantial subsidies but, despite this, spinners earnings are very low indeed. As, in addition, the capital investment in Khadi is almost twice as great, per unit of production, as that required for full-scale mill manufacture it is clear that justification must be sought on social rather than economic grounds.

Work has continued on the development of human powered spinning machines and an improved pedal driven charka has now been available for some years. This has twelve spindles and a number of other features which combine to raise yarn quality above that produced by the earlier machines. So far the twelve spindle charka has not found widespread acceptance largely because it requires to be supplied with cotton in the form of a roving of significantly higher quality than that used in the earlier machines. To meet this requirement 'service centres' are being developed which will prepare rovings of the required quality and supply them to the charka spinners. Standard mill rovings would be technically satisfactory but attempts are being made to produce a design of small-scale service centre which will be able to make roving of satisfactory quality at low cost under rural conditions. Substantial progress has been made and a prototype centre, with the capacity to process about 50 Kg of cotton per hour (approximately one tenth of the capacity of a standard mill line) is now in use.

Experience with the new twelve spindle pedal charkas has made it clear that further increase in the number of spindles would be counter-productive because of the greater effort which would be counter-productive because of the greater effort which would be required to drive the machine. However, local entrepreneurs have found it worthwhile to take two or three of the new charkas, gang them together to make 24 or 36 spindle units and drive them electrically. These enterprises appear to be commercially successful despite the fact that cloth made from the yarn they produce does not qualify for the Khadi subsidy. It seems likely from this that a small-scale industry based on simply constructed, power driven ringframes of 40 or so spindles, provided with roving from small-scale service centres of the type already developed, could be truly viable.

Although the foregoing analysis relates to the spinning of cotton, the situation is almost identical in wollen spinning except that, as wollen yarns tend to be coarser than cotton yarns, the spinning of them tends to be less tedious

Weaving

Viable alternatives to modern mill-scale weaving are available in bewildering variety - from primitive backstrap looms and pit looms through the horizontal frame looms of mediaeval Europe and the power looms of the 19th century to the automatic looms of today, all are suitable for use on the smallest possible scale. The only proviso which must be made is that a supply of yarn of adequate quality must be available suitably packaged. The simpler looms can be operated reasonably efficiently using yarn of indifferent quality, but modern ultra-high-speed looms are critically dependent on yarn quality for their viability.

In selecting the type of loom to be used in a small-scale weaving industry the most important considerations are the market for which the cloth is intended and the quality of yarn available. For sale to international mass-market garment makers cloth must be almost completely fault-free. In practice this means that these markets are effectively closed to any small-scale weaving concern dependent for its yarn on small-scale spinners. For domestic consumption much higher fault rates are acceptable as, in general the common minor faults do not materially affect durability of the product. In this situation probably the 'best buy' for small-scale use is the simple power loom, without automatic weft replenishment means, such as was widely used in Europe from about 1840 to 1940. In more primitive situations and where power is not available there is a wide range of hand looms from which a choice may be made on the basis of the traditional activities and skills of the people for whom they are required.

2.9.6 Beyond Current Alternatives

Spinning

Currently available alternatives are all based on the ring-and-traveller system or, in the case of wool, the spindle-and-flyer system. Both these systems necessarily require a fairly high power input and this fact is clearly limiting their potential for manually driven use. Traditional jenny spinning requires very much less power and also possesses the valuable attribute that it produces yarn more uniform in thickness than the roving with which it has been fed. Another feature of the jenny spinning which contributed to its initial popularity is its simplicity and the low standard of engineering expertise required for its construction and maintenance. On these grounds it could well find a place, not only where manual operation is necessary but also in rural situations where power is available but engineering skills are lacking. Manually powered jennies with 50 or so spindles were once quite common and power-assisted jennies with as many as 500 spindles were installed in large mills. There is currently considerable interest in the possibility of a modern version of the jenny being developed for small-scale use but, so far, there has been no open publication of a successful design.

An alternative which has not yet been developed would be a small-scale machine using the principle of open-end spinning. Such a machine could achieve a very high production rate per spindle (3 to 6 times that of a ring spindle), would require less driving power and would not need a well prepared roving but could work quite satisfactorily when fed undrawn silver. Against this must be set the fact that all current commercial open-end spinning machines, although essentially simple, are built to very high engineering standards. The extent to which these very high standards are strictly necessary has not been explored. It could well be that for small-scale, rural use, as distinct from very intensive, very high speed use in ultra-modern automated factories, very much lower standards of engineering would suffice. This approach is therefore worth pursuing.

Weaving

There is no need to seek alternative methods of weaving, nor are there any features of the newer principles of weaving now finding a place in the high speed looms of today which appear to have anything of value to the small-scale weaver. Efforts should, however, be directed towards rationalisation of the design and methods and materials of construction of looms of proven value for small-scale use. It is probable that this would lead to enhanced performance, lower cost and easier maintenance.

2.10 FOOD PROCESSING

2.10.1 Introduction

A general review of the options for food processing and preservation is followed by two specific sub-sectoral studies which illustrate the range and breadth of considerations which need to be taken into account for a fully objective evaluation of the costs and benefits of various ways of meeting this most immediate and basic of human needs. For the purposes of this discussion "food" will be used in a broad sense to include both food and drink for human use and food for livestock that can be produced in small-scale plant by the conversion of raw materials. Distinction will be drawn where appropriate between primary conversion, which may be no more than cleaning, grading or drying, or the simple grinding, milling or other destructive process applied to a raw material, and secondary processing, where a more advanced product results. In general primary and secondary processing plant can often be distinguished by the degree of specialisation or complexity of processes. The sub-sectoral studies cover:

a) Cane sugar processing
b) Bread baking

In view of the enormous range of technologies that are available to process and preserve the many different types of food product available, it is impossible to offer useful generalisations on the merits of small-scale vis a vis large-scale in food manufacturing and preservation. The question of taste cannot be neglected particularly in richer countries where food products account for a reducing share in disposable income. However for the poor and hungry in developing countries, even if food can be obtained its preparation entails repetitive activity such as the pounding of grain in mortars by hand. Such drudgery could be eliminated by the introduction of small mechanical hammer mills, which would retain the benefits of low cost and dispersed production as well as providing a potential avenue for agribusiness based on rural industrial development. The cost need not be onerous, particularly if the power source is not exclusive. For example, small static engines, carefully related in size to the biogas generation potential of the village animal production unit are used in much of China south of the Yangtze River to power a village hammer mill by day and drive an electric generator for a few hours in the evening.

2.10.3 Cost and Benefits of Smaller Scale Plants

Because food processing has the complementary roles of preservation, improved security of storage and of providing greater convenience in the feeding of urban communities, and because furthermore transport, both of raw materials and of products can easily assume a high proportion of the cost to the consumer, there is a primary case for decentralised production. Indeed much food processing in most third world countries is hardly recognized as an industry. Attempts to set up large town-based industries, or to open up the market to packages foreign substitutes have often had an adverse effect on local food industry without yielding any real compensatory benefits to the consumer.

In addition to economic considerations, there are technological questions particularly concerned with quality control, including packaging, sociological questions concerned with esteem for alien products that must be addressed when small-scale plant is under discussion. If these questions can be satisfactorily resolved, then the multiplier effect arising from large numbers of small and successful processing units, accompanied by a reduction of the need for long-distance transport would appear to be very attractive. The attraction is much increased if local, small-scale plants are related as precisely as possible to local resources.

2.10.4 Presently available alternatives

Drawing upon a wide variety of scattered information coupled with a general assessment based upon comparative experience, table 1 presents an assessment of scale suitability for 41 separate food processing technologies[1]. Table 2 provides an analysis of the primary, secondary and tertiary processing available for carbohydrate raw materials (cereals and bulk starch crops)[2]

1) Source: Data supplied by DR C LEAKY, Consultant to Intermediate Technology Consultants Ltd (Publication pending) Reproduction by permission of the author.

2) As 1 above.

TABLE 1. FOOD PROCESSING TECHNOLOGIES CLASSIFIED BY SCALE, ENERGY AND HAZARD

Process description	Examples of crops & products	Suitability for:* Traditional & domestic	Small plant	Large plant	Notes	Plant requirements for energy: Heat	Mechanical power	Plant requirements for toxic or hazardous chemicals
Low temperature drying without chemicals	Numerous, e.g. tomatoes - salsa (Arab); dried okra (major Sahel region food; small fish; dates.	9	6	1	Sunlight reduces carotene and vitamin C. Protein losses in fish and meat	Open sunlight; improved solar driers.	-	-
Drying with simple chemical treatment such as sulphiting, sodium carbonate or gaseous fumigant.	High quality okra; starchy root crop or breadfruit chips; raisins or other dried succulent fruits. Ginger (with the use of sodium benzoate).	7	5	5	Sodium carbonate reduces or destroys thiamin and Vitamin C. Sulphiting reduces or destroys thiamin.	As 1.(above)	-	Sulphiting very mildly hazardous; fumigants may require special precautions
Drying (high temperature) with use of pneumatic driers, flash drying, drum drying, fluidised bed drying.	Cassava meals from wet slurries; high protein extracts from oil seed meals etc..	0	1	6	High temperature, pneumatic dried starch crop flours may usefully be blended with moist. High protein materials to produce pelleted flakes at storable moisture.	High grade fuel (oil) usual, but low grade heat can be used additionally by suitable design.	Powered movement of inputs & products usual.	-
Vacuum dehydration.	Reduction of fruit liquids to powders, milk drying, coffee.	0	1	5		Low heat.	Mechanically powered vacuum pumps.	-
Cracking, dehulling.	Removal of groundnuts from shells; opening cashewnuts & other nuts; removal of testas from leguminous oils & pulses. Stripping cereal grains from husks.	6	8	4	Reworking (air or mechanical screening) of the shells or hulls can often lead to recovery of useful amounts of commodity, e.g. coffee from husks.	Local heat source often required	Technology suitable for most 'renewable' power sources, esp. water, wind, biogas, animal power.	-
Controlled splitting & cleaning.	Many legume pulse crops, e.g. split peas, pigeon peas, lentils.	4 (localised)	8	2	Recovery of broken (not just split) grains is worthwhile.	-	Suited to low power sources.	-
Milling/grinding (destructive).	Preparation of meals and flours from dried cereal grains, dried root crops etc. Roast cocoa beans to liquor; roast coffee beans to consumer coffee.	9	9	9	Crude meals & flours retain most nutrients but liable to rancidity.	-	Versatile according to scale. N.B. water, wind power historically of major use.	-
Controlled abrasive milling/polishing.	Rice, sorghum, barley, wheat(modern mills).	2	3	6	Low extraction flours lose energy value (fat) protein, thiamin, riboflavin, niacin, minerals.	Low	Fossel fuel and electricity (with good control)	-
Light cooking(parboiling)/ re-drying.	Rice(with improved nutrient availability)	2	4	2	Parboiling before milling improves nutrient recovery.	Local heat source with 'improved' solar relevant.	Low (or zero).	-
Par-boiling + microbiological fermentation.	Dawa-dawa(from Parkia), idli (from black grams), tempeh(from soyabeans).	8 (localised)	8	2	Convergent technology from many areas of the world is remarkable.	Low grade.	-	Probably to disregard traditional processes.
Par-boiling + salt fermentation.	Oriental fish products; oriental soy products (miso & shoyu), potent sauces.	5	6	6 Few but very popular bottled sauces.	Many products have very strong flavour, high nutritional value.	Low	Low	Low
Toasting, (light roasting) - mainly for enzyme destruction.	Soyabeans, breadfruit(Reef Islands).	1 (very local)	8	3	The traditional S.Pacific storage technology for breadfruit failed to be transferred to other areas.	Good control, fossil or electric cost convenient(Residual heat from firestones in Reef Islands)	Not required in batch toasting but motive power desirable.	-
Pressing without preheating.	Fresh fruit juices for sale in retail trade or further processing.	3 (local)	5	3	Produces juice of low shelf-life - easy spoilage.	1 -	Harnessing of cheap local power sources possible.	-
Pressing/expelling, with preheating.	Groundnut, sesame, sunflower and local oil-bearing crops. Oilpalms etc.	7	7	4 (usually preliminary to solvent extraction)	Heat assists coagulation of protein & freeing of the oils.	Local heat sources including burnt hulls etc. often available.	Water, wind, animal power appropriate. Note Chinese type draught animal mills also in W.Sudan.	
Sprouting.	Small-seeded grain legumes.	3 (S & S.E. Asia) only.	6	2	Digestibility & nutrient value usually increased. Natural toxins often removed, Vit.C. synthesized and riboflavin increased.	-	-	-

* Note on scales: Figures based on summation of scores for criteria, not strictly objective

a) requirements for product uniformity and quality control in different circumstances.
b) suitability to probably available energy sources
c) acceptable level of hazard within the limits of expected management expertise
d) east of sustainability and maintenance
e) probable marketing and distribution problems
f) suitability for flucatuating labour availability or raw materials
g) management capability.

