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MONOGRAPHS
ON APPROPRIATE INDUSTRIAL TECHNOLOGY

APPROPRIATE INDUSTRIAL TECHNOLOGY FOR TEXTILES

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

Vienna

Monographs on Appropriate Industrial Technology
No. 6

APPROPRIATE INDUSTRIAL TECHNOLOGY FOR TEXTILES

UNITED NATIONS
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EXPLANATORY NOTES

A full stop (.) is used to indicate decimals.

A comma (,) is used to distinguish thousands and millions.

A slash (/) is used to indicate "per", for example t/a = tonnes per annum.

A slash between dates (for example, 1979/80) indicates an academic, crop or fiscal year.

A dash between dates (for example, 1970–1979) indicates the full period, including the beginning and end years.

References to dollars ($) are to United States dollars.

References to rupees (Rs) are to Indian rupees. In October 1978 the value of the rupee in relation to the dollar was $1 = Rs 7.90.

The word billion means 1,000 million.

The word lakh means 100,000.

The following notes apply to tables:

Three dots (. . .) indicate that data are not available or are not separately reported.

A dash (–) indicates that the amount is nil or negligible.

A blank indicates that the item is not applicable.

Totals may not add precisely because of rounding.

In addition to the common abbreviations, symbols and terms and those accepted by the International System of Units (SI), the following have been used:

Commercial terms

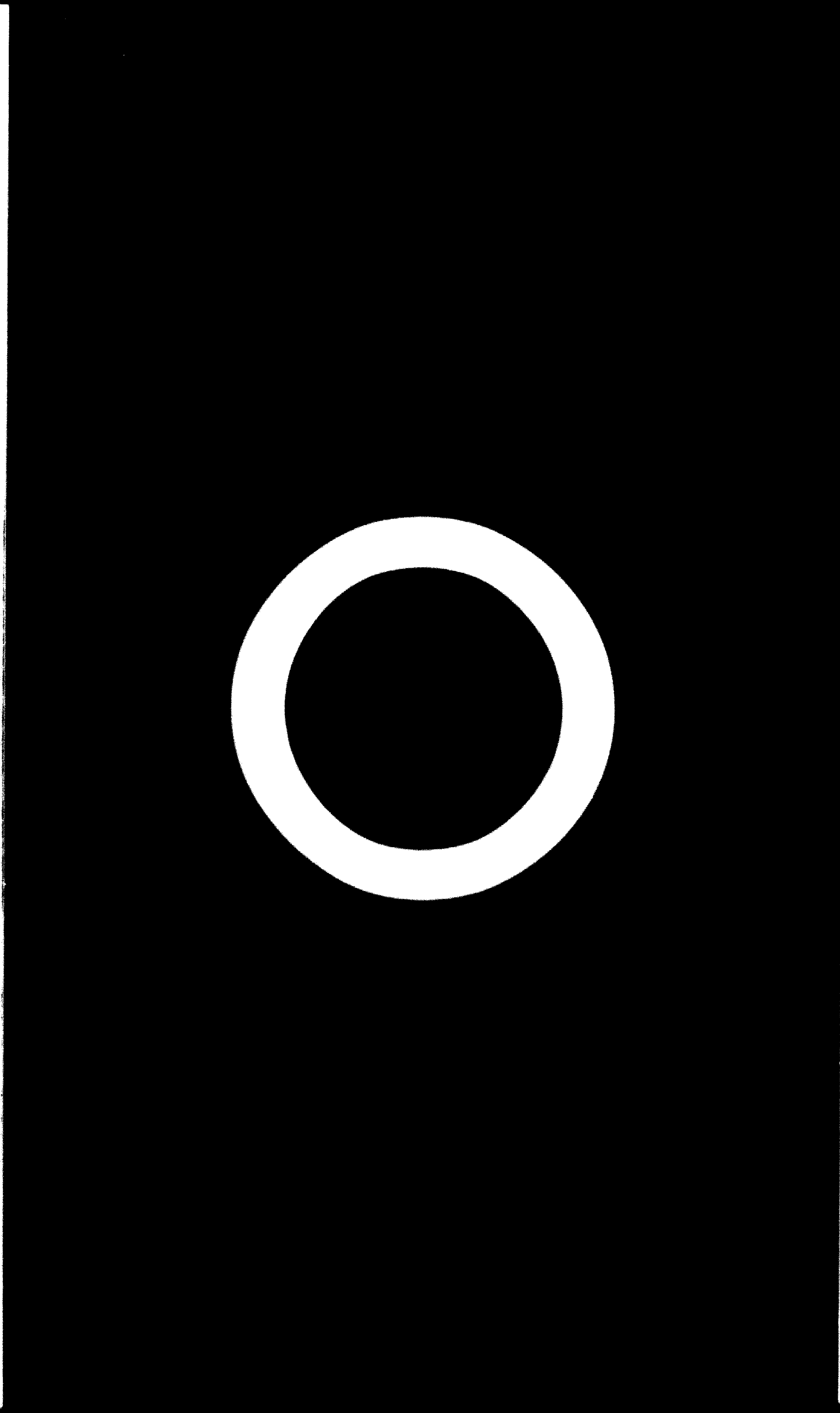
GDP	gross domestic product
NPV	net present value
PVC	present value of costs
R and D	research and development

Technical abbreviations and symbols
(with approximate metric equivalents)

hp	horsepower (1 hp = 746 W)
Ne	English cotton count
rpm	revolution per minute
yd	yard (1 yd = 0.914 m)
yd^2	square yard (1 yd^2 = 0.836 m^2)

Organization

ATDA	Appropriate Technology Development Association (Lucknow, India)



The concept of appropriate technology was viewed as being the technology mix contributing most to economic, social and environmental objectives, in relation to resource endowments and conditions of application in each country. Appropriate technology was stressed as being a dynamic and flexible concept, which must be responsive to varying conditions and changing situations in different countries.

It was considered that, with widely divergent conditions in developing countries, no single pattern of technology or technologies could be considered as being appropriate, and that a broad spectrum of technologies should be examined and applied. An important overall objective of appropriate technological choice would be the achievement of greater technological self-reliance and increased domestic technological capability, together with fulfilment of other developmental goals. It was noted that, in most developing countries, a major development objective was to provide adequate employment opportunities and fulfilment of basic socio-economic needs of the poorer communities, mostly resident in rural areas. At the same time, some developing countries were faced with considerable shortage of manpower resources; in some other cases, greater emphasis was essential in areas of urban concentration. The appropriate pattern of technological choice and application would need to be determined in the context of socio-economic objectives and a given set of circumstances. The selection and application of appropriate technology would, therefore, imply the use of both large-scale technologies and low-cost small-scale technologies dependent on objectives in a given set of circumstances.

Report of the Ministerial-level Meeting, International Forum on Appropriate Industrial Technology

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Foreword

As part of its effort to foster the rapid industrialization of developing countries, the United Nations Industrial Development Organization (UNIDO), since its inception in 1967, has been concerned with the general problem of developing and transferring industrial technology. The Second General Conference of UNIDO, held at Lima, Peru, in March 1975, gave UNIDO the specific mandate to deal in depth with the subject of appropriate industrial technology. Accordingly, UNIDO has initiated a concerted effort to develop a set of measures to promote the choice and application of appropriate technology in developing countries.

Appropriate industrial technology should not be isolated from the general development objective of rapid and broad-based industrial growth. It is necessary to focus attention on basic industrial development strategies and derive from them the appropriate technology path that has to be taken.

The Lima target which, expressed in quantitative terms, is a 25 per cent share of world industrial production for the developing countries by the year 2000, has qualitative implications as well. These comprise three essential elements: fulfilling basic socio-economic needs, ensuring maximum development of human resources, and achieving greater social justice through more equitable income distribution. Rapid industrialization does not conflict with these aspirations; on the contrary, it is a prerequisite to realizing them. But, in questioning the basic aims of development, we also question the basic structure of industrial growth and the technology patterns it implies.

Furthermore, it is easy to see that the structure of industrial growth that should be envisaged and the corresponding structure of technology flows should be different from what they are today; a fresh approach is called for. This does not mean that the flow of technology to the modern sector and the application of advanced technologies are unnecessary. On the contrary, it is essential to upgrade the technology base in general, and it is obvious that to provide basic goods and services, there are sectors of industry where advanced or improved technology is clearly necessary. It would be difficult to envisage a situation where the dynamic influence of modern technology is no longer available for industrial growth and development in general. However, an examination of the basic aims of industrial development leads to the conclusion that there must be greater decentralization of industry and reorientation of the design and structure of production.