TABLE 1 page 2

	Process description	Examples of crops & products	Suitability for: Traditional & domestic	Small plant	Large plant	Notes	Plant requirements for energy: Heat	Mechanical power	Plant req. for toxic hazardous
15.	Extrusion cooking.	Soyabeans, grain legumes, cereals etc.	0	8	3	Developed in USA initially for vegetarian foods, but now widespread and a valuable technology.	None (generated in extruder by pressure & fric	High and controlled, 3-phase electrical.	-
17	Puffing.	As above.	0	2	2	Rather unimportant; attempts to scale down 16.	As above	Manual or small power source.	-
18.	Popping (form of roasting)	Pop corn; grain amaranthus, Ñuña beans (Peru).	3	5	2	Originally an Andean technology applied to 3 plant families.	Local	-	-
19.	Roasting/deep frying (high temperature with heating of endogenous or exogenous oils)	Coffee beans; cocoa beans; pop grains (see above) sliced starchy roots & tubers; cereal & mixed dough products; protein curds.	3	6 (fire hazard)	6	Believed originally Portuguese, but has spread worldwide. Fire & burning danger from boiling oil.	Local, or electricity or oil.	Little.	-
20.	Sugar-based osmotic preservation (syruping, candying, glazing etc.)	Many raw materials; fruits, stems (angelica), rhizomes (ginger), breadfruit male inflorescences, flowers, nuts (marrons glacés).	4 (local)	8	3	Most valuable, under-exploited technology. Protection of products from insects necessary.	Local or exogenous heat sources, but only moderate temps.	-	-
21.	Pickling in alcohol, vinegar or fermented rice water.	Fruits & veg. to pickles & chutneys. Eggs. Fruits in alcohol.	5	8	3	Very ancient technology for seasonal food preservation, capable of expansion in non-traditional areas.	Minimal - washing & preparation only.	-	Flammability [illegible] alcohol, [illegible] acrid.
22.	Solvent extraction.	Primary or secondary extraction of vegetable oils from oil seeds. Cocoa butter separation from cocoa liquor, oleo resins from spices.	0	2	6	The norm of modern oil technology, but much use- oil seed processing can be done without it.	Well controlled electrical or fossil fuel fired.	-	Solvents hi[illegible] hazardous.
23.	Liquid or wet milling of oil-bearing seeds.	Soya (oriental), coconuts (esp. Thailand)	5 (soymilk)	6	3	Almost all traditional Oriental use of soyabeans is based on wet processing.	Controllable heat hot break generally better than cold area also for enzyme destruction.	Electrical or fossil fuel for driving high speed mechanical breaker.	-
24.	Wet pulping to remove unwanted soft tissues.	Coffee (cherry to parchment).	1	5	2	Removal of sugar-rich outer fruit may result in serious pollution of waterways. But pulping residues may be converted for biogas and/or animal feed.	-	Elec. or fossil fuel (or biogas) or producer gas (from coffee wastes).	-
25.	Green forage or leaf vegetable pulping/ fractionation.	Alfalfa, amaranths, basella, jute leaves, vegetable processing residues.	0	3	7	Fractionation as an aid to dehydration & for leaf protein extraction are now developed technologies. Veg. protein should become a by-product of jute.	Controllable heat for protein coagulation.	Controllable power, electric, fossil fuel or biogas (from wastes).	
25.	Steam blanching.	Usually preliminary to drying or curing, canning or apertisation. Okra, vanilla, pulse veg. freezing, peeling.	0	2	5	Purpose mainly of surface sterilization & enzyme destruction.	Controlled electric or fossil fuel.	Movement of materials in plant because of high temperatures	-
27.	Autoclaving + high temp. drying.	Meat and fish meals	0	3	5	Steam hazard and need for regular maintenance and inspection of equip.	Electrical or fossil energy or renewable energy possible.	-	-
28.	Apertisation (canning and bottling.	Vegetables, fruits, meat and fish.	0	3 (e.g. village produce guilds)	6	Precise conditions process times and temps. required for safety. Bottles if local glass industry.	Well controlled heat but non-fossil sources applicable.	Low	-
29.	Freezing	Fruits, veg. etc. Meat, fish including cooked products.	0	2	5	Creates major requirement for frozen transport and storage.	Electrical, or by absorption refrigeration from other heat sources.	Mechanised movement of frozen material desirable.	
[illegible].	Freeze drying. (lyophylisation)	Specialised high value products, e.g. durian powder for flavouring.	0	3	3	Expensive technology but possibly great value for specific products.	As above.	Low.	-

TABLE 1 page 3

Process description	Examples of crops & products	Suitability for: Traditional & domestic	Small plant	Large plant	Notes	Plant requirements for energy: Heat	Mechanical power	Plant requirem[ents] for toxic or hazardous chem[icals]
31. Salting/brining	Vegetables such as lima beans peas okra etc. Fish, shell-fish, olives etc.	2 (local)	6*	2	Only appropriate with plentiful supplies of edible grade salt.	Low(making up brine.)	-	-
32. Conserving with sugar. (jams, marmalada, sweet-meats).	Many fruits, (special interest marmalada from fruits with seasonal surpluses, guava, mangoe, durian etc.)	5	7	4	Need for insect-proof work spaces. Local' sugars can be used.	Any heat source, but temp.measurement in pans essential.	-	-
33. Evaporation concentration.	Tomatoes, blackberry juice, citrus juices. Milk.	0	2	4	Most plants are large but successful down-scaling in India.	Low.	Electrical or fossils for vacuum pumps.	-
34. Distillation.	Alcohol. Fermentation followed by distillation possible from many fruits and juices.	6	7	3	Design and leak-proof of systems important, but good local technologies are widespread.	Any source, but avoid naked flames.	-	Fire hazard fr[om] alcohol. 'Bush' alcohols be dangerous t[o] drink.
35. Re-distillation (fractionation).	Conversion of bush alcohols to potable or food grade and fuel or industrial fractions.	0	2	4	Uganda case study with 'waragi' as alternative to outlawing bush stills.	Well-controlled electrical heat.	Mechanised handling with pumps etc.	Fire & theft.
36. Steam distillation.	Flavours and fragrances from herbs and spices, e.g. cardomom oil, clove oil, natural vanillin, peppermint oil.	1 (local)	6	2	Extensive R & D undertaken by TPI, London. Experience callable.	Any heat source	-	Low.
37. Smoking.	Fish, lean meats, cheeses.	4	5	5	Scottish kipper industry (small & large scale) a useful model.	Suitable bark with non-toxic volatiles giving acceptable aroma, e.g. oak or hicory.	Low.	Despite tradit[ional] use of smoked f[ood] hazard is sugge[sted] if food use excessive.
38. Formulation (dry product mixes).	Infant foods, school meal packs, emergency packs, service ration packs, convenience foods.	0	6	6	Has received substantial attention but with much emphasis on food aid components.	-	Handling & portioning advantageous.	
39. Composite flours.	Preparation of baking flours containing significant proportions of local ingredients.	5	6	6	Extensive R & D experience available, e.g. FAO programme to underpin practical applications.	-	Power for mixing and handling.	
40. Pre-packed convenience foods for retail trade. (Platscuisines)	Legume pulse products, peas pudding, soup mix, bean mash. Meat & veg. mixes, cassoulet, pork & beans etc.	0	2	5	Rapid expansion and with potential for substantial fuel saving.	Well controlled & regulated heat.	Probably mechanized handling & packaging.	-
41. Integrated food production and fast food retailing.	Soup kitchens, canteens, pizza parlours etc.	6 (local)	6 (exp. for urban dev.)	3	Growing world-wide, quality control and hygiene should be combined with positive attitude.	Positive at both processing and distribution.	-	-

TABLE 2

FOR CARBOHYDRATE

PRIMARY, SECONDARY AND TERTIARY PROCESSING AVAILABLE BY CLASS OF RAW MATERIALS

	Primary processing (On farm or local)	Product	Secondary processing Nearby rural desirable for Small Scale Plants	Product	Tertiary processing Small Scale Plants at district, or Large Scale Plants regional or national.	Product
CEREALS						
Wheat	Drying, threshing, cleaning.	Millable grain.	Destructive milling (7) Controlled extraction milling (8)	Wholemeal % extraction flours	Dough making and baking, opportunity for mixing in composite flours.	Bread, nan, kisra, biscuits etc.
Sorghum	Threshing	Grain with hull.	Feed formulation or brewing and some traditional domestic food use.	Animal feeds, beer, local foods.		
			Controlled abrasive milling(decorticating(8)	Decorticated or pearl sorghum & high grade flour.	Baking, alone or in composite flours	Bread etc.
Pearl millet	Threshing and clipping	Whole grain.	Parching	Lahis		
			or with milk curd, yoghurt etc.	Sattu.		
			Grain cracking(5)	Cracked grain or grit.	Cooking Soaking (eaten uncooked) W.Africa.	Soups, gruels
			Milling (7 or 8)	Millet flour	Baking.	Chipatti, roti or bhakri.
					Baking with other flours	Bread.
Maize	Removal of grains from cobs	Grain maize	Destructive milling (7)	Grits (maize meal)	Cooking	Gruels, porridge etc.
				Whole maize flour.	Baking	Tortilla etc.
			Flaking + solvent extraction(22)	Maize flakes + corn oil	Cooking(and malting)	Animal feeds (cornflakes)
					Hydrolysis	High fructose corn syrup.
Rice	Threshing and winnowing.	Padi	Parboil	Parboiled rice	Cooking or milling.	
			Hulling	Clean rice	Polish	White rice
					Ferment with a legume such as black gram	Idli.(India)
						Ragi(Indonesia)
					Ferment & distil	Rice wine.
					Ferment with soya	Miso (Japan)
BULK STARCH CROPS						
General	Cleaning, slicing drying.	Dry root chips	Destructive milling(7)	Meals & flours.	Mixing into composite flours for bread-making or similar.	Bread, biscuits etc.
	Peeling, pounding drying.	Root meals.	Controlled microbiological conversion.	40% protein feed ingredient.		
	Peeling, pounding, fermenting.	Fermented products e.g. gari				
	Peeling, pulversiation in water, gravity separation.	Starches & bitties.	Acid cleaning	Fine starches..		
	Peeling	Clean root	Mechanised pulping + settling or autoclaving + high temp.pneumatic drying	Dry, whole root powders.	Formulating with moist, high protein materials.	Controlled composition feeds or food
Cassava		Peeled roots	Anaerobic fermentation of coarsely ground root for 2-4 days.	Gari.(W. Africa)		
			Aerobic fermentation with powdered ragi.	Peujeum(Indonesia)		
		Dry root Chips.	Finely sliced, deep fried salted, (packeted,	Cassava chips		
Sweet potato	General (see above)	Peeled roots	Canning.			
			Finely sliced, deep fried	Chips.		
		Peeled, mashed roots.	Anaerobic fermentation in closed pots.	Poi(See taro)		
Taro.	General(see above)	Clean whole root.	Cooked in [illegible] retorts, cooled, washed, peeled, milled and anaerobically fermented.	Poi	Stabilised by heat treatment at [illegible] C. to extend life(Hawaii)	

TABLE 2 page 2

Yam	General(see above)(but too valuable for purely industrial use.	Whole roots	Cleaned and peeled, boiled and pounded to a heavy glutinous dough.	Fufu (Nigeria)		
Sago.	Felled palm cut into 1-2m.lengths,bark removed,pith scraped out or rasped out with special tools.	Wet pith	Filter to separate fibre.Sludge liquid passed to a trough and starch separated by sedimentation.		Wrapped in leaves draining heated to dry.	Sago meal.
Breadfruit.	Controlled heating of ripe fruits to soften skin & denature enzymes Cooled fruits peeled halved,cored, sliced washed(in sea water). Dried over hot stones then air dried.	Nambo(New Hebrides, Reef Islands)	Can be milled to meal or flour for out-of-season food use.		Component of composite flour for breadmaking etc.	
	Peel,slice,parboil, deep fry.	Breadfruit crisps. (Caribbean)				
	Peel,separate cores, mash, treat with antioxidant(Vit.C.or sulphite),dry,mill.	Breadfruit flour.	Grain substitute for fermentation to alcohol			
			Composite flour mix.	Bread.		
Potato	Peel or cleaned.		Dried flakes or flour.		Incorporated with other flours for bread.	

Since generalisation over the full range of possible technologies would not be helpful, the following two sub-sectoral studies are put forward to illustrate some of the considerations that need to be taken into account in formulating policy for the food processing and preservation sector.

2.10.a Cane-sugar Processing[1)]

An analysis of the relationship between small and large-scale sugar processing technology assumes significance for three major reasons. First, it is one of the dimensional-product industries described in Part 1 whose central processing technology involves inherent scale economies of the so-called "six-tenths rule" type. Second in many developing economies the sugar-industry is important - in India it is the second largest industry after textiles, whilst in many island economies the industry accounts for over ten per cent of GNP. And, third, it is one of the few industries in which indigenous developing country technology provides a viable alternative to the large-scale, capital-intensive sugar-mills.

a.1 The Technologies

There are two major families of technology, vacuum-pan (VP) and open-pan sulphitation (OPS). The major difference between the two processes stems from the use of multiple effect evaporation in VP mills, leading to very high thermal efficiencies. VP technologies are inherently subject to economies of scale, whereas OPS is a batch process and increases in capacity are achieved by multiplying the number of units, so any economies of scale are incidental to the basic technology.

In figure 2.2 these economies of scale are illustrated, for both sets of technologies. In the case of VP, data exists for both fixed investment and total operating costs, whilst for OPS firm data only exists for investments costs.

As is obvious from the figure, fixed investment costs are the major source of scale economies in VP plants, declining from around 30 per cent of unit costs at 1250 tcd to 17 per cent at 10,000 tcd. However the major scale economie are realised at a capacity of 5,000 tcd. The

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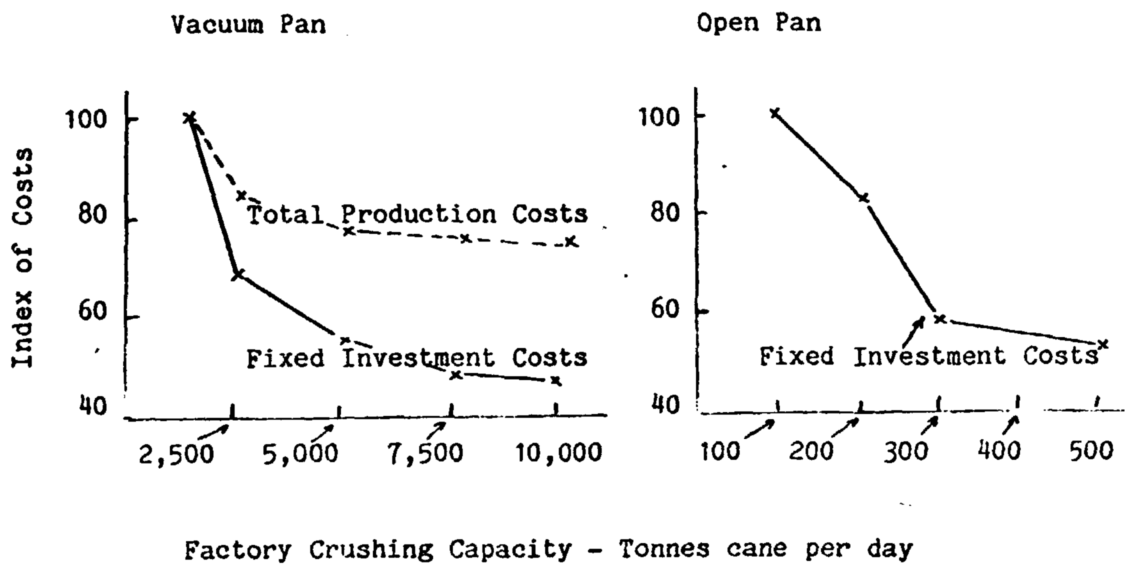
1) Although beet-sugar accounts for around 40 per cent of global production, it is a temperate-climate crop and is almost exclusively produced in developed economies. Therefore "sugar" in this sectoral study refers only to cane-sugar. Also excluded from analysis is the production of non-crystalline jaggery and liquid-sugar, and coru derived high fructose sweeteners.

major source of scale diseconomies in VP plants arises from transporting the cane to feed the mill - these rise from around 4 per cent of units costs at 1250 tcd to 10 per cent at 10,000 tcd.

Figure 2.2 Economies of Scale in Sugar Processing



Source: Tribe and Alpine, and Kaplinsky 1983 b.

Although the question of scale economies within each type of technology is of obvious relevance the key concern arises with respect to the balance between technologies. This is a widely researched and disputed topic, but there are reasons to believe that two recent technological advances made by Indian technologists have altered the balance in favour of the small-scale OPS plants unless VP plants operate at a capacity in excess of 5,000 tcd[1]. The major disadvantages from which the OPS plants suffer is their lower sugar recovery rate and their inferior energy-efficiency, but they are able to compete with VP mills due to their lower unit transport, labour and investment costs. Moreover VP plants characteristically operate at lower levels of capacity utilisation due to their organisational difficulties in ensuring adequate supplies of cane.

1) Median plant size in India is around 1400 tcd; in Africa it is in the order of 2,500 tc.

a.2 Product Characteristics

A well functioning, properly equipped VP plant is able to produce refined sugar which is very white and has an even crystal size. By its nature, existing OPS technology is unable to meet these product specifications, although it is possible to supply a product which is very similar to the mill-white sugar generally produced for internal consumption in developing countries. Although it is often asserted that this represents an inferior product, the only absolute disadvantage arises in the use of sugar in the food-processing industries since the higher molasses content of OPS sugar has a slight effect on taste and colour. However, insofar as direct consumption of sugar is concerned, consumer preference is relative - in India OPS sugar sells at a discounted price; in Kenya the two products are marketed interchangeably.

a.3 Working Conditions

As with many small-scale plants, working conditions in non-unionised OPS plants tend to be significantly worse than in unionised VP mills. Wages are substantially lower, hours longer (usually two 12 hours shifts compared to three 8 hour shifts), noise levels higher and safety conditions inferior. Moreover some observers in India have argued that historically VP mills have been introduced by the State to undercut the money-lending power of jaggery and OPS owners over peasant cane-suppliers.

a.4 Linkage and Skill Implications

The extent to which each of these technologies are associated with backward and forward linkages clearly varies between countries. In the larger and more industrialised developing economies, local industry is able to supply VP equipment. In these cases the issue is not so much one of the extent of backward linkages but rather their locus. This is because there are scale economies in the manufacture of the equipment so that only a limited number of large factories will be able to operate, generally sited in large towns and cities. Given the relative technological complexity of the VP technology[1] there is a tendency for the equipment suppliers to be part of a large diversified enterprise so that many of the learning effects are internalised within the firm. By contrast the production of OPS technology is much more dispersed, both in relation to the number of firms involved and their locus. Its production is much more likely to be associated with the emergence of rural growth poles. However since many of the equipment suppliers also make a range of other equipement, and labour mobility tends to be relatively high[2], many of the learning-effects are externalised.

Insofar as skill is concerned, plant operation in both types of technology is similar, although the introduction of process controls in the large-scale VP mills makes them inherently less susceptible to variations in worker performance. However in plant construction the manufacture of VP mills has been significantly more skill-intensive[3] and where it occurs in developing countries, has generally been associated with technological licensing from developed country machinery suppliers.

For these and other reasons it is likely that the small-scale OPS plants will be more susceptible to local repair and maintenance and to the extent that these involve learning effects, their external economies within rural areas may exceed those involving VP plants.

a.5 Relative Factor Productivities

Aside from broader social issues involved in the choice between the two types of plant (such as the distributional implications, the quality of work and the social relations involved in production) it is instructive to observe their relative factor productivities.

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1) In India, for example, some VP equipment suppliers use numerical-control machine-tools, which is relatively unusual in Indian Industry.
2) In an analogous way in the VP vs OPS plants, working conditions in OPS equipment supplies tend to be worse than those producing VP equipment.
3) It is interesting to note that the maturation of VP technology in the 19th century stretched the boundaries of existing knowledge and was directly responsible for the emergence of chemical engineering as a specialised discipline.

In both India and Kenya it can be seen from table 2.8 that if total existing sugar productin was met by either vacuum pan[1] or OPS, the operating implications would vary significantly. OPS involves many more dispersed plants, a reduction in capital investment and an increase in aggregate employment. However, the lower sugar recovery rate which is currently inherent in OPS production means that the SS technology is significantly more land-intensive, requiring around 20-30 per cent more cane to provide the same output of sugar. Hence defining the optimum balance between the two types of technology involves considering the availability and price of all three factors of production.

Table 2.8 INVESTMENT AND LABOUR UTILISATION REQUIRED TO MEET TOTAL EXISTING SUGAR PRODUCTION: INDIA AND KENYA

		Annual Sugar Production (tspa)	No of Plants	Capital Cost (Rsn;K£m)	No of Employees
India	1250 tcd VP	5,150,000	327	26,160	284,490
	200 tcd OPS	5,150,000	2,682	18,492	836,784
Kenya	7000 tcd VP	380,000	2.6	520	4,420
	200 tcd OPS	380,000	81	91	25,920

a.6 Attempts to Change Technology

As can be seen from figure 2.2 in part 1 of this report, recent improvements in OPS technology have had a significant impact in changing the relative balance between it and the VP alternatives. For example in N Indian operating conditions, the average VP mills operate at a 9.6 per cent recovery rate; equivalent OPS plants have achieved around 7.2 per cent, but with the recent improvements introduced in crushing and furnace design, the OPS average is likely to improve to around 8.2 per cent. It is of interest that less than a decade back, some observers mistakenly argued that the gap between OPS and VP technology was likley to increase rather than decrease.

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1) In India 1250 tcd plants are considered since this is the officially encouraged capacity; In Kenya plants aim to expand over time and 7,000 represents the largest and most efficient of current VP mills.

In this context it is interesting to note that the Indian technologists responsible for the recent improvements in OPS technology are now turning their attention to additional advances. Because of the essential difference between the two types of technology (involving the temperature at which the juice is boiled) it is unlikely that the existing recovery differential could be significantly narrowed with the use of current type of technology. Traditionally the OPS practice is to extract a first crop of crystals from the concentrated juice, then to boil the molasses again and take a second crystal crop. This process is operated for a third and sometimes a fourth crop. This is obviously a tedious procedure requiring additional plant capacity. Thus there is a proposal under consideration to take the first crop of sugar as before but then to treat the first molasses by an ion exchange process which would remove all the inorganic impurities from the molasses, leaving a clear solution of invert and non-invert sugars. At that stage either the liquid sugar could be marketed in its own right or could be evaporated and treated by another process to produce a fine powdered sugar (called "bura" in India.)

If one or both of these technological developments are successful, the existing recovery-inefficiency of OPS technology - which has historically been a major obstacle to its widespread diffusion - is likely to be eroded. In either case sugar processing technologies represent a major example of Third World indigenous technological capability which has led to the maturation of a viable small-scale technology.