Such decentralized industry in the developing countries calls for technologies and policy measures that often have to be different from those designed for the production of items for a different environment, that of the developed countries. As a result, there is a two-fold, or dualistic, approach to an industrial strategy. Morever, the two elements in such an industrial strategy need to be not only interrelated but also integrated.

In approaching the question of appropriate industrial technology from an examination of basic development needs, a mechanism is necessary to link and integrate appropriate industrial technology to the overall development process. Through such a process the concept of appropriate industrial technology could be placed in the mainstream of the industrial development effort.

It is hoped that these monographs will provide a basis for a better understanding of the concept and use of appropriate industrial technology and thereby contribute to increased co-operation between developing and developed countries and among the developing countries themselves.

It is also hoped that the various programmes of action contained in the monographs will be considered not only by the forthcoming meetings of the United Nations Conference of Science and Technology for Development and UNIDO III but also by interested persons working at the interface over the coming years.

Abd-El Rahman Khane
Executive Director

Preface

To focus attention on issues involved in choosing and applying appropriate technology, UNIDO organized the International Forum on Appropriate Industrial Technology. The Forum was held in two parts: a technical/official-level meeting from 20 to 24 November 1978 at New Delhi and a ministerial-level meeting from 28 to 30 November 1978 at Anand, India.

In response to a recommendation of the ministerial-level meeting, UNIDO, with the help of a generous contribution by the Swedish International Development Authority, is publishing this series of monographs based mainly on documents prepared for the technical/official-level meeting. There is a monograph for each of the thirteen Working Groups into which the meeting was divided: one on the conceptual and policy framework for appropriate industrial technology and twelve on the following industrial sectors:

Low-cost transport for rural areas
Paper products and small pulp mills
Agricultural machinery and implements
Energy for rural requirements
Textiles
Food storage and processing
Sugar
Oils and fats
Drugs and pharmaceuticals
Light industries and rural workshops
Construction and building materials
Basic industries

The monograph on the conceptual and policy framework for appropriate industrial technology also includes the basic part of the report of the ministerial-level meeting and some papers which were prepared for the Second Consultative Group on Appropriate Industrial Technology, which met at Vienna, 26-29 June 1978.

PART ONE

Issues and considerations

Note by the secretariat of UNIDO

INTRODUCTION

The industrial revolution began with the mechanization of textile production, and the industrial development of the developed countries owed much to the vigorous expansion of their textile manufacturing industries. In the developing countries, the textile industry was one of the first industries to be established. For these countries, the textile sector is important both for its high employment potential and for the value added to the manufacturing sector. It also has a great many employment linkages with agriculture, transport and trade. Thus, the orderly structuring of textile production assumes great significance in the industrialization programmes of developing countries.

The selection of textile technologies can be based on socio-economic goals, as well as on productive efficiency. Opportunities for product and process integration and for bringing industry to the population exist. Textile production has all the possibilities for becoming a highly dynamic sector rather than the static one it has been.

After half a century of stagnation, technological progress in the developed countries during the last two decades has brought a new life to textile production. The production capacity of textile machinery has increased dramatically. Automation is now being applied at all stages of fabric and fibre processing. Furthermore, an entirely new range of raw materials has been developed that has influenced the world textile trade. Although the share of developed countries in world textile production has declined slightly during the last 10 years, their exports in machinery and equipment have increased sharply. This trend may well accelerate rapidly, since most of the traditional textile-producing developing countries are planning to modernize their large-scale production units.

I. THE TEXTILE INDUSTRY IN DEVELOPING COUNTRIES

The levels of labour and machine productivity in the textile industry of the developing countries have always been significantly lower than those prevailing in the major advanced textile producing countries of the world. The productivity levels of developing countries are considered to be between one third and one half of those achieved in developed countries.

In the developing countries the average annual production per spindle for

20s count is 82.5 kg, as against 200 kg in the developed countries. A substantial part of the difference results from lower spindle utilization. Furthermore, the spindles in the developing countries are on the average worked 22.5 hours daily for only 300 days a year. In contrast, textile mills in developed countries generally work around the clock.

Of the total installed spindles in the developing countries, only about 80 per cent are utilized, as against an achievable level of 96 per cent. If spindle utilization were increased to the maximum levels, the annual production per spindle could be increased from 82.5 kg to 125 kg. That would still leave a productivity gap of nearly 75 kg.

The productivity levels in weaving are also much lower because of the lower levels of both labour and machine productivity. The contribution of labour productivity to the overall productivity gap is likely to be more than that of machine productivity.

The problems of the textile industry in developing countries are of two major kinds: (*a*) technological problems relating to quality, productivity and higher production and (*b*) socio-economic problems relating to employment, management and capital.

Proper machinery selection is one of the key problems in the development of the textile industry. The machinery must suit the twofold requirements of most developing countries: while it should be adequate for competitive production, it should not reduce labour input at the expense of higher capital input. From among the modern technological alternatives a level should be selected that strikes a balance between fixed costs based on depreciation and variable costs based essentially on wages.

The prices of textile machinery have sharply increased all over the world during the last two to three years. The determination of prices and cost competitiveness of capital goods is normally a difficult exercise, since international prices are usually influenced by the size of the manufacturer's domestic market and marginal costs.

While the core of a given technology might be the machinery, its efficient utilization involves several other factors, of which technical skill, organizational and managerial support, infrastructural facilities for transport, communication and storage, and the availability of appropriate raw materials are the most important. The machinery can be imported relatively easily, but the supporting facilities are more difficult to establish and maintain. The lack of such facilities has been equally important in deciding the suitability of imported technologies in developing countries. Because of bad roads and long distances between the spinning units and the weaving sheds, the cost of yarns varies from one location to another as a result of freight charges. Moreover, the weaving sheds are obliged to maintain large stocks of yarn to ensure a regular supply.

The textile industry in the developing countries is now operating under unfavourable conditions. Productivity is very low, the density of workers is high, integration is low, management skills in production and in marketing are inadequate, and there is a shortage of finance. These factors lead to high production costs and the inability to compete with imported products.

Synthetics have managed to penetrate cotton markets in three ways: through new products, through new properties in existing products, and through new processes. Other major contributory factors have been extensive promotion campaigns by the synthetic fibre producers, price stability and guaranteed availability.

In developing countries, synthetic fibre textiles can cost two or three times as much as those made from cotton. Of still greater importance to the developing countries is the fact that a single worker in a synthetic fibre plant can displace up to 33 persons associated with cotton production.

II. REVIEW OF ALTERNATIVE TECHNOLOGIES

In the developing countries, the production of textiles is normally undertaken in organized sectors and dispersed sectors. The organized sector comprises large-scale mills and can be further subdivided on the basis of ownership into private, public and co-operative sectors. The dispersed sector comprises small-scale mills and textile activities in the rural areas. It includes hand spinning, hand looms, power looms (including looms for weaving (viscose, rayon, filament yarn), knitting, chemical processing and so on). Within each of these subsectors, the individual units can span a wide range of size, output, turnover, technical competence and, to some extent, level of technology.

For the most part, the textile industry in developing countries has yet to adopt the most recent technological developments. Production is generally restricted to conventional technology; machinery incorporating the most modern advances must be imported. In view of the high cost of imported machines and the high levels of import duties, imported technology is very often too costly for most factories, although individual ones with specialized production patterns may find certain imported technologies attractive. The upkeep and operation of modern machinery are also likely to pose problems in many mills, although there is a sufficient number with the necessary competence and skills.

At the same time, the productivity levels in the organized sector are low, even when allowances are made for the overall level of technology, low machine utilization as a result of raw material shortages, power cuts and labour unrest. However, a more important factor is that the machinery in many mills is old and obsolete. However, while modernization is urgently needed, it does not imply only changing over to more advanced technologies. The replacement of machines that are in poor mechanical condition or in need of renovation (that is, converting existing machines for higher productivity) is a more realistic and feasible approach.

The decentralized sector is even more heterogeneous. The definition of the decentralized sector is largely based on the scale of production and does not always take into consideration the technological factors. Thus, in the knitting sector, there are warp and circular knitting machines which represent a fairly high level of technology. Similarly, between the organized and power loom sectors, there is no basic difference in the level of technology.

At the other extreme, the decentralized sector continues to employ techniques which have remained unaltered over decades if not centuries; hand spinning, hand weaving and block printing are some typical examples. It would be erroneous to equate the decentralized sector with outmoded technology.

Recent technological developments in spinning, weaving and finishing are outlined in the papers contained in this monograph. Developing countries need not adopt the most modern and sophisticated technologies; they have a wide range of alternative technologies and machinery to suit their own factor situations and markets. A judicious exercise of choice is called for.

Economies of scale fall into two distinct categories: first, there are those that arise from the possibility of organizing the manufacturing process more efficiently when the volume of output increases, but without the processes themselves undergoing any fundamental change. Machinery and equipment are available in a limited range of sizes, and sometimes even the minimum size may have a productive capacity greater than required. It is rarely possible to balance the productive capacity of equipment at each of the many stages of manufacture, and there will always be idle machine time. As the installed production capacity grows, however, there is a reduction in the proportion of machine time which must be idle, even when the plant as a whole is operating at maximum output. Larger machines, with a larger output, need not require more operators. Economies can be expected in respect of machine maintenance, stocks of spare parts and so on.

Decentralized spinning

In the textile industry, the weaving part is already decentralized, and technological alternatives are available and in use. There is also a gradual upgrading of technologies, and appropriate production scales are employed. However, there is a lack of proper technology for decentralized cotton spinning; the existing technologies for spinning yarn are centralized.

Many types of looms are available from traditional to improved varieties to semi-automatic power looms, together with dobby and Jacquard arrangements to weave more complex pattern cloths. Given the parity in the cost of yarn both qualitatively and economically, the hand-loom weavers in rural cottages can withstand the competition of mill production. Some reduction in the cost of various ancillary operations, such as beam-winding, sizing, reeling, dyeing and calendering, are no doubt needed, but again no great technical problem is involved: it is more an organizational problem of getting groups of weavers to come together and make collective use of machinery that is already available but which has a minimum operating capacity that is more than sufficient for an individual weaving family.

If a breakthrough could be made whereby technologically sound and economically viable decentralized cottage spinning could be evolved, the textile industry in the developing counntries could be decentralized considerably. The economic conditions of the cottage weavers, where they still exist, as in India, could be improved from the subsistence level to a viable level.

If these weavers could be supplied yarn at the same price at which it is available to the mills, with greater surety of supply, their incomes would increase and they could be in a position to satisfy their financial and other needs for future development. The only solution appears to be to develop a spinning technology in villages, preferably within the weavers' families, so that much of the marketing and transport expenses of yarn could be avoided. These efforts would further create approximately one million new jobs in rural areas in India.

Technology of finishing

Since finishing is primarily concerned with enhancing the visual and ornamental appeal ot textiles, it must respond, more than any other branch of textile production, to the constantly changing demands of fashion and taste. The introduction of man-made fibres has been accompanied by new dyes, auxiliaries and machinery especially suited to them Similarly, the growing popularity of knit fabrics has initiated special finishing techniques such as jet dyeing. Cotton finishing has also undergone significant changes to meet the strong competition of man-made fibres. Wash-and-wear and durable-press finishing of cotton fabrics have been developed in an attempt to match the easy-care performance of man-made fibres. The increasing concern about fire hazards of textiles and pollution has resulted in legislative measures for safety. These steps have in turn catalysed new developments in finishing, of which fire-retardant finishing, solvent processing and transfer printing are some major examples.

As with the technologies of yarn and fabric manufacture, finishing technology has also undergone changes towards higher speeds and continuous processing. Continuous bleaching and dyeing have been widely accepted. Machine speeds in many of the finishing operations have also substantially increased, so that the total time required for fabric finishing is far less than it was a couple of decades ago.

A large number of the composite mills have their own processing facilities. In addition, some of the spinning mills carry out yarn bleaching and dying on a limited scale. In recent years there has been an appreciable increase in the volume of finishing, particularly in dyeing and printing.

Most mills process only their own fabrics. The processing of fabrics produced in other mills is not common, even though surplus machine capacity is generally available. Large and independent process houses with modern machinery, which buy cloth for finishing or undertake contract finishing, are, however, increasing steadily.

The organized sector has been quicker to introduce the more recent developments in finishing compared to spinning and weaving. Some of these such as high-pressure continuous bleaching, jet dyeing and rotary screen printing are in regular use in a number of mills. The value added in finishing being substantially greater than in spinning or weaving, a versatile range in finishing enhances the profitability of mills. This consideration perhaps explains the relatively quick adoption of the more recent developments. The textile machinery manufacturing industry in India, for example, has been prompt to establish manufacture of several modern machines.

The problems in comparing different technologies are less severe in the case of printing than in the case of spinning, weaving or knitting. Although the various methods differ with respect to styling possibilities, intricacy of pattern, clarity and the like, there is adequate common ground for comparison. It is seen that hand screen printing compares favourably with the other technologies in terms of labour cost. The advantages of hand screen printing will be even greater in the short run. This technology is also labour intensive. It should be noted, however, that space requirements for hand screen printing are considerably higher than for other techniques. The cost of land and building will add to the capital requirements; these have not been included in the present analysis because they vary significantly from region to region.

III. RESEARCH AND DEVELOPMENT

Research and development (R and D) for the benefit of developing countries is needed in many areas; these are some of them:

(a) Development of domestic spinning machinery;

(b) Improvement of the aesthetic and performance characteristics of cotton-containing products through appropriate manufacturing processes and product modifications (including the use of blends or admixture with man-made fibres) to meet market demands;

(c) Improvement of quality of cotton-containing textile products, both woven and knitted, as it affects:

"Easy-care" performance (structure, finishes, application procedures, optimum blend ratios)

Shape retention and dimensional stability

Durability (especially in conjunction with modifying processes)

Launderability and ease of drying

(d) Minimization of the problems caused by impurities in raw cotton (ginned lint);

(e) Improvement of the quality of batik by mixing 20 to 25 per cent high-quality wool to the cotton content;

(f) Development and evaluation of processes and processing systems for making cotton-product manufacture more economical.

IV. POLICY

Textiles, being the oldest industry, has been the concern of policy-makers in both developing and developed countries. The developed countries want to protect their industries against the competition of textile imports from developing countries. The developing countries, on the other hand, want to modernize their organized sector and develop their competitiveness in the world market. The problem at the national level is therefore to reorient and restructure the textile industry not only to produce better products but also to develop industrial units that would fulfil the socio-economic objectives of promotion, of employment opportunities and redistribution of income. The question to be considered therefore is how to find the best technological solutions, as in the use of decentralized spinning at competitive levels to meet domestic requirements. This does not imply that developing countries should not adopt the most modern processes, particularly in areas such as knitting, which is making inroads into weaving and in areas where export potential exists. The entire question of harmonious integration of textile production should be looked into more closely, especially since there is a whole range of alternatives in spinning, weaving and finishing, as well as alternative production scales. With these considerations in mind, the following policy-level actions are suggested:

(a) The fiscal and development policies of the Government are the most powerful tools for shaping the future pattern of growth. Formulation of a long-term and comprehensive policy is necessary. The policy should cover raw-material supply, targets, time schedules, alternative approaches, the role of other manufacturing sectors and the role of co-operating organizations;

(b) A higher utilization of the existing capacity in the organized sector should be striven for. Government, management and labour must take concerted action to remove the impediments to higher utilization. Judicious renovation and modernization, correction of imbalances in existing capacity and stricter machinery maintenance are all steps that, by themselves, would generate a substantial volume of the additional production required to meet increased consumption. They should therefore, receive priority over capacity expansion;

(c) The aim of government in the developing countries is to modernize the textile industries and increase productivity. However, any import of textile machinery must fall in the group of machines that will increase productivity in the context of appropriate technology and labour and yet be acceptable under protective import rules and regulations;

(d) The technology of the textile machinery manufacturing industry in the developing countries, although apparently not producing the high-speed, fully automatic machinery currently used by the developed countries, is nevertheless filling the most important gap and mainly producing machinery and equipment suited to the requirements of the developing countries. It is therefore suggested that Governments should encourage this sector to introduce technological innovations but at the same time produce machinery appropriate for use in the dispersed sector;

(e) Technologies of knitting and garment-making that combine a fair degree of mechanization with labour intensiveness can be advantageously used for meeting the internal demand and for exports. Facilities for expansion of these segments should be created;

(f) In most developed countries, wastes of cotton, wool and rayon, blended or otherwise, are used in the production of non-woven fabrics. A full-scale market survey would be useful to evaluate the possibilities of doing the same in the developing countries;

(g) The technology in the decentralized sectors must be improved. This area has not received sufficient attention, and efforts so far have been unco-ordinated. The objective should be to enhance labour productivity and product quality with only marginal increases in capital costs. Favourable features of the more advanced technologies can be adapted to suit the requirements of this sector.