2.10.b Bread

The bread industry has come to assume an important role in many developing countries, particularly those in Africa and S. America in which consumer taste patterns have been shaped by European and North American influences. The primary reason for the growth of this sector has been that the product constitutes an ideal convenience food since it stores relatively well, is relatively nutritious and is not too expensive. However the high-protein strains of wheat required in its manufacture only grow in climates with a harsh winter which means that developing country wheat has be to blended with imported hard varieties. In the context of the present study, it is worth noting that small-scale bakeries still predominate in developing countries (and the large-scale factory production of bread is generally on the retreat in industrialised countries.) Yet it is a sector to which large investors are attracted by the prospect of a large captive market, and they may seek to take the large-scale route as a means of dominating that market in spite of strong countervailing socio-economic arguments.

b.1 The Technology

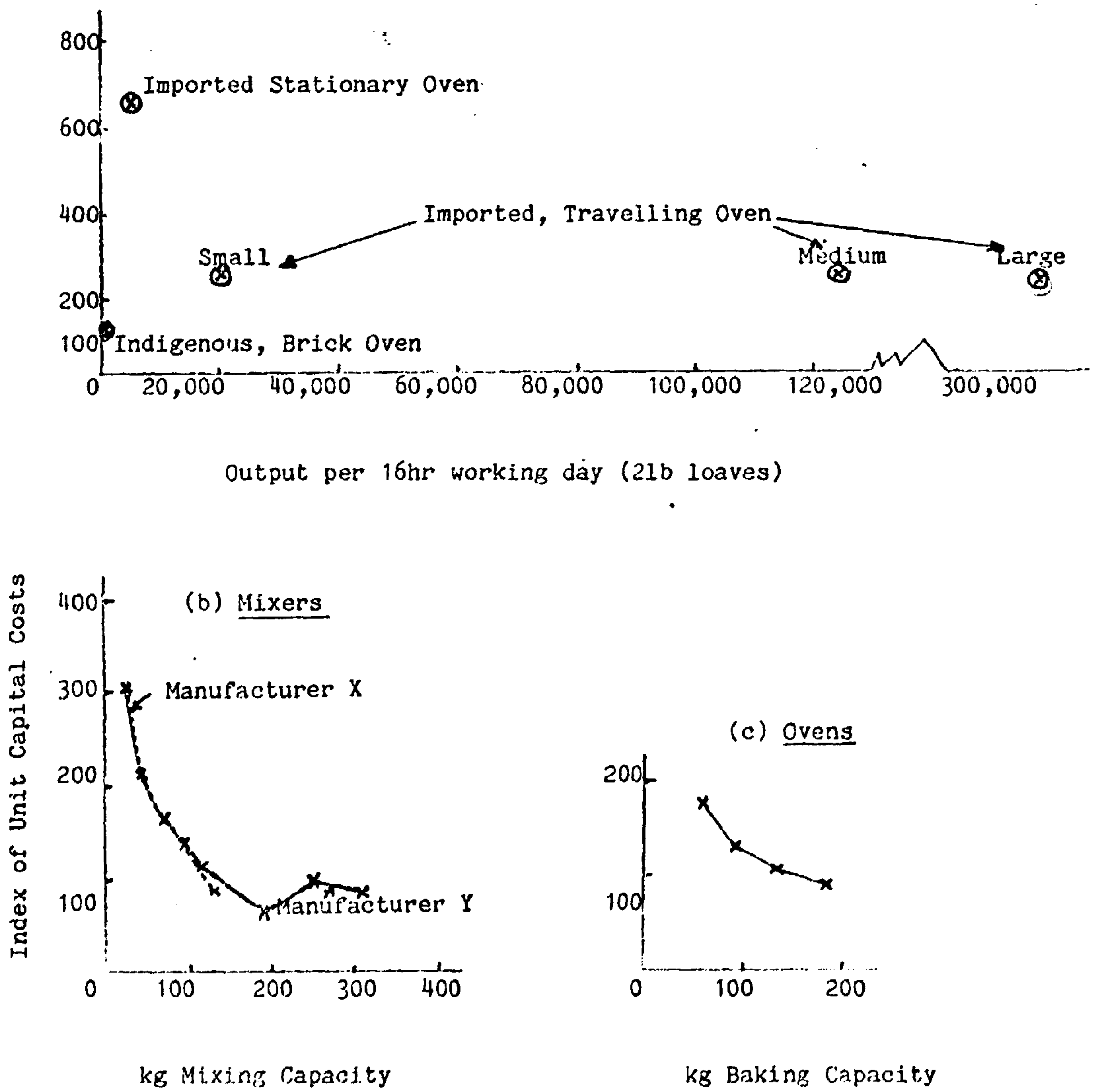
There are seven distinct sub-processes involved in the baking industry, namely mixing, proving (two or three times), moulding, dividing, baking, slicing and packing. Whilst each of these is important in relation to both product "quality" and costs of production, two (the oven and the mixers) are of critical importance. The oven is the only set of equipment which is essential to production. Here there are three major technologies available, the choice of which defines the character of the enterprise. At the smallest scale lies the wood-burning brick oven, which is constructed on site from indigenous materials. Next in terms of both complexity and scale is the stationary "peel" oven which is generally of modular form and can use a variety of energy sources. In most developing countries these ovens are either imported or produced under licence.

At the larger scales there are travelling[1] ovens which transform a batch-baking industry into one which proximates continuous-process industries; these bakeries are characteristically referred to as "factories" or "plant-bakeries". The second key sub-process is that of mixing, which over the last two decades has seen the development and diffusion of a high-speed mixing technology which involves the intensive mechanical working of the ingredients under vacuum conditions within a short period of time. In so doing it reduces dough preparation time from hours to minutes, reduces working space and increases the absorption of water (hence increasing the yield of bread from flour). However it produces a particular type of product, uses more yeast and requires a carefully controlled operating environment. As such its use is almost always tied to large-scale travelling ovens.

1) In these the bread - not the oven - does the travelling!

Therefore in considering the question of scale economies in the bakery industry, it is important to distinguish between scale economies <u>within</u> particular sub-processes (and often these may differ between types of sub-process as in mixers or ovens) and those between different <u>types</u> of bakery. This is illustrated in figure 2.2[1]. Here we can observe [2.2(a)] the question of scale economies in the unit capital costs of different types of bakery. Clearly the major differences arise between different types of technology - within a particular group of bakeries (eg) plant bakeries) there is little evidence of economies of scale in direct production cost. However within particular sets of equipment [figures 2.2 (b) and (c)] there is more evidence of scale economies but these are swamped in the aggregate costings of the whole bakery.

Figure 2.2 (a) Types of Bakery



b.2 Quality and Technology

The "quality" of bread reflects the types of equipment used, the types of input used, the recipes and the management of the bakery. Despite the noticeable differences between bread produced by different bakeries, there is no absolute measure of quality in bread save that which defines its specific volume, its moisture, the hardness of the crumb and the absence of mould. Cultural differences are overwhelmingly important in defining "quality", and within each cultural taste pattern there are established norms. However in general these norms are easily realised and technological barriers to entry are thus low. Nevertheless differences in product type are evident and have a major bearing on market share. Three major variations are evident. First is the question of product life, since by adding chemicals, shelf-life can be extended significantly. In general this know-how is associated with plant bakeries and larger-sized stationary-oven bakeries; the use of plastic-bags to sustain product life is widespread throughout the industry. Second is the issue of freshness and here, for obvious reasons, the large-scale plant bakeries find it difficult to compete with small-scale enterprises. Finally there is the consistency and "image" of the product. Small-scale bakeries, particularly those using brick-ovens, tend to produce more variably textured and crusted bread[1]. Moreover even-crumb texture and and white-colouring[2] are a specific consequence of using mechanical mixing technologies, especially high-speed and continuous mixers.

b.3 The Social Impact of Technological Choice

Since the technological and financial barriers to entry are low there are many factors which favour the dispersion of this industry in rural areas, to meet rural demand markets. Two additional factors favouring decentralised small-scale production are the natural protection accorded by transporting a low-value product, and the relatively short shelf-life of bread. The consequences of such decentralisation are often attractive to policy-makers. Small-scale brick ovens are

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1) Largely due to the uneven temperature-regime in the ovens.

2) Whiteness is significantly affected by bread cell-shape and its ability to reflect light.

locally-fabricated (but only viable if wood is readily available) whereas the larger-scale technologies are imported or produced in major centres. They are also relatively labour-intensive - under Kenyan operating conditions, for example, capital-costs per workplace are seven times greater in plant-bakeries than in those using brick-ovens; at the same time the small-scale bakeries are also surplus-maximising technologies so that there is no conflict between output-employment and growth-maximising objective in the choice of technology[1]. However, in common with many other sectors the working conditions in small-scale plants tend to be inferior and product "quality" more variable; this latter factor stems directly from the labour-intensive nature of the processes involved.

Despite the inherent attractiveness of small-scale bakeries to policy-makers and entrepreneurs alike, there is an increasing trend in many developing countries towards plant-bakeries. In part this arises from the logistics of trying to ensure supplies in large cities. But it is also possible to put forward an explanation in terms of political economy since, although the total surplus may be greater with many small-scale bakeries, it is more difficult for large-scale capitalist enterprises or the state to appropriate a widely dispersed surplus than one which is conveniently concentrated.

b.4 Linkages and Skill-implications

There are few barriers to entry in this industry save for the problems involved in marketing a product which may be preceived to be "non-modern" by consumers. Decentralised production is hence an attractive proposition and it is consequently interesting to consider the backward and forward linkages which the industry might encourage. First there is the question of skills required to run a small-to-medium-sized bakery can be relatively easily acquired, either through formal learning or via on-the-job experience. The latter avenue is more problematical in the case of plant-bakeries where the move to a semi-continuous process makes greater demand for formal training. Similarly the supply of equipment follows the same pattern - small-scale brick

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1) Compare this with the view of observers such as Emmanuel (1982) who, as noted in Part 1, argues that such a conflict is inherent in the choice of technology.

ovens can be constructed by ordinary masons (although optimised designs can be fuel-saving), whilst travelling ovens and some stationary ovens (eg turbo-ovens) are more technology-intensive.

Second, equipment for both the brick-oven and the simpler stationary ovens can be constructed in many developing economies by local equipment suppliers with experience in the food-processing industry (eg mixers are of a common, although not identical, design). However high speed mixers, travelling ovens and some ancillary equipment (eg moulders and dough-dividers) are more specialised, so that manufacture, repairs and maintenance are all likely to entail some degree of import-dependency.

Third, the large-scale plant bakeries have more extensive upstream and downstream requirements, and hence induce more linkages. The production environment they require is more specialised, thereby involving more tightly specified inputs - for example high-speed mixing not only requires running water, but its temperature has to be less than 15°c. Downstream the major linkage involves a developed transport and marketing infrastructure. Indeed this example suggests that the generation of linkages need not in itself always be a desirable phenomenon. In passing it can be noted that since compared to the dry ingredients bread is over fifty per cent more bulky and thirty per cent heavier, extensive deliveries of bread entail the expensive luxury of transporting entrapped air and water around the country.

b.5 Technological Change

Currently most of the commercially-financed scientific inputs are going into improving the large-scale mixing, baking and process-controls, notably involving the introduction by developed-country machinery suppliers of micro-electronic controls to enhance flexibility and energy-efficiency, and to reduce labour inputs. Yet, despite their existing attractiveness in developing-country operating environments, the small-scale brick ovens are most suitable for technological enhancement, particularly in relation to energy-efficiency and the introduction of designs (involving external heat generation which allowed for operation with non-wood fuels. In many cases the external temperature of these ovens approaches 90°c.

The redesign of these brick ovens is not a complex process and a number of improved variants have been developed. Yet their diffusion to small-scale rural bakeries in developing counties has been slow, and the transfer of this design technology to existing and projected enterprises could counterbalance the research and development bias enjoyed by the modern multinational plant and machinery manufacturers.

B. REVIEW OF SECTOR STUDIES

The key points arising from the sector studies are as follows:

Basic Investment Industries

2.1 Iron and Steel: An interesting features is the surprising impact over the past decade of small, efficient and flexible mini-steel plants, which have been taking business away from the established large, integrated steel producers in most industrialised countries (and have in fact captured over half of national output in Italy). Such a massive change in the optimum scale of technology puts a premium on nimble and far seeing pre-investment review procedures, since the unwary investor could well have commissioned a large "modern" steel manufacturing complex when it was on the point of obsolescence.

2.2 Machine tools and workshop equipment: The study reviews the impact of the new technology of numerical control upon the machine tool industry, as well as the potential impact during the 1980's of the long-heralded expansion of robotics. The conclusion is that economies of scale at the advanced technology end of the spectrum appear to be growing more powerful, although developing countries should nevertheless attempt to build up their technological capabilities in this area. Among simpler technologies, the study reviews recent approaches to the development of simple workshop equipment that is appropriate for manufacture and use in the rural areas of developing countries.

2.3 Agricultural equipment: In view of the disparate nature of the industry as a whole the study focusses on the hoe, which remains the most important agricultural implement for many millions of farming households in Africa and Asia. This tool can be manufactured at virtually any scale, from the mass production capital-intensive die forging and rolling industry to the level of the village blacksmith. Unfortunately quality is generally directly related to scale, although the study quotes a recent UNIDO document which suggests that, with appropriate technical assistance, a village production unit could be viable with an output of 4,000 tools per annum.

2.4 <u>Computer aided design</u>: This study provides an example of the impact of a new knowledge-intensive electronic technology upon a rather traditional aspect of manufacturing activity, and its effect on the balance of advantage between large and small scale firms. It notes the importance of synergistic linkages in the development of the technology and the danger that this might slow its diffusion to the Third World, which could pose a real threat to continuing industrial growth.

2.5 <u>Building materials</u>: Cement is the key construction material, and its absence or shortage is frequently the root cause of delays and price escalation on capital projects thoughout the third world. Again quality is a factor that has favoured the larger plant, but it is estimated that only 20% of worldwide consumption of cement requires the full strength of international Portland cement. For the remainder, there is scope for genuine technology choice on the basis of local considerations, particularly transportation costs of the finished product (which can exceed production costs) and the potential for energy savings. Thus the attractions of a network of small and mini plants, to supplement basic supplies of high strength cement, are likely to grow and lead to a better balance in the use of resources.

<u>Process Industries</u>

2.6 <u>Petrochemicals</u>: Petrochemicals is a sector that showed startling growth during the period 1950-73, coupled with technological advances which yielded quick profits to investors in new, large plants. However, the adjustment of oil prices since 1973 led to a drastic change in the cost mix, increasing the cost of feedstock and undermining the economies of large plants with high break-even points. There are now indications that the flexibility of small, relatively simple plants may well offset the apparently better technical efficiency and target financial performance of large, sophisticated complexes. This is particularly true in the increasingly uncertain operational and economic environment that will appear when oil production peaks (probably) in the 1990's, and new (or revised) technologies based on coals or biomass become viable alternatives.

2.7 <u>Pulp and paper</u>: The pulp and paper industry is another in which innovation has been concentrated on the large-scale plant, due to a production-oriented market and a vigorous machine-manufacturing industry. Large-scale wood-based pulp mills do retain distinct technical advantages, although these may be offset if the real costs of forest maintenance, felling, roads and transport equipment are taken into account (smaller plants might not require any major specific infrastructure provision). On the other hand, technical developments in non-wood pulp mills have brought down the lower limit for continuous pulping to 15 tonnes per day, and small plants have distinct advantages in reducing transport costs due to smaller raw material collection zones. Choice of scale in paper-making plant is more complex, and is analysed under the eight headings of quality, speed, instrumentation and control, stock preparation plant, efficiency of production, production costs, capital costs and market considerations. The conclusion is that there is a need to develop simple, standardised machines, for which the inherent cost and energy advantages would be bolstered by economies in maintenance and cost of spares, simplicity in operation and easier training.

Light Industries

2.8 Bicycle manufacture: The bicycle is the most common wheeled vehicle in the world, and is in fact a primary utility vehicle for the movement of both people and goods in developing countries. It is frequently manufactured in large factories, although the assembly process is relatively labour-intensive, and small scale operations are feasible in terms of physical facilities and services, while certain components (such as rims, spokes and nipples and bottom brackets) are also successfully manufactured on a small-scale in certain Asian countries. The study explores the potential to encourage scaling-down by appropriate design, such as Oxtrike load-carrying tricycle which can be economic at production levels of around 500 units per annum, as well as the feasibility of widely dispersed (village level) repair and maintenance facilities.

2.9 Textiles: Plant size is a relatively unimportant factor in the viability of textile manufacture. In spinning the capital cost per unit of productive capacity is substantially independent of plant size above a threshold of about 500kg of fibre per hour, while in weaving it is completely independent of plant size from a single loom upwards. Future developments among small-scale spinning machines and looms are likely to be directed towards simplification to achieve enhanced performance, but with lower costs and easier maintenance.

2.10 Food manufacturing

Following the general review of the effects of scale on the food manufacturing industry, two sub-sectoral studies cover:

a. Cane sugar processing: Besides being a very important industry in its own right in many developing countries (second largest after textiles in India), it is one of the dimensional-product industries described in Chapter I whose central processing technology involves inherent scale economies of the so-called "six-tenths rule" type. However, it is also one of the few industries in which an indigenous developing country technology provides a viable alternative to the large-scale, capital-intensive sugar mills.

b. Bread: Bread is an ideal convenience food since it stores relatively well, is relatively nutritious and is not too expensive. An important element favouring plant bakeries in developing countries can be explained in terms of political economy, since although the total surplus may be greater with many small-scale bakeries it is difficult for this decentralised surplus to be appropriated by large-scale capitalist enterprises or the state. Overall there are many factors favouring the deliberate dispersion of this industry in rural areas, particularly if attention is directed to the redesign of small-scale brick ovens.

It is difficult to generalise from the above sectoral studies, except to note that the debate between the proponents of large and small scale has frequently generated more heat than light. This divergence is exemplified by the discussion of appropriate sugar technology[1)], where the issue is essentially a question of the relative importance of internal, technical economies of scale vis a vis possible external economies of scale. Given certain assumptions, Forsyth[2)] summarises

1) FORSYTH D. Appropriate Technology in Sugar Manufacturing. World Development. Vol 5 No. 3, 1977.
HAGELBERG G. Appropriate Technology in Sugar Manufacturing - a rebuttal. World Development. Vol 7, 1979.

2. Op Cit.

the results of some research[1] which shows that the most economic small-scale plant (producing 10,000 tons per annum) is that which uses the most labour-intensive set of techniques, while the most economic large-scale plant (producing 50,000 tons p.a.) is the most capital-intensive. However, the profitability of the best small-scale option is well below that of the best large-scale (50,000 tons) option, and is in fact lower than 20 enumerated large-scale options.

On the other side of the argument a number of issues are conventionally brought into the discussion, and Hagelberg[2] introduces them in a 'rebuttal' of Forsyth. His main point is that technology is a 'package' involving 'hardware', organisation, management, supply of materials and skills; in addition other factors are important - infrastructure, location, distribution of project income, degree of external dependence, market size, timing of benefits. One of the results of an 'unbalanced package' (e.g. large-scale capital - intensive technology but underdeveloped infrastructure - transport, power etc..) is that there is considerable excess capacity. Excess capacity is a prevailing problem for many developing industrial sectors[3] which prevents plant reaching rated capacity or achieving the theoretical economies of scale.

On the other hand perhaps the single most critical constraint on the real world adoption of small plants, which is generally ignored in micro-studies of technology, is that of effective organisation and management. Taking the sugar industry example again, on the basis of the scale alternatives mentioned above, 50 factory managers are required in the small scale option for every single one in the case of a large scale plant.

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1. Research carried out by the Livingstone Institute, Strathclyde University.
2. Op Cit.
3) See PHILLIPS D. Choice of Technology and Industrial Transformation - the Case of Tanzania. Industry and Development Vol 1 No. 5, 1981. (UN)

However, there is a trade-off between quality and quantity, for effective managers of a large-scale enterprise are a rare and expensive breed. Renumeration packages for top executives in the USA and Europe can run as high as US$ 1 million per year, and they must be supported by high level professionals in specialities such as design, production marketing, finance and personnel management. Where, for socio-political reasons, productive enterprises are located in the public sector, it is particularly difficult to contrive realistic pay scales for top management since these are required to bear some relationship to civil service pay scales, even if such high level entrepreneurial personnel were available for recruitment. Thus the actual performance of large-scale parastatals frequently falls far below predicted levels (the X-inefficiency factor introduced in Chapter I)

The supply of efficient innovative managers varies between countries, relative to demand, largely reflecting the extent of development of the class structure (the political economy) rather than the extent of development of technical resources per se. Small-scale industrial development, at least of the organised factory sector, is therefore a function partly of factors completely unrelated to techno-economics.

C. SCOPE FOR SMALL-SCALE PRODUCTION

It would clearly be convenient for policy-makers if some form of league table could be drawn up, listing those industries which should be conducted using large-scale plants, those where small plants are more appropriate, with a small band in the middle which should be considered on a case-by-case basis. Unfortunately the lesson of the sector studies is not so clear cut, and there are only a few industries which fall clearly into either of the former categories. Certainly there are a group of industries for which internal economies of scale are significant enough to limit downscaling to levels which would still require large amounts of investment, employment (and infrastructure) per plant. These include metal processing, petroleum, petro-chemicals, certain types of paper, certain industrial chemicals, including, probably chemical fertilisers (although small plants have been used in China[1]). Heavy engineering would also come into this group, because the tooling and setup costs would be large. Rotary kiln cement plants would also be confined to larger scale, although we have noted the recent revival of smaller vertical shaft kiln plants.

There remains potentially extensive scope for small industry production outside the above group of industries. In India the estimated share of the organised small factory sector (defined as units with less than Rs 1 million in fixed assets) has been over 50% of registered output in industries such as grain milling, fruit canning, oil extraction, sugar, textiles garments, knitwear, leather, sawmilling and furniture. Lowest shares have been applicable to steel, chemicals, non electrical machinery, cement and vehicles.[2] In S. Korea[3] in a similarly very wide group of industries in 1975 small enterprises employed more than 50% of workers in the particular industry. This included a wide range of engineering products in more than 1000 small enterprises, ranging from handtools to pumps, instruments and machine parts for the textile, foods,

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1) See SIGURDSON J. Technology and Employment in China. World Development March 1979

1) Source: Statistics of the Development Commission for Small-scale Industries, Government of India.

2) Small-scale Enterprises in Korea and Taiwan. SAM P S HO. World Bank (Working Paper No 284) 1980

chemicals, paper, printing, glass and plastic machinery sector. There was no obvious pattern discernible in the shares of SSI. Share were lowest (below 25% of industry employment) in a range of industries which included milk products, tobacco, fertilizers, fuel oil, vehicles, sugar, cotton spinning, tyres and tubes, plywood, newsprint, cement, radio and TV receivers, electronic tubes. A number of industries reported as having insignificant SSI share were industries in which economies of scale would not normally be considered important.

Finally, a point should be made about one of the major single justifications for SSI - i.e. capital saving. An early study by Hoselitz[1)] showed a clean relationship between scale and capital - intensity (capital - value added ratio) in Japan, implying that capital is used more efficiently at smaller scale of plant (but not below 10 workers). These findings were confirmed elsewhere but a frequent finding has been that the most efficient users of capital tend to be plants of around 100 workers in the small factory sector[2)]. In other studies (e.g. Philippines[3)]) the general finding is that capital - efficiency has risen with scale. In the above Korean study the most capital - efficient firms were those employing 100-199 workers, but larger plants (employing over 200 workers) were generally more capital efficient, at the aggregate level, than those employing below 100 workers.