Financial and credit policies, including incentives and concessions for the decentralized sectors, are needed;

(h) Governments should be made responsible for encouraging the development of a wide range of ancillary industries and contributing to the growth of decentralized production by making available expertise in technnology and management to small-scale and cottage-industry sectors;

(i) The growth of the small-scale and cottage-industry sectors has been slow mainly for want of satisfactory marketing arrangements for their products and a lack of raw materials. Measures such as purchase preference and reservation for exclusive purchase by government departments and by public-sector undertakings should also be used to support the marketing of these products.

Report of the Working Group

INTRODUCTION

Basic issues

It is generally agreed that the textile technology appropriate to large-scale operations in the urban sector may not be so appropriate to small-scale operations in the rural sector. There is, however, no general agreement as to the precise extent of this difference. Some think that the urban sector should as far as practicable use sophisticated, capital-intensive equipment and the rural sector, mainly labour-intensive equipment. Others think that extreme labour-intensive technology such as found, for example, in hand looms is no longer economic in any circumstances; still others are sceptical about the relevance of shuttleless looms to developing countries. There is also an implied difference of opinion as to how far these sectors should be complementary or self-sufficient. Some think that whatever can be manufactured by small rural industries should be reserved for them, others that the rural sector should make maximum use of the intermediate products of the urban sector, while still others think that, by a suitable redesigning of machinery, the rural sector can be made virtually self-sufficient.

Examining these differences in detail, the first point that requires clarification is what is meant by "appropriate". In general, the evaluation of alternative technologies made in the background papers relate to commercial profitability, although information on investment requirements and on employment is also given so that the commercial criteria can be qualified to some extent.

It might be useful here to consider the skill requirements of the various technologies, as there appears to be no consensus on this point Machines are becoming increasingly automated, thus requiring decreasing skills to operate them. That is perhaps the reason why the gap in machine efficiency between developing and developed countries diminishes when more sophisticated technology is used. Even among non-automated processes, the more advanced technology can be simpler to operate than the less advanced. Thus, open-end spinning is more easily managed than ring frames. On the other hand, while the number of maintenance engineers is limited, a higher level of education is still thought necessary on more sophisticated equipment than when less sophisticated machines are used.

Given the desirability of taking into account social considerations in evaluating technologies, the question arises of how to make a technology that is both socially and commercially attractive. Two complementary approaches have been advocated. First, it is practicable to improve the commercial attractiveness of labour-intensive technologies by concentrating on the processes that are the least disadvantageous, for example, hand-loom weaving, and by obtaining the yarn from either the urban sector or a co-operative spinning facility established for the purpose. Such improvement can also be achieved by designing appropriate machines. Thus, for example, the Appropriate Technology Development Association (ATDA) of India estimates that a small-scale spinning plant can be established at only 45 per cent of the cost per spindle of a large-scale one. Secondly, some feel that workers in the rural sector should accept lower incomes and levels of social services to the extent necessary to make small-scale technology commercially attractive, while others feel that the rural sector should be protected if necessary and that it might be useful to consider the various possibilities open to the Government for this purpose.

The modern versus the traditional sector

It is convenient to characterize the textile industry in terms of the degree of mechanization and the scale of operations. Normally, both criteria would work in the same direction so that the modern sector would be mechanized and of large-scale, while the traditional sector would be non-mechanized and small in scale.

The foregoing connotations of modern and traditional are used in the present report, although hard-and-fast definitions are difficult to find, and in this regard there are, as usual, exceptions. Thus in some cases, power looms and knitting machines may be found in small units. Where this happens it would usually be convenient to regard them as belonging to the traditional rather than to the modern sector.

Most developing countries have modern and traditional sectors in their textile industries, although the extent to which the modern has encroached on the traditional sector varies. Some Governments have had to take account of the relationship between the two.

I. ALTERNATIVE TECHNOLOGIES

Technology is construed in the broadest sense as the relationship between all inputs (including those of management) and outputs. Compared to others, an appropriate textile technology should:

(a) Be economically viable by commercial criteria or by a social cost-benefit analysis or both. Should these two measures of viability conflict, social cost benefit would normally prevail;

(b) Make less demand on scarce capital;

(c) Provide more employment;

(d) Contribute as much as possible to increasing income equality and improving the urban/rural economic and demographic balance;

(e) Be flexible and able to accommodate different types of fibres and yarns and to manufacture products for both the domestic and export markets.

A thorough application of these criteria would, through the use of cost-benefit analysis, automatically allow for such factors as the desirability of using local materials and conserving foreign exchange. Cost-benefit analysis provides considerable scope for flexibility, so that decision-makers can, for example, attach a high premium to employment should circumstances seem to warrant this. Nevertheless, the generation of a real financial surplus is an objective that should be kept in mind. While these criteria are generally applicable, the choice of an appropriate technology could be made only on the basis of country-specific variables. In this sense, appropriate technologies could range from the simplest to the most recently developed equipment in the spinning, weaving and finishing stages of the industry. The range of technology choice can be increased further by adding composite technologies comprising various technically independent alternatives available at the subprocess level.

In the modern sector, although economies of scale are more important in the preparatory stages of yarn and fabric manufacture, it is at the final stages that capital costs and employment are greatest. In the production of yarn, two alternatives are available for spinning: open-end (break) and ring spinning. In weaving, the three principal options are ordinary, conventional automatic shuttle and shuttleless looms. In knitting, the alternatives are flat, circular and warp knitting. The finishing process is more difficult to describe briefly.

In the traditional sector, hand spinning and hand weaving can still be used. Hand spinning is less prevalent than hand-loom weaving and is largely to be found in India, where nevertheless it still accounts for less than 1 per cent of total yarn production. In weaving, a wide range of looms are in use, from the very old pit loom to the fly-shuttle loom.

Notwithstanding the wide range of possibilities, the choice of such modern equipment and processes as the shuttleless loom, open-end spinning and continuous finishing would in many countries give rise to certain difficulties in the modern sector. Generally speaking, the most modern equipment is complex, with built-in control systems. These, in turn, need instrument engineers, who are in extremely short supply. The need for mechanical engineering is reduced consequently there is less scope for training mechanical engineers. The machines are more sensitive to variations in raw materials and ambient conditions than, for example, automatic looms and ring-spinning frames. In addition, shuttleless looms and other recently developed equipment have not been sufficiently widely used in developed countries to permit objective evaluation of the claims made by their manufacturers, so that they are, in this sense, relatively untested. On the other hand, modern equipment requires less skill to operate than traditional equipment.

Ring-spinning frames, automatic looms and other equipment of given technical specifications can be obtained from, countries in Northern America (United States of America), Asia (China, India, Japan) and Eastern and Western Europe. Equipment originating from developing countries is normally less sophisticated and less costly than that from developed countries. Developing countries might find it economically more efficient to use the new sources of supply rather than the traditional ones.

Low productivity is a major problem in many developing countries. It is sometimes argued that the introduction of very modern technology would serve to increase it. Technically speaking, there is some truth in this. It is necessary, however, to recognize that economic considerations must also be taken into account. Moreover, a mere change of technology will not, of itself, remove all the causes of low productivity. Thus, serious efforts should be made to increase the productivity of present technologies so as to deal with the underlying problem.

II. POLICY

Governments should have a well formulated long-term textile policy that covers both the modern and traditional sectors and takes into account the complementarity and competitiveness of the two sectors. To pursue this objective there must be a mechanism for the collection and dissemination of information relating to alternative technologies.

The modern sector

The question of appropriate technology applies as much to the modern sector as to the traditional, so that the criteria for identifying an appropriate technology are relevant to the choice of technology in this sector as well. It should be noted that the variation in profitability between modern technologies is often narrow when compared with the corresponding variation in investment cost and employment. This means that the economic incentive to choose the most capital-intensive (least labour-demanding) technology is not unduly great.