Such findings are subject to various sources of uncertainty but they cast doubt on the case for promoting small-scale industry on capital saving grounds, at least at a general level. (For specific industries however capital - efficiency has been found in many cases to decrease with scale in Korea and the Philippines). The general case for SSI must therefore be based largely, if not entirely, on external economies of production. For particular industries there is no substitute for a case-by-case evaluation of efficiency, since external conditions (e.g. infrastructure, location etc..) are highly variable.

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3) HOSELITZ B. The Role of Small-scale Industries in the Process of Economic Growth. Nouton 1957.

2) IBRD. Employment and Development of Small Enterprises - Sector Policy Paper. Feb 1978 (p 67)

3) ANDERSON D. Small Enterprises and Development Policy in the Philippines. World Bank (Working Paper No. 468) 1981

1. Introductory points

Inevitably (and rightly) individual countries will wish to frame policies on industrial scale in keeping with their local environment, resources and requirements. Whilst this paper does not presume to pre-empt these decisions, it is already clear that many countries are seeking ways in which inherent biasses towards large-scale solutions can be redressed through the active promotion of plants and industries in the small-scale sector. Thus this chapter is concerned with mechanisms for promoting small-scale industry, and the incroporation of SSI into industrialisation strategy. The promotion of SSI is examined at the level of macro-economic policy as well as direct promotional measures.

SSI promotion is then considered in both the national and the international context, the latter discussion being framed in terms of channels of international cooperation and the constraints on cooperation which have emerged during the recent economic recession.

2 Typology of industrial promotion

The measures used to promote SSI may be divided into two main categories - (1) general economic policy instruments (2) instruments of direct promotion. For the first category, some of the remarks of section 1.1 are applicable, i.e. the structural features of developing economies particularly during the early industrialisation phase tended, according to most writers, to work to the disadvantage of small enterprises. This was because protection favoured centralisation and capital-intensive production, and the tariff policies also favoured importation of industrial materials. This structure tended to be underpinned by overvalued domestic currency exchange rates, which cheapened imports. Consequently SSI, which tended to be labour-intensive and domestic resource based (especially in the case of processing industry) was subject to disadvantages. The 'distortions' in the economy worked through all product and factor markets to some degree, affecting particularly interest rates, the ratio of domestic to import prices, and the structure of wage rates. General economic policy is therefore designed to offset possible general impediments to SSI by influencing the supply, demand and price of factors and products.

Direct promotion involves intervention largely in the supply side. It includes specialised schemes for increasing availability and possibly reducing prices of inputs into industry, including skilled manpower, materials, equipment, supporting services (e.g. repair and maintenance), power, and finance. It also operates on the demand side through specialised schemes for procurement of products, protection (e.g. through tax relief or reservation).

The following is a typology of the different types of scheme available, based on a similar table in Sinha[1].

Table 3.1 SSI PROMOTIONAL INSTRUMENTS

	Input Supply	Product Demand	Technology
General economic policy	Exchange rate changes. Tariff adjustment Monetary policy (interest rate level, and supply of finance, financial and investment incentives)	Policies affecting distribution of income. Exchange rate changes. Fiscal policy (tariffs, differential taxes, excise duties, etc.)	General technology policy. technology transfer controls, licencing etc.. Technology development mechanisms - AT centres, information services, design centres, Entre-preneurship incentives.

1) SINHA S. Planning for Rural Industrialisation; A Review of Developing Country Programmes. Intermediate Technology Development Group Ltd. 1983.

	Input Supply	Product Demand	Technology
Direct promotion instruments	Provision of infrastructure.	Subcontracting promotion.	
	Central material purchase.	Reservation of products to SSI.	Information Services.
	Guaranteed supply (power etc..)	Specific fiscal incentives.	Extension Services for tech. advice.
	Manpower training Advisory services.	Marketing advisory and information services.	Demonstration/ pilot projects.

The list of measures set out above stops short of state intervention in regular production, although pilot projects may come into this category. It was pointed out in chapter I that there are two different interpretations of the role of SSI in industrial development (1) that the small factory sector has been eroded as a result of technological dualism; (2) that the sector expanded, replacing crafts, and is in turn superceded by larger-scale production. If the first interpretation is accepted there these are grounds for positive state intervention in production, in order to build up either a corps of public sector entrepreneurs, or to provide a lead for the private sector. In this case SSI promotion would involve public ownership of small factories, at least in new technology areas. This was for example the policy adopted by the Small Industries Development Organisation (SIDO) in Tanzania from 1973, where a series of 'new technology' plants have been established in industries such as sugar, paper, fruit preservation etc. Tanzania has also embarked for some time on a policy of generating entrepreneurship in the public sector through 'District Development Corporations' under the direction of public authorities.

3. Internal and external constraints on small plants

SSI's in all countries tend to suffer from certain 'internal inefficiencies' to a greater or lesser degree, in comparison with larger-scale units. It is these inefficiencies, in addition to the external problems of supply and markets which promotional policy addresses.

The principal problems are a) lack of financial control or records b) lack of management skills, especially the skills required to handle expansion above household or craft/artisan scale. Evidence on these constraints is extensive, from Nigeria, India, Korea, Philippines and Thailand[1]. In Britain the 1971 Bolton Commission[2] and the 1979 Wilson Committee[3] found parallel problems in the case of small plants, as follows: (1) need for improved organisation and financial control (2) need for improved record keeping and documentation (aided through reduction in cost of statutory reporting to government). In addition the various UK committees investigating the matter mentioned similar external constraints as exist in many countries: (1) lack of finance (including export credit), (2) lack of technological information, (3) lack of market information (especially for exports), (4) shortage of efficient entrepreneurs, (5) shortage of skilled labour. The shortage of entrepreneurs in Britain is thought to have arisen because of a cultural bias in favour of employed (salaried) work, as well as other structural changes.

4. The Indian Experience

In all these areas India, of all developing countries, probably has the longest experience. From about 1953 an extensive government apparatus was established in India, with organisations such as the Small Scale Industries Development Organisation (SSIDO), the Khadi and Village Industries Commission. In the handloom, silk and handicrafts sectors special boards were established. The SSIDO controlled a network of Small Industries Service Institutes (SISI's), Extension Centres, training centres, and since 1978, District Industrial Centres set up to replicate at local level the work of the SISI's. The functions have included business start-up advice, surveys, technical information, providing demonstration workshops (including mobile workshops), market research for small businessman, model schemes, business training, and technical training. An associated organisation, the National Small Industries Corporation, set up in 1955, was concerned with (1) machinery hire purchase, (2) assistance in making use of a government central stores

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1) ANDERSON D. Small Industries in Developing Countries, Some Issues. op cit.
2) PHILLIPS D The Role and Promotion of Small-scale Industries in Britain. op cit.
3) Ibid.

purchase programme (3) sales outlets for SSI products (4) distribution of raw material through depots (5) importation of equipment and components on behalf of SSI (6) construction and running of industrial estates and prototype centres. The State banks and financial corporations set up liberalised credit for working capital. Furthermore, as far back as 1960, the Indian Government introduced a credit guarantee scheme for SSI whereby the Reserve Bank Shared the risk of losses on loans with the lending institution. The lending institutions in the scheme included a majority of commercial (scheduled) banks, state financial corporations, and cooperative banks. The guaranteed loans were for machinery and working capital.

One of the standard methods of providing concentrations of infrastructure and supporting services to small enterprises is through the construction of industrial estates. The Indian Industrial Estates programme is the most extensive of these. Over the first 4/5 year plans over 500 estates were constructed, and over 10,000 factory units actually started operations.

Entrepreneurship development has been undertaken in India via what are known as 'intensive campaign' which involved SSIDO agencies moving into target districts in order to mobilise business interest in establishing manufacturing units. These campaigns usually took place in the more rural districts, in an attempt to aid relocation of industry. (As much as 50% of hire purchase funds have gone to 4 metropolitan cities). The campaign involved largely information provision, but were backed by the hire purchase organisation, and success was measured in terms of the number of applications for funding that materialised during the campaign. According to SSIDO figures intensive campaign in number of states have resulted in more applications for hire purchase funding during the course of the campaign than in several years of normal promotional activity.

Finally, a further promotional mechanism introduced in India is the 'reservation' policy. By the 6th plan some 834 products were reserved for SSI producers. The Indian 'model' has been replicated in principle, but on a smaller scale, by many other countries. However, interestingly, the drive for industrial estate construction in India gained impetus from the example of the UK industrial estate programme of the 1950's. Yet the promotion of small enterprises in the UK is otherwise in its infancy, and it was not until 1979 that a loan guarantee scheme was suggested (by the

Wilson Committee) and 1982 when it was implemented.

5. Subcontracting and intra-industry markets

One feature of small-scale industry development which has attracted attention is the possibility of promoting small units as satellites, or ancillaries, of large-scale production. The Japanese experience has been the model for this. In Japan, subcontracting has been important in a number of industries, including fabricated metal products and transport equipment. In sewing machine manufacture, for example, between 1941 and 1963 the average number of components produced by each enterprise fell from 60 to 3[1] while production increased from 0.25 million units in 1950 to 4.8 million units in 1969.

In Korea[2] contract sales have been important in textiles, chemicals, rubber, paper, metals and machinery. Rapid growth of the engineering industry is generally supposed to have been due to growth of subcontracting (although in Taiwan engineering firms have tended to be vertically integrated.) 17% of total sales are on contract to other industries. But the level of subcontracting rises with scale of enterprise. At below 10-worker scale about 8% of sales are on contract to domestic industry, rising to 25-30% at 100-worker level.

International subcontracting has emerged as a significant factor especially in electronic equipment. A number of S.E. Asian countries have recorded very high growth rates of exports. Singapore recorded 66% per annum over 1967-73 rising in 1976-78, while S. Korea recorded similar rates of growth.

An important question for SSI promotional policy is the extent to which special efforts should be made to promote export subcontracting. In Korea, according to the above mentioned study, export orientation increases very significantly with scale, as follows:

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1) WATANABE S. Subcontracting, Industrialisation and Employment Creation. Int. Labour Review. 1971.

2) HO. Op cit.

Table 3.2 SCALE AND EXPORT ORIENTATION OF INDUSTRY: SOUTH KOREA 1975

Scale	5/9 wkrs	10/10	20/49	50/99	100/199	TOTAL
Total Sales						
Overseas Sales	2%	6%	17%	26%	29%	20%
Domestic Sales	98	94	83	74	71	80

Source : Ibid

This is possibly to be expected, since an export oriented strategy tends to encourage economies of scale in production by widening potential markets. But certain implications follow for SSI policy - namely that international subcontracting is relatively insignificant for small enterprises, and that the domestic market is still predominant as the outlet for SSI products. This implies that, even for a major LDC exporter such as Korea, small industry promotion must remain largely concerned with domestic markets and as a consequence, domestic resources and growth of domestic incomes. In Korea between 1968 and 1975 the share of 'dispersed resource processors' in total SSI employment (e.g. agro-industry) remained constant at 23%. Market-oriented activities (i.e. domestic market oriented) increased share from 19.1% to 26.3%. Service activities also increased from 5.8% to 9.8%. These activities, accounting for 60% of output, are presumably domestic resource and market based. This supports the above conclusion that much of SSI activity is still in 'traditional' areas, even in a major LDC exporter, and that the bulk of SSI promotion should still be concerned with its role in the domestic economy. Within the domestic economy of Korea the major growth industries over 1963-75 were textiles, garments, footwear and electrical machinery which between them accounted for almost 50% of total additional manufacturing employment. At small-scale level (below 100 workers) however the major <u>relative</u> increase appear to have been in paper, printing, metal products and non electrical machinery. SSI captured only 12% of the additional employment growth in electrical machinery, but 30% or more in the above cases. This tends to confirm that SSI products are largely directed to the domestic consumer or producer.