The traditional sector

Among the questions relating to policies in this sector are the following:

(a) Institutionalized arrangements to extend on-the-spot consultancy, training and technical services;

(b) The formation of co-operatives to reduce the present and almost crippling vulnerability of the sector in raw-material procurement, finance and marketing;

(c) Methods of efficiently securing and supplying yarn of suitable quality at lower cost to the traditional sector;

(d) Rationalizing government procedures with respect to the sector.

There are important elements in national policies that apply more or less equally to both sectors. Thus, fibre policy should be an important part of overall policy. Cotton is grown in many developing countries and plays an important part in their economies. Nevertheless, in recent years, synthetic fibres have made inroads into areas previously dominated by cotton, and allowance should be made for this fact. Basically, each country should decide for itself what proportion of its future fibre consumption will be met by synthetic fibres and choose equipment accordingly.

Another consideration applicable to both sectors is that of ensuring an adequate and continuous supply of spare parts. The cost of holding an ample supply of spare parts can often be less than the cost associated with production lost when spare parts are not locally and immediately available.

If free competition prevailed between the modern and traditional sectors, it is likely that the traditional sector would be quickly eliminated. This suggests that the first policy question relating to both sectors considered together is whether to permit the traditional sector to survive. If the answer is yes, the next question is how its survival is to be achieved. At present, this is done by designating certain products for exclusive manufacture in the traditional sector and by a series of fiscal and other incentives. The justification for these measures is most commonly the preservation of employment. This is an important objective but, it is extremely important that measures designed to preserve the traditional sector should also be designed to stimulate dynamism and increase productivity in it. Even when product reservation is practised, there are normally links between the modern and traditional sectors, since the yarn used in the traditional area is frequently supplied by the modern sector. In this sense there already exists a supplier-user relationship between the two sectors; it is in the interest of both to develop this relationship and make it as intimate and harmonious as possible.

The use of appropriate technology in both sectors should increase the price advantage of their products in foreign markets. Some products in the traditional sector often have considerable appeal in developed countries; this should be exploited to the fullest possible extent. Since the technology policy of developing countries affects production for both domestic and international markets, this policy should not be seen in isolation from the trade policies of the developed countries. Thus, given this link between technology choice and exports, it is doubly important that the developed countries be discouraged from their present practices, which make textiles among the most sensitive imports.

III. PROGRAMME OF ACTION

In countries where the textile industry is of sufficient size and importance, textile research institutes should be established. Where the size of the national industry is not yet sufficient for this, such institutes should be established on a subregional or regional basis. The functions of these institutes should be to advise the Governments and industries on the choice and import of technology and raw materials; to provide technical services, including those of testing raw materials, intermediate inputs, final products and, to the extent possible, machine performance; to provide consultancy services to the Government and industry; and to conduct techno-economic research.

In order to assure the close links between the institutes the industry and the Government, the institutes should be financed by the industry and Government themselves and only initially by external contributions. In this regard the Indian experience, where a number of co-operative textile institutions have been functioning successfully for several years, is encouraging.

The institutes should be staffed by well-qualified personnel. For an initial period this may involve the use of expertise from developing and developed countries, and should certainly involve the systematic training of appropriate and qualified nationals. The institutes should be dynamic bodies; the relative weights assigned to their various roles should be allowed to change with time.

The existing and proposed institutes should apply themselves to the traditional as well as to the modern sector. Much of the work of existing institutes has been directed towards the problems of the modern sector, although in India a number of activities that relate to the traditional sector are under way. These include modifications to the *ambar charkha* and the hand loom; the development of scaled-down machines for use in the various stages of spinning and the development of new products that can be manufactured in the traditional sector.

Given the importance of cotton and the increasing threat to it from synthetic fibres, it is important that appropriate R and D be undertaken to strengthen its relative position.

In view of the differences in levels of development among developing countries and the links between such levels and appropriate technology, much could be gained from systematic examination of the experience of countries at various levels.

Because of the underlying economic strength of the modern sector, thought should be given to the location of the industry within that sector.

Some of the areas in which fruitful investigation could be taken up are:

(a) A study of the Indian experience in multiple sectors in order to extract from it whatever might be relevant to other developing countries;

(b) A comparative study of the relative advantages of locating hand looms in the cottages and locating them more centrally in the villages;

(c) A study of methods to reduce the cost of yarn to the traditional sector;

(d) An inter-country comparison of productivity in the traditional sector in relation to the technology employed;

(e) The development of improved finishing machines for use in the traditional sector.

In considering appropriate technology for textiles, the importance of education in the broader sense should not be overlooked. It is necessary to have trained personnel at all levels within the industry. It is also to be expected that improvement in technology, whether modern or traditional, can be accelerated by trained persons. Unfortunately, the courses taught in many developing countries are almost exclusively oriented toward the modern sector and often have a rather academic character.

To provide guidance to decision-makers at various levels, it would be useful to produce and keep up to date a technical memorandum for the textile industry. It should comprise a reasonably detailed description of alternative technologies, economic evaluations of them and a guide to further information, including that relating to equipment supplies.

PART TWO

Selected background papers

Production of cotton with special reference to African conditions

J. Pickett and R. Robson†*

INTRODUCTION

This paper addresses itself primarily to the problem of employment and the related one of designing industrial policies that will contribute to overall economic growth and satisfy basic needs. In this connection, a distinction is drawn between rural and urban areas, the former being areas of relatively low-cost labour, negligible infrastructure and limited local markets, thus being more appropriate for labour-intensive small-scale industry than for large-scale activities.

It is organized in three parts. The first briefly considers world production and trade in textiles and textile machinery, the second gives some details of the structure and character of textile production, and the third analyses the results of economic evaluation and draws policy conclusions from them. One feature of the paper that should be explicitly mentioned is that particular emphasis is placed on African conditions.

WORLD PRODUCTION AND TRADE

The production of woven cotton cloth in developing countries rose from an average annual level of 17.7 billion m^2 in the period 1966–1968 to 19.3 billion m^2 in the period 1973–1975. Over the same years, the average annual woven cotton cloth production in the developed market economies of the world fell from 37.4 to 34.0 billion m^2. As a result of these changes, the share of developing countries in total output rose from 47 per cent to 57 per cent. The share of developing countries in world production of synthetic cloth is much smaller than in cotton textiles. Nevertheless, it also increased from 5 per cent (130 million m^2) to 12 per cent (690 million m^2) in the period considered.

Developing countries accounted for 34 per cent of world exports of cotton cloth in the years 1973–1975, compared with 29 per cent in 1967–1969. In both

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of these periods the developing countries contributed relatively more to exports of grey goods than to finished cloth, the respective shares being 64 per cent and 27 per cent. The share of the developing countries in world exports of non-cotton cloth, including cellulosics, showed little change over the period and was about 13 per cent. Their share of world exports of yarn was about 25 per cent for cotton and 4 per cent for synthetics.

As would be expected, developing countries contributed relatively little to exports of textile machinery–0.9 per cent in 1967–1969 and 1.8 per cent in 1973–1975. They did, however, represent a relatively large market for such equipment; the proportion of world imports sold in such countries rose from 30 per cent in 1967–1969 to 38 per cent in 1973–1975.

THE STRUCTURE AND CHARACTER OF TEXTILE PRODUCTION

The trade figures presented in the previous section reflect the general nature of the textile activities undertaken in developing countries. Finishing is less developed than weaving, while clothing manufacture is growing steadily in importance, largely as a consequence of the relatively high labour-intensiveness of the clothing industry and of the relatively small scale at which it can be conducted efficiently.

The main objective when considering cotton cloth production is to elucidate those characteristics of the structure and methods of production that have a bearing on choices of scale, location and technology. Market size will therefore be considered first, since it is frequently linked to technical economies of scale, and then the relationships between such economies and efficiency will be examined more specifically. Next, machines and processes will be discussed, with brief mentions of the alternatives at each manufacturing stage. This procedure both sets the stage for economic evaluation and facilitates the discussion of policy alternatives.

Market size

The relationship between market and domestic textile industry size is given in table 1.

Although the correlation is not perfect, it is broadly true that the larger the market, the larger the share held by the domestic industry. Thus, for the eleven largest markets, the median share is 66 per cent, and for the eleven smallest it is 39 per cent. There are some anomalies; the proportion in Sudan is low, but there has been considerable development there since 1975; that in Tunisia is high, possibly because of the importance of exports; and the high figures in Chad and the Central African Empire may result partly from the large supplies of locally grown cotton in contrast to the position in, for example, Senegal and Somalia.

TABLE 1. DOMESTIC PRODUCTION AND MARKET SIZE IN AFRICAN COUNTRIES. ANNUAL AVERAGES, 1970/71 TO 1974/75

Country[a]	*Domestic demand for woven cotton and man-made fibre cloth*	*Production of woven cotton and man-made fibre cloth for domestic demand*	*Share of domestic production in domestic consumption*
	Millions of square metres		*Percentage*
Egypt	902 (1)[b]	718	80 (1)[b]
Nigeria	396 (2)	264	66 (2)
Sudan	271 (3)	96	35 (15)
Morocco	133 (4)	86	65 (10)
Algeria	128 (5)	80	62 (9)
Zaire	113 (6)	62	55 (12)
United Republic of Tanzania	102 (7)	78	77 (5)
Ghana (1968–1972)	95 (8)	49	51 (13)
Ethiopia	90 (9)	80	88 (4)
Madagascar	81 (10)	72	90 (3)
Uganda	53 (11)	40	76 (6)
Angola	52 (12)	20	38 (16)
Senegal	50 (13)	9	18 (21)
Mozambique	43 (14)	19	44 (17)
Tunisia	33 (15)	23	70 (7)
Zambia	32 (16)	12	37 (18)
Togo	28 (17)	10	35 (19)
Niger	28 (18)	11	39 (14)
Somalia	26 (19)	3	19 (20)
Chad	20 (20)	12	60 (11)
Central African Empire	12 (21)	8	67 (8)

Source: Yearbook of Industrial Statistics, 1975, vol. 2 (United Nations publication, Sales No. 77.XVII.8) and *Yearbook of International Trade Statistics, 1976*, vol. 1 (United Nations publication, Sales No. 77.XVII.14).

[a]In order of market size.

[b]Rank ordering in parentheses.

Technical economies and efficiency

As a general rule, producing for a small market tends to be uneconomic either because the capacity of certain machines in the production process is too great in relation to the volume of demand for them to be fully utilized or because a sufficient volume can be achieved only by accepting an unduly wide range of products and therefore of short runs. This capacity constraint need not operate uniformly at all stages of the production process.

In textile spinning and weaving, the key machines (spindles and looms) are individually of small capacity; the only large-capacity machines in the entire process are in the opening range of the spinning process and in the warping and slashing stages of the weaving process. Thus, the conventional ring-spinning sequence involves an opening range with a capacity equal to that of 16,000 spindles on 20's counts (or, for a balanced cloth, about 750 automatic looms) and scutchers with half that capacity. The conventional weaving preparation involves a warping machine with a capacity at 50 per cent efficiency, equal to that of about 1,500 automatic looms, and a sizing machine with a capacity of about one half of this.

These figures determine the minimum size of plant necessary to utilize capacity fully. As table 2 reveals, however, the costs of the "constraining" machines are so small in relation to those of spinning and weaving that working at less than capacity could be readily tolerated economically since, when overall capacity is matched to that of the opening line, the relevant proportion is less than 8 per cent. Moreover, even if the spinning and weaving capacity were reduced to one quarter of the level assumed in the table, the spinning and weaving machinery would still cost more than twice as much as the other equipment covered by table 2.

TABLE 2. MANNING AND CAPITAL COST OF CERTAIN TEXTILE MACHINES UNDER MEDIUM-WAGE AFRICAN CONDITIONS

Machine	*Number of machines*	*Capital cost 1976 prices in thousands of dollars*	*Manning*
Opening line	1	200	8
Scutcher	2	80	2
Ring spindle	16 000	1 840	30
Warping	1	80	6
Sizing	1	100	6
Loom	800	4 000	160
Total		6 300	212

In finishing, however, a distinction has existed for some time between continuous-processing and batch-processing machines, the former being of much larger capacity. The roller printing machine has an output, when running, equal to that of about 600 looms, but screen printing and, at a higher level of output, mechanized screen printing are small-scale alternatives. Similarly, the normal dyeing vessel (jig) has a capacity of about 1,000 yd^2 (836 m^2) of cloth, while continuous dyeing at 70 yd^2/min (58.5 m^2/min) has a capacity equal to that of 800 looms, and the modern tenter a capacity equal to that of 1,200 looms.

The actual output of a machine depends on its speed, the time it is running (length of run) and the time required to set it up. For continuous processing machines, high speeds and long setting-up times are the rule. For machine printing, setting-up time, apart from the time needed to engrave the rollers, may range from one to eight hours, according to the complexity of the design, while the average time needed to set up continuous dyeing is about four hours. Long runs are therefore necessary for economic performance, and finishing works are normally associated with large-scale production. Usually, in a large market, a single finishing plant takes the output of several weaving plants, while in small markets where demand may be as little as 1,000 yd^2 (835 m^2) per style, the jig is the standard machine.

The time required to set up spinning and weaving activities is much smaller than that involved in continuous finishing, so short runs can thus be accommodated more readily. In weaving, the warp on a weaver's beam may average 3,000 yd (2,700 m) about 600 loom-hours on automatic looms and 1,000 looms-hours on ordinary looms. These figures indicate the length of the run between drawing-in or knotting the new warps. The drawing-in process, if done manually, might employ two persons for five hours. With Sulzer looms, however, the time for drawing-in is several times longer, although this would be cut by automatic drawing-in. If variety is such that a new-sized warp is required at the beginning of each run, the minimum run is about six times as long, so that, with a setting-up time of 2.5 hours, the normal efficiency of operation would be about 50 per cent.

In spinning, a change of count is a small matter unless a change of roving or, still more, of mixing, is involved. Changes at the winding stage, however, can cause long delays, reducing efficiency to 75 per cent if automatic winders are involved.

The saving of time involved in adjusting machines is only one advantage of long runs. Greater advantages are probably obtained from the reduction in administrative and clerical expenses, which in developing countries average about 10 per cent of total costs, and in the holding of stocks of materials and accessories. More generally, if a high degree of specilization can be realized in the deployment of labour; capital and raw material inputs can be optimized so work loads and incentives can be established and raw material and machine usage can be more closely related to production.

Machine availability

Turning now to machine availability, technical progress in textile machinery (particularly in spinning and weaving) has increased the speed and degree of automation of conventional equipment. The increase in speed has saved capital in some cases, and automation has invariably saved labour, and especially skilled labour, since automated machines may be staffed by relatively unskilled operatives and a few skilled engineers.

Moreover, new techniques of spinning and weaving have been discovered that have greatly increased productivity. Thus, the latest model of carding engine has ten times the output per attendant of the 1955 model and also costs less per unit of output. In spinning, the modern ring spindle has an output about 50 per cent greater than that of 20 years ago, while the open-end rotor on 20's counts costs twice as much as a ring spindle per unit of output but requires only one half the labour input. In weaving, the modern automatic loom has an output for the latest model about 40 per cent above that of 20 years ago and requires 25 per cent less labour, while shuttleless looms have outputs up to three times those of shuttle looms and cost about 50 per cent more per unit of output.

In general, therefore, the choice of machines is between capital saving and labour saving, although in some cases, like that of the carding engines, the modern machine saves both and is therefore more efficient. It may also be the case that, after an initial proving period, some of the more recent developments such as open-end spinning may turn out to have a lower long-term cost of production than more conventional machines. Within the present framework, however, the choice of machine appropriate to a low-wage country would be different from that appropriate to a high-wage one and, similarly, large-capacity machines that might be appropriate to a large market would not be so for a small one. It might also be appropriate to obtain machinery from China or India, where all but the latest high-speed, high-capacity models are available at prices considerably below those of Western suppliers. Moreover, where wages are low and markets small, hand spinning and weaving eqipment also can be reasonably considered.