6. The Effectiveness of Small Industry Promotion

6.1 Constraints on Credit Supply

Despite the efforts of many countries to increase the supply of finance to small firms, certain problems occur in the provision of funds, particularly when credit supply is in the hands of 'traditional' banking institutions. The problem lies in the risk factor associated with defaults on SSI loans, which are relatively frequent, and in addition the extra administrative costs of dealing with a portfolio of small enterprise loans. A high default rate with high associated administrative costs means that in order to cover the cost of supplying funding, banking institutions would have to raise interest rates to small enterprises to relatively high levels, but typically higher interest rates tend to attract high risk borrowers - so that the probable default rate on high interest rate loans would be still greater; in fact the risk adjusted interest rate would be politically unacceptable; in many countries interest rates charged to small enterprises are in fact lower that for industry in general. Consequently, credit is restricted largely only to low-risk (larger-scale) borrowers or to 'well-connected' small entrepreneurs. (Economies of scale in financing are also recognised as important in the increasing scale of enterprises in the UK).

In order to boost the credit supply to SSI from the banking system it is necessary to lower the risk factor and, simultaneously to raise profitability of small enterprises - and at the same time also increase the cost of funds which such enterprises are able to bear - i.e. shift both supply and demand curves for funds at near risk free interest rates. This requires state intervention through various mechanisms, such as loan guarantee schemes, whereby the state banks guarantee a proportion of the loans against default. It also requires extension services coupled with finance, on the assumption that such extension services will be the mechanism for boosting the profitability of SSI, and, as a consequence, the demand price for funds. Extension services are also essential, in principle at least, in order to improve enterprise operating efficiency (e.g. record keeping and financial control), to provide data for assessing the bankability of particular enterprises, and to lower the 'transaction costs' of finance - for example by making access to finance easier for small enterprises.

A further important issue concerns the financing of working capital. Typically this is handled by separate institutions (e.g. commercial banks), which complicates the problem (raises the transaction cost) of access to credit for small enterprises. The banking systems in developing countries also tend to favour fixed capital finance rather than 'operational' finance - i.e. finance for expansions and working capital finance[1]. However the combination of working and fixed capital finance in one institution would probably provide several advantages - (1) Since working capital loans are less risky - self-liquidating, the overall risk element on loans would be reduced, so that general interest rates to SSI borrowers would be reduced (2) Working capital financing involves closer ongoing links between bank and borrower, allowing more control over the efficiency of fund utilisation, an opportunity for regular consultation between enterprises and lenders, this raising operating efficiency and lowering riskiness in lending. (3) Access to a 'package' of finance would lower transaction costs to borrowers. Banks offering a 'package deal' would in themselves take on an extension role. (In Tanzania, a recent World Bank Credit for Small Industries has been channelled through the commercial banks and backed by a loan guarantee, since prior investigations had suggested that the commercial banks which already ran an extensive country-wide network of branches, were in fact in an ideal position to handle longer term fixed capital loans).

Schemes that are in force include (a) direct financing (subsidised) by state banks (b) rediscounting by central banks, covering a proportion of risk and administrative cost (3) loan guarantees by central banks against a percentage of loss[2]. A final possibility is the hire purchase type of scheme, as operated in India and some other countries, where the machinery supplied under credit is mortgaged to the credit supplier and therefore remains the property of the credit supplier. This reduces risk in the sense that the fixed assets can be repossessed, at least in principle.

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1) ANDERSON D. Small Industry in Developing Countries; Some Issues. Op cit. World Development 1982.

2) SINHA S. Planning for Rural Industrialisation; A Review of Developing Countries Programmes. IT-DG 1983

A final point concerns the extent to which small enterprises require outside finance even given access and acceptable interest rates. It is pointed out in many studies that up to 90% of SSI funds are internally generated[1]. As a result that the long run elasticity of demand for external financing may be relatively low. However, the experience of the Indian hire purchase schemes during the 'intensive campaigns' mentioned in section 4.3, suggests that upward shifts in the demand curve can be induced, particularly when finance is supplied as a package, along with machinery supply, technical advice, and other promotional measures.

6.2 The efficiency of promotional programmes

The arsenal of possible promotional measures, including micro measures, is undoubtedly formidable. Promotion, however, is subject to a number of practical problems, stemming from the fact that it is largely a supply-side instrument, although efforts have been made to protect or give preferential access to markets for SSI products. Supply-side measures cannot provide the long term market prospects required for SSI investment and expansion. On the other hand, if, as appears to be the case in a number of countries, the SSI sector is expanding as a complement to medium/large industries, and has a constructive role in accelerating growth, promotional measures on the supply-side could be more effective.

Leaving aside the more 'cosmic' aspects of SSI promotion however, the mechanics of promotional measures themselves have not often achieved the targets set for them.

Consultancy work has generally had limited reach, and has, as a result, incurred high costs per production unit. For Kenya estimates have been made of a cost of £8-£11 per hour for SSI consultancy. In Nigeria scarcity of experienced technicians in Zarla has prevented adequate staffing of a common facilities centre, and prevented any coverage of the surrounding states. In Botswana, jobs created as a result of promotional activity by B.E.D.U. have cost well in excess of the general cost per job created in the small factory sector. In India, despite the rapid growth of industrial estates (see above), less than 70% of the sheds are in active operation, and the number of units operating account for less than 5% of the total number of units registered with SSIDO. Similar problems

1) Ibid.

have beset the Kenya Rural Industrial Development Programme. In Tanzania the outreach of common facilities workshop has been restricted because of lack of skilled manpower, and lack of transport facilities. The implementation of 'pilot plants' for, for example, small-scale sugar manufacture, has been considerably delayed. Mobile workshops attached to central engineering facilities in two locations have never been able to fulfil their functions due to lack of maintenance personnel, as well as lack of spares. In many countries promotional facilities tend to be duplicated, often as a result of the activities of outside aid agencies, contributing to a lack of coordination of effort.

The case of Tanzania is of special interest because particularly concentrated effort was made to promote small industry, under the direction of a relatively powerful organisation (SIDO), and in the context of decentralisaiton of government, and redistribution-oriented government policy. SIDO was charged with the tasks of promoting technical training, setting up regional extension services, implementing and managing the industrial estate programme, administering a machinery hire purchase fund, establishing new technologies in a series of pilot plants, and promoting small business generally country-wide. Over 10 years since its foundation a large concentration of resources, both local and foreign have been brought to bear on the problem. Indian promotional ideas were initially adopted, and since have been developed through local experience and outside proposals (e.g. the so-called 'sister industry' programme sponsored by Sweden, whereby Swedish firms set up and manage plants on Tanzanian Industrial Estates, financed through S.I.D.A). SIDO produced a comprehensive 5 year plan for small industries designed as an indicative plan for the purposes of promotion. It also included plants earmarked for establishment by local development authorities (i.e. more than indicative). 20 regional extension centres were set up, ultimately to be attached to 20 industrial estates with common facilities centres. Fulfillment of the indicative plan would imply a clear reversal of the declining trend in the SSI share (see above Chapter I, table 1.3). Up to 1982, 12 industrial estates were completed or under construction, of which the majority were sponsored by some foreign aid agencies.

Any pioneering programme must face unanticipated difficulties and the SIDO programme has been no exception. The main problem areas have been as follows[1]:

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[1] Based on a report for the World Bank (1980) on financing of small industries by PHILLIPS D (unpublished - extracts provided by permission of the the author

(1) The aided industrial estates showed considerably higher capital-intensivity than those set up by local efforts. The units set up in one estate, Arusha, were technologically relatively advanced and of possibly excessive capacity (e.g. a foundry).

(2) The hire purchase scheme by 1981 had a large arrears problem, with a majority of payments being behind schedule.

(3) Long delays in implementation of the first industrial estates, especially the Dar Es Salaam estate.

(4) Implementation delays for projects in the plan. These were reported as due to lack of entrepreneurs, finance for equipment, and material procurement.

(5) Extension centres act primarily as liaison and information offices, rather than providing field assistance. Some centres, in the main towns, are inadequate to provide guidance for all planned projects. In the rural centres there is a better possibility.

(6) The industrial estate common facilities centres have suffered from problems such as low capacity utilisation (e.g. of foundries). Furthermore there are shortage of technicians and some lack of motivation.

(7) Some of the technical training (outside SIDO's production-cum-training centres in new technologies), was considered to have been theoretical in nature, and without clear applicability to the demands of an extension service.

6.3 Technical promotion policy - concluding points

The experience with technical/manpower support in a number of countries has been forced by problems which are often of a similar nature. Some of these can be summarised.

(a) There is a general tendency for promotional effort to be spent on provision of hardware in centralised (even if local) extension facilities. Field work tends to take a lower priority, sometimes because of infrastructural inadequacies (e.g. transport and rural electrification), but generally because the orientation of the extension staff is bureaucratic and concerned with relations with the centre, i.e. the extension service H.Q.

(b) Machinery provided in the extension centres, frequently through foreign bilateral aid, is often of relative advanced technology, and not necessarily appropriate for the conditions facing rural, or semi-rural, artisans and small industrialists. It is difficult to get away from the 'demonstration effect' approach.

(c) Industrial estate programmes nearly always precede detailed planning of the types of production units which are to be established within the estates. This has led to low capacity utilisation of the estates, and also to the setup of enterprises which are unlikely to benefit greatly from the facilities provided. (e.g. service industries, or simple packing operations are not likely to make use of common engineering facilities or material provision). Thus potential economies of concentration are not realised.

(d) Formal training of technical staff is often inappropriate to the specific needs of operating enterprises, and technical extension workers are not in a position to give effective help in problems faced by enterprises. The expertise in improvisation and running repairs and maintenance is very much a learned skill, and its development is a function of experience.

Finally, it has to be pointed out however that promotional services are in a sense an 'infant industry'. Ultimately a learning process has to take place. Initially extension services tend to be little more than information or liaison offices, screening loan applications or advising entrepreneurs on how to take advantage of incentive schemes on otherwise helping them to cut a path through bureaucratic procedures. The emergence of the technical arm of the service depends on the development of appropriate skills, and an orientation towards the 'field', supported by adequate infrastructure.

7. International Cooperation and the Role of External Assistance Agencies in the Promotion of SSI

7.1 The Effects of the Economic Recession

The areas in which small industry development is most likely to be affected through the general problems of the world economy are as follows: a) cuts in external assistance provisions, b) foreign exchange shortages (in oil importing countries) caused by general balance of payments problems, c) protectionism in industrialised countries, d) cuts in resources available to national governments for financing domestic promotion programmes, e) recession in markets for small industry products within the domestic economy.

In other words general recession affects small industries on the supply side, especially for finance, imported materials, and state financed supporting services, and on the demand side, markets, both domestic and exports.

The combined current account deficit of oil importing developing countries more than trebled between 1978 and 1982, and many poorer developing countries experienced negative GDP growth[1]. However the most pronounced falling off in economic growth affected the industrialised economies as a whole, which experienced growth rates levelling off towards zero from 1980 to 1982. But up to 1980 the proportion of manufactured imports of industrialised countries from developing countries continued to increase, from 5.3% in 1962 to 13.1% in 1980. Rapid growth of commercial bank financing resulting in increases in interest rates was the principal cause of more recent deterioration in current account deficits of oil importing developing countries. The share of official development assistance in capital flow fell steadily during the 1970's from 0.43% of GDP in 1970 to 0.35% in 1979. During the period it managed to maintain a positive real rate of growth, even from the oil importing industrialised countries; however since 1980 a slowdown has occurred.

The effect of the rise in the share of commercial financing has been a rapid rise in debt service payments, in 1982 oil importing countries

1) Source: World Development Report 1982 (IBRD)

debt service payments ($bn 81.9) amounted to 19.5% of export value, compared with 14.7% in 1979, largely due to rises in interest rates. A large number of cases of debt renegotiation have resulted. For a number of countries however, dependence on soft (O.D.A.) loan financing will continue for the foreseeable future

Demands for import restrictions in industrialised countries have not as yet been widely put into effect, although quotas do exist in industrial products such as vehicles, footwear, textiles and steel in various countries.