Textile manufacturing processes

Textile manufacture consists of a number of successive processes, in each of which alternative technologies are available. Limiting consideration to the production of woven cotton cloth, the following stages may be distinguished:

Opening and cleaning of raw cotton

The object of this process is to blend cotton so as to obtain a uniform raw material, remove leaf dirt and trash, open up the fibres after they have been compressed in the bale and deliver a clean uniform product in a suitable form to the next stage. The process begins with the feeding of cotton, which may be manually or mechanically plucked from the bales, and ends with the scutcher, which either forms a lap (which is then either manually or automatically doffed) or chute-feeds the material to the next stage. The modern opening line has a capacity of about 1,200 lb/h (540 kg/h); the scutcher, 600 lb/h (270 kg/h). The small-scale machine used for hand spinning has a capacity of about 8 lb/h (4 kg/h), and the associated lap-formers about 2.5 lb/h (1 kg/h).

Carding

The purpose of carding is to attenuate the lap into a sliver (about 100 draft) and to make the fibres parallel for the next stage. As indicated above, the modern high-production card is the most efficient machine, producing about 70 lb/h (32 kg/h) with a 130-hp (98-kW) motor. The small alternative produces 2.5 lb/h (1 kg/h) and has the usual 0.5-hp (0.4-kW) motor.

Drawing

Drawing evens the sliver. As with the card, the modern draw frame with a production of about 135 lb/h (61 kg/h) is more efficient than its predecessors. An alternative automatic model may be used if it is desired to proceed to open-end spinning, omitting the moving stage. The small-scale frame for use in hand spinning has the usual capacity of about 2.5 lb/h (1 kg/h).

Roving

Roving further attenuates the sliver to about 7 draft. The latest model of roving spindle runs at about 1,300 revolutions per minute (rpm) but a cheaper model at about 1,000 rpm is also available. Hand-powered roving frames are used in hand-spinning systems.

Spinning

There are two main types of spinning: ring spinning and open-end or break spinning. In ring spinning, the roving is further attenuated by roller drafting to the fineness of the yarn required–usually a draft of about 20–and at the same time twist is applied to give the yarn the necessary strength. Full bobbins may be manually or automatically doffed. The maximum speed of the spindle is about 15,000 rpm. In open-end spinning, the sliver from the draw frame is broken into its constituent fibres within the spinning vessel (rotor), which revolves at about 50,000 rpm. Both systems may also be used in hand spinning, but speeds are lower, averaging about 4,000 rpm and about 12,000 rpm respectively.

Cone winding

Cone winding facilitates subsequent processing by rewinding yarn on to a large package and removing faults. Three alternative machines are available, all running at about the same speed of 1,000 to 1,250 yd/min (915 to 1,140 m/min) but differing widely in degree of automation from manual to advanced, which feeds ring tubes and automatically pieces up breakages.

This stage is not necessary for hand spinning, which does not benefit from rapid processing, and it is not strictly necessary in open-end spinning, since the spun package is already large enough. Again, if yarn can be spun on a small package that can be used directly in the weaving shuttle, rewinding of the weft may be avoided.

Warping

The warping step assembles the warp threads in a form suitable for sizing and drawing into the loom. As indicated above, the modern beaming machine is a high-capacity one that can handle about 7,000 yd/h (5,850 m/h) but is more efficient than its predecessors. For hand weaving, a warping machine of about 15 yd/h (12.5 m/h) capacity can be obtained.

Slashing

After warping the yarn is sized to reduce breakages at the weaving stage. The capacity of the modern slasher sizing machine is about 3,500 yd/h (3,200 m/h) although a less efficient machine would be equally satisfactory if neither were used at full capacity. In hand-weaving operations, hand sizing is used.

Drawing-in

The drawing-in of the sized warp threads through the heddles, reeds and drop-wires of the loom may be done either manually by a pair of workers drawing some 480 ends per hour or by one worker with a reaching-in device, or automatically at about 1,200 ends per hour.

Pirning

The pirning operation consists of winding the yarn on to a package suitable for insertion in the shuttle of a loom. It is unnecessary for shuttleless looms or where direct spinning is possible. There is a choice between semi-automatic and automatic machines, the latter having automatic feed. The small-scale hand-powered machine used for hand looms operates at about 80 yd/min (73 m/min) compared with 1,000 yd/min (914 m/min) for power winding.

Weaving

The main choice at the weaving stage is between shuttle looms and shuttleless looms. Shuttle looms range from hand looms through non-automatic power looms to automatic looms, the progression being towards more automated, labour-saving and capital-intensive machines. Within the automatic looms class there are a number of alternative models varying in speed and ease of operation. Accessory labour-saving devices such as box and unifil are also available.

At present there are three types of shuttleless looms: projectile (Sulzer), rapier and air-jet. They are all considerably faster than the automatics and cost more, resulting in considerably lower labour-cost but somewhat higher capital requirements per unit of output.

A complete manufacturing profile involves one technology from each of the stages outlined above so that the total number of possible profiles runs into thousands.

ECONOMIC EVALUATION AND POLICY CONCLUSIONS

The large number of technological profiles mentioned above forms the set from which particular alternatives may be selected in the pursuit of particular industrial, economic and social objectives. In order to make such a selection, however, two interrelated things are required: additional, principally economic information, and a method of evaluating the alternative technologies. Moreover, given what has been said earlier about the importance of the economic surplus, evaluation should at least initially be made to turn on profitability. Once alternative technologies have been thus evaluated, it becomes possible to consider policy questions in an informed way. In the light of the foregoing, it seems logical to organize the following section in three parts covering additional information, evaluation and policy conclusions.

Additional information

In order to select the least costly technology, it is necessary to know both the operating costs, including wages, materials and power, and the capital costs, including machines, buildings and working capital. Since these cost elements vary from country to country, it would be very difficult to arrive at firm results that would be valid for all developing countries. Consequently, it would seem more useful to extrapolate single-country findings to a region rather than make international generalizations across regions and, on this basis, to limit consideration to Africa.

Africa is, in general, a low-wage region with a *per capita* gross domestic product (GDP) of less than one third of that of Latin America. According to United Nations industrial statistics, earnings *per capita* in the textile industry in 1974 ranged from about $450 in Ethiopia and Kenya to about $1,000 in Ghana and Egypt. Comparable figures for Hong Kong and India were $2,350 and

$550, respectively. To lend even wider perspective to the figures given for Africa, those for Mexico ($3,000) and the United States ($7,000) may be cited.

These limited statistics illustrate the well-known fact that Africa is not a homogeneous region. In order, therefore, to increase the specific content of the evaluation to come, it is useful to take two African countries that are representative of the two wage régimes identified above. These, in the light of the international range, may be described as medium-wage and low-wage areas respectively.[1] Selection on the basis of wage régime is justified, that is, made usable by the fact that, as shown in table 3, there is a broad correlation between wage levels and productivity.

TABLE 3. ESTIMATED PRODUCTIVITY PATTERNS IN TWO AFRICAN COUNTRIES, 1976 (UNITED KINGDOM = 100)

Item	*Medium-wage country ($15 per hour)*		*Low-wage country ($6.67 per hour)*	
	Spinning	*Weaving*	*Spinning*	*Weaving*
Output per unit	90	90	85	90
Units per operative	36	47	16	25
Output per operative	32	42	14	22
Annual wage cost	47	36	47	30

Two observations should be made. First, the units involved in table 3 are ring spindles and automatic looms of modern design, of about 1965 vintage, and the staffing is comparable with practice in the United Kingdom. Second, even though the sample is small, there is some variation around the average. In particular, one firm in three investigated in the medium-wage country, with good management and air-conditioning and located favourably with regard to labour, was able to operate at levels of productivity comparable to those in the United Kingdom.

An important characteristic of wage rates in African countries is that, as shown in table 4, the earnings of unskilled labour are relatively low and those of skilled labour relatively high, within the overall wage structure, in comparison to a developed market economy such as that of the United Kingdom.

TABLE 4. RELATIVE WAGE STRUCTURES IN TEXTILE PRODUCTION IN TWO AFRICAN COUNTRIES AND THE UNITED KINGDOM

Type of labour	*United Kingdom*	*Africa*	
		Medium-wage country	*Low-wage country*
Unskilled (labourers etc.)	80	65	60
Semi-skilled (machine tenders)	100	100	100
Skilled (mechanics, clerks)	125	150	160
Supervisory	150	200	200

[1]For a fuller account of the operating conditions in the two countries, see J. Pickett and R. Robson, "A note on operating conditions and technology in African textile production", *World Development*, vol. 5, No. 9/10 (1977).

This phenomenon also applies to administrative salaries, partly because of the importance of expatriate management in Africa.