For the immediate future certain encouraging signs are in evidence - e.g. the falling rates of interest will reduce debt service. Protection of industrialised country markets may be less likely if GDP resumes growth, concessional aid and private foreign funding (especially export credit) are expected to resume growth, albeit at a low rate. A number of countries - notably in S.E. Asia, India, Ivory Coast, Kenya and Malawi, have achieved relatively satisfactory growth sales even during 1980-82. India achieved 8% growth in industrial output and 7% increase in exports. If growth resumes in industrialised countries the 1980-82 slump in non-oil commodity prices may be reversed. In additions the growth rates of manufactured exports from developing countries may accelerate after a slowdown in 1979-81. (Textile and footwear imports to industrialised from developing countries increased from $bn 28.6 in 1979) The share of manufactures in developing country exports between 1970 and 1979 rose rapidly in a wide range of countries. The most dynamic export growth industries were clothing, and machinery and transport equipment.

It should also be pointed out that, on the basis of the data of section 4.4, small-scale plants of under 100 workers in S. Korea are under represented in export markets, and the smallest units, of under 20 workers, export less than 4% of total output. Consequently, small industry has tended to be less affected by recession in industrialised countries, or protectionism. Lower capital and import intensity also means lower dependence on foreign exchange. There is indeed some evidence that shortage of foreign exchange and constraints on exports depress large-scale industry and can stimulate development of small enterprises able to utilise domestic resources. An example of this is the emergence of small-scale engineering sector on Tanzania over 1975-1982 capable of recycling scrap and producing parts and fabricated metal products.

7.2 International Cooperation for SSI Promotion

Small industry programmes have been established by a number of international agencies. The World Bank for example planned an increase in the share of DFC lending allocated to small industries from about $50 million in 1977 to $300 million in 1981, an increase from 5% to 30% of disbursements[1]. In 1975 the UNIDO second general conference at Lima embarked upon a programme for international cooperation on the development of appropriate technology, and a large number of SSI-oriented projects have emerged from this. In this section a few observations are relevant, stemming from the previous analysis, about the mechanisms for international financial and technical cooperation, both between industrialised and developing countries, and between developing countries themselves.

There are certain features of international assistance to SSI which are, prima facie, not entirely consistent with the character and objectives of intermediate types of technology. International assistance programmes involve, obviously, the use of external resources by SSI, and also in some cases the transference of technologies which may not be appropriate in terms of capacity or technological sophistication and capital intensity. (This is probably the case for example with the Tanzanian-'sister-industries' programme cited above).

One of the principal rationales of SSI development has been the ability to mobilise domestic resource - materials, entrepreneurship, technology, and concomitantly, finance. Tanzanian experience with the industrial estate programme suggests that the implementation period of locally financed and controlled estates has in some cases (e.g. Songea) been somewhat faster than those sponsored by external organisations. International cooperation in the establishment of geographically widespread small projects has been inevitably subject to extra difficulties - especially in obtaining clearance to go ahead with projects, submitting documentation for funding approval, and general

1) IBRD. Employment and Development of Small Enterprises. Op cit.

coordination of resources inputs from diverse sources. The Indo-Tanzanian agreement for transfer of technology is a good example of similar problems which tend to occur with cooperation between developing countries. This was perhaps a pioneering project in direct South-South intercontinental technical cooperation. The agreement was effective from July 1977 for the provision of machinery and technical assistance, combined with training and finance, for 48 small-scale 'new technology' projects, to be geographically dispersed within and outside industrial estates. By the end of 1980 only a minority of these plants was in operation. The delays were due not so much to problems locally, since much of the infrastructure and buildings were ready well before 1980, but due to inevitable difficulties of coordinating external resources in plant installation, technical advice, and shipping of the plant. Finance had also been allocated to new equipment and not for spare parts stocks. Similarly another project involving the setup of common facilities engineering centres, under UNDP auspices, involved the provision of (relatively sophisticated) machine shop equipment from USSR, but no tools, spare parts, and minimal technical assistance beyond installation.

The object of citing the above instances is not to make criticisms of detail but to point out that international cooperation within a geographically diverse and complex productive sector requires particularly good coordination and project design. It is well known that an adequate level of control however implies relatively high administrative costs per project, and per job created. The high cost involved in setting up such programmes can only be justified by a learning process within the programme's operations, and the assumption that there are external benefits associated with small-scale industry in general.

As far as financial assistance is concerned, the extra costs of handling external finance (in terms of requirements for documentation, lengthy decision - processes etc..) would have to be offset by designing financial assistance in order to minimise such transaction costs.

One method of achieving this is to open up general lines of credit to national banks, preferably combining fixed and working capital provision, which are then controlled and on lent to local industries with a reasonable degree of discretion allowed to the local banks (i.e. permitting on lending without regular referral back to the donor institutions) The existence of a 'financial package' under local control would facilitate access to finance, thereby lowering transaction costs.

The problem of financial risk must also be faced. International assistance in financing small industry should take account of this factor via the provision of additional funds to support loan guarantee schemes. In some cases (e.g. with the European Investment Bank) special financing facilities channelled through national banks are earmarked for equity financing with repayment conditional on generation of profits. UNIDO have proposed industrial loan guarantee schemes on a regional cooperation basis whereby developing country governments acting as project sponsors, spread the risks of lending to economically viable but financially risky projects in a regional fund.

Attempts at promoting international transfer of technology between developing countries (e.g. by ITDG in the field of textiles and metal products) would be greatly strengthened if means where found whereby they could be combined in 'package deals' involving finance, technical assistance, and follow up.

Chapter IV. CONCLUSIONS AND RECOMMENDATIONS

1. Conclusions

This paper has been concerned with issues surrounding the strategy for promotion of small scale industries. It has looked at trends in SSI development, the relative efficiency, and general economics, of small-scale plants, promotional mechanisms and their defects, and some problems of international cooperation. The major implications of the above arguments may be summarised as follows:

(1) Small-scale industry should be treated, for development purposes, not as a technical category (e.g. restricting assistance to industries of below a certain number of employees), but as a functional category, whereby assistance is provided to industry which provided a feasible alternative investment option which involves decentralisation, less managerial and technical sophistication, employment potential, wider dispersal of income and production both geographically and between social classes, and greater use of local materials.

(2) The relative efficiency of small vis a vis large plants is not easily assessed in a generalised way. The economic case for small plants is often associated with external diseconomies associated with large plants in particular developing country conditions - e.g. where infrastructure is deficient and markets and source of supply are dispersed geographically. Given these factors, wide scope appears to exist for decentralisation of production except in a group of industries where internal technical scale economies are predominant. Particular mention may be made of the light engineering sector, which has shown rapid growth at small-scale and is not generally subject to significant technical scale economies, but at the same time is a critical industry from the point of view of skill generation and innovation.

(3) Trends in small-scale production are subject to conflicting interpretations. On the one hand there appears

in some countries to be a problem of deepening dualism and erosion of the small factory sector. On the other hand the experience of other countries suggest an expanding and dynamic small factory sector, acting as a link between traditional artisan industry and medium to large scale production. These two different interpretations imply different promotional approaches. The first implies some pessimism about possibilities for SSI development, regardless of what promotional measures are in force, and suggests that active intervention by the state in production is essential. The second implies that SSI promotional policy is likely to be more effective in that the underlying investment condition for SSI are more favourable. Current experience in for example S.E. Asia suggests that the second view might be gaining ground.

(4) Promotional mechanisms are diverse and have proliferated in many countries, often taking the early Indian experience as a model. Even accepting that SSI promotion is acting within a favourable general economic environment (see above) there remain a lot of problems associated with the efficient use of promotional instruments. Excessive bureaucracy and lack of field-orientation has often prevented extension services from achieving even their limited goals. The extension services may be regarded as infant industries, and a learning-process is required before they are able to be fully effective. Financing of SSI needs to take account of methods of boosting credit through lowering lender's risks, and of easing access to funds if an adequately wide spread of borrowers is to be serviced.

(5) International cooperation in SSI has been affected, along with cooperation in other sectors, by the world economic recession. However the lower dependence of SSI on imports and exports may have given it some advantage over larger-scale production during the recession. Foreign exchange scarcity has stimulated small plants (for example engineering workshops in Tanzania) to recycle scrap and utilise indigenous materials. The signs are that external

assistance may recover its growth, if at a lower rate than previously. However, external assistance, both financial and technical, to geographical dispersed small projects is relatively costly and difficult to coordinate. Assistance schemes must be carefully designed and coordinated and must concentrate on lowering the transaction costs (facilitating easier access) to smaller plants of seeking external inputs, both financial and technical. This can be partly achieved probably by concentrating on 'package deals' of finance, combined with technical and managerial advice.

2. Recommendations for UNIDO Assistance Policy

This concluding section develops some of the above conclusions into specific guidelines for SSI external assistance in the technical area.

Technology Choice

In view of the changing balance of advantage between large and small-scale technologies both within and between sectors, UNIDO is well placed to assist policy-makers in their search for optimum technological solutions to suit their particular resources and needs. UNIDO's potential contribution in those areas could be realised in three main ways:

i) Support to the development of industrial products and processes which are susceptible to small-scale production techniques and for which the overall demand although substantial, is too dispersed to attract conventional commercial investment in research and development. This support could be effectively delivered through joint activities with established non-governmental organisations (NGO's) specialising in this field such as the Intermediate Technology Industrial Services (IT-IS) unit within ITDG.

ii) Promotion of specialist state-of-the-art meetings in various industrial sectors to assist national decision makers in the optimum choice of technology.

iii) Promotion of information and publications on choice of technology to ensure that the various advantages and disadvantages of various scales of industrial operations are more generally understood across the full range of potential alternatives.

Industrial Extension (Technical)

Particular effort should be made to ensure that extension centres and their satellite units are equipped with machinery and equipment which is of a similar technical level (eg type of power source) to that which is actually used by existing and planned local small enterprises. Along with equipment it is essential that an adequate stock of tools, spare parts, and usable instruction manuals are provided. In countries with underdeveloped engineering skills, provision of assistance should include installation testing and commissioning of equipment, and provision of personnel for training and interim operations of extension centres (see below).

Industrial Extension (Business Advisory Services)

Along with technical extension work business advice should be available involving aid with project studies, loan applications, knowledge of government procedures and available fiscal and monetary incentives. Operational assistance is also essential in financial control, marketing advice, facilities for raw material provision (or aid in identifying them in situations of scarcity). This type of assistance should be closely tied to the banking sector, possibly handled by local bank branches if not a part of an integrated extension service.

The Objectives of Extension Advisory Services

It should be made clear exactly what the extension service is expected to do. One common mistake is to provide an excessively lengthy and detailed terms of reference including, for example, business advice, technical advice, training, equipment prototype manufacture, repair work, field extension work, common facilities provision, appropriate technology promotion, supply of materials and marketing assistance. The result of this type of TOR is that no single function may be effectively carried out. Priorities have to be decided, and the extension service has to be designed with a view to meeting these priority needs. Field work would be expected to figure as a general priority.

Personnel

The ideal type of personnel for promotional work in small industries is the practical and experience generalist - ie an individual who has gained experience in (a) production, (b) business management. This would involve experience of repair and maintenance work, (improvisational skills), selection of equipment, and planning and production. It will also involve experience of purchasing, selling, elementary financial record keeping and control This type of personnel is not necessarily educated formally to a high level, but has learned from experience. Formal qualifications, publications etc. are of little relevance to these type of skills, although ceteris paribus, they may be partial indicators of appropriate skills.

It is similarly essential that personnel should be field-oriented, rather than oriented towards the extension HQ. The practically experienced small businessman is likely to show these qualities. Alternatively, efforts should be made to recruit technicians and business advisors together, who show motivation, and appreciation of practical problems.

For more centrally located personnel (eg in planning agencies) field-orientation is obviously of less significance. However, experience or qualifications which involve operational understanding of small business, either managerial or technical, are of importance for any kind of advisory or promotional assistance in small industry development.

Final Points

Technical extension assistance should be carefully designed to avoid the "demonstration effect" approach, and to operate with clearly defined objectives laid down in relation to local resources and production conditions. It is desirable that they operate through existing institutional channels and serve to strengthen them, rather than duplicating them and causing proliferation of institutions and problems of effective co-ordination.