Turning now to capital costs, Africa is entirely dependent on imported machinery. It is estimated that freight and insurance adds about 10 per cent to free on board prices where coastal locations are concerned and a higher percentage for interior locations. In addition, installation costs can add a further 5 per cent.

Building costs, which usually involve imported steel and other components, are also relatively high (quotations of about $15 per square foot ($161 per square metre) for a good single-storey steel structure were obtained in 1976). In addition, electrical and plumbing equipment, air-conditioning, boiler house and workshop can amount to more than the cost of the building or, with the building, about one half the cost of the textile machinery installed. Working capital is important because of the need to keep adequate stocks of materials and spare parts–normally at about twice the levels maintained in developed countries.

It should be clear that the purpose of this discussion of additional information on African costs is not to cover all operating and capital costs exhaustively, although these are included in the evaluation of technologies; rather, it is to concentrate on the more obvious costs and those most likely to influence technology choice. It is the purpose of this discussion to highlight some of the difficulties that must be overcome in the design of a basic needs (or indeed any systematic) strategy of industrial development.

Evaluation of profiles

To identify the lowest-cost technology it is necessary to combine capital and operating costs, and this involves a decision on the expected return on capital. It has become almost customary to use a discount rate of 10 per cent for this purpose; annual receipts and costs are discounted at 10 per cent over the life of the plant to give the net present value (NPV), which is generally accepted as the appropriate measure of the surplus. Projects are approved which have an NPV greater than zero. This rate should be applied to real costs and real receipts, but if it is assumed either that prices will be constant or that all will increase in step, then current prices also may be used for the selection of projects on a commercial basis. For most developing countries, however, it might be that 10 per cent is too low, considering the shortage of capital and that only projects which pass at a 20 per cent rate should be accepted.

As noted earlier, the major stress of this paper is the relations among technology, costs and employment. This may be comprehensively illuminated by considering four of the many possible alternatives: hand spinning and weaving; and three types of power spinning and weaving, namely production on non-automatic looms and ring spindles, on automatic looms and ring spinning and on Sulzer looms and open-end spinning. Some figures are provided in table 5 for a low-wage African country. Capital costs and operating costs are grouped into four sections; spinning, preparation, weaving and administration. It will be noted that, where technologies are the same, the minor differences in cost result from levelling up to the same output.

At the spinning stage the capital cost of open-end spinning is about $1.5 million higher than ring spinning but saves about $200,000 on annual cost. Combining capital and operating costs at 10 per cent discount present value of costs (PVC) for open-end spinning comes to $75.75 million and for ring spinning $75.63 million, which is a negligible difference that partly results from lower cotton consumption, which should be offset to some extent by sales of waste. At 20 per cent discount, however, the gap widens, the relevant figures being $45.8 million for open-end and $45.1 million for ring spinning.[2]

At the weaving stage there are much greater differences in investment, the capital cost of Sulzer equipment being about twice that of automatic looms and about 10 times that of non-automatic, but differences in operating costs are lower. Discounting at 10 per cent, the PVC is lowest for three-width automatic weaving ($13.66 million) and then, in order, non-automatic ($14.37 million), Sulzer ($15.16 million) and, finally, single-width automatic weaving ($16.43 million). At a 20 per cent discount rate, non-automatic looms become the cheapest. At the preparation stage, shuttleless looms (Sulzer) gain slightly because no pirning is necessary.

TABLE 5. CAPITAL AND ANNUAL OPERATING COSTS AND MANNING REQUIREMENTS FOR THE PRODUCTION OF 28 MILLION SQUARE YARDS[a] OF COTTON CLOTH PER ANNUM IN A LOW-WAGE AFRICAN COUNTRY

(Thousands of 1976 dollars)

	Technology			
Stage or activity	*Open-end spinning and Sulzer weaving 3-width*	*Ring spinning and automatic weaving 3-width*	*Ring spinning and automatic weaving 1-width*	*Ring spinning and ordinary looms*
1. Up to and including spinning				
Capital				
Machinery	4 949	3 471	3 428	3 428
Buildings	604	671	663	663
Working	179	205	203	203
Operating costs				
Labour	136.0	229.2	226.3	226.3
Power	172.5	160.8	158.8	158.8
Maintenance	178.5	205.3	202.7	202.7
Cotton	7 740.8	7 893.4	7 795.2	7 795.2
Number of employees	247	547	540	540
2. Preparation				
Capital				
Machinery	1 140	1 361	1 344	1 344
Buildings	320	322	318	318
Operating costs				
Labour	124.8	142.9	141.1	141.1
Power	0.5	0.5	0.5	0.5
Maintenance	43.8	52.7	52.0	52.0
Number of employees	234	276	273	273

[a]Sales of waste are not included.

TABLE 5. *(continued)*

Stage or activity	*Technology*: *Open-end spinning and Sulzer weaving 3-width*	*Ring spinning and automatic weaving*: *3-width*	*Ring spinning and automatic weaving*: *1-width*	*Ring spinning and ordinary looms*
3. Weaving				
Capital				
Machinery	7 600	3 056	3 978	733
Buildings	620	1 096	1 015	1 075
Working	3 040	3 064	3 065	2 850
Operating costs				
Labour	141.2	422.6	567.0	1 031.2
Power	63.1	111.6	157.9	66.9
Maintenance	253.5	233.5	259.1	44.0
Number of employees	264	801	1 119	1 896
4. Administration				
Buildings	3 000	3 000	3 000	3 000
Labour	650	650	650	650
Utilities	246	246	246	246
Materials	120	120	120	120
Number of employees	500	500	500	500
5. Total				
Capital				
Machinery	13 689	7 888	8 750	5 505
Buildings	4 544	5 089	4 996	5 056
Working	3 219	3 269	3 268	3 053
Operating costs				
Labour	1 052.0	1 444.7	1 584.4	2 048.6
Power	482.1	518.9	563.2	472.2
Materials	7 860.8	8 013.4	7 915.2	7 915.2
Maintenance	475.9	481.5	513.8	298.7
Number of employees	1 245	2 274	2 432	3 209

[a]23.6 million m^2.

In the light of the concerns of this paper, it is necessary to redirect attention from technology to investment costs, profitability and employment. This is done for the three modern technologies in table 6.

The differences in PVC are small, but the differences in employment are large and those in investment costs not negligible. At both discount rates, the ring spinning and ordinary loom technology would be the economically efficient choice. It would also have the lowest investment cost and provide the most employment. At the medium-wage level, the weaving wage cost would be increased by 20 per cent. This would be sufficient to make Sulzer weaving the lowest in cost, the PVC figures for the technologies in the order of table 6 being: $105,890,000, $106,210,000, $108,210,000 and $106,620,000. The association between wage levels and productivity would affect capital costs and employment but not sufficiently to invalidate the first sentence of this paragraph.

TABLE 6. PVC, INVESTMENT AND EMPLOYMENT FOR THREE TECHNOLOGIES IN A LOW-WAGE AFRICAN COUNTRY

Technology	*PVC* 10 per cent	*PVC* 20 per cent	*Investment*	*Number of employees*
	Millions of 1976 dollars			
Open-end spinning and Sulzer weaving	105.45	69.52	21.45	1 245
Ring spinning and automatic weaving				
3-width	105.25	67.18	16.25	2 274
4-width	107.02	68.52	17.01	2 432
Ring spinning and ordinary looms	104.97	65.89	13.61	3 209

The advantage of non-automatic weaving depends on the skill of the operatives and, although the rates taken for a low-wage area are representative (nine looms per weaver for automatic looms and two for ordinary looms), there is more risk of output falling below target in ordinary loom weaving both in quantity and quality. On the other hand, administrative charges might easily be lower than shown in table 5, since a simple factory building and no air-conditioning might be adequate.

Turning now to the effect of scale of operation on the profitability of the various technologies, if the scale of operation were doubled, nothing much would happen in regard to costs. Probably the only saving would be at the warping stage, which would then be fully occupied. Moving to progressively lower levels of output, however, leads to significant changes. These come partly from administration where, broadly, a reduction in scale of operation by one half will reduce administrative costs by only one quarter, so that administrative costs per unit will rise by one half. Furthermore, the technical factor becomes steadily more important; as soon as output falls below 28 million yd^2/a (23.4 million m^2/a), the opening line can no longer work to capacity on three shifts, and this is soon also true for warping and slashing equipment. To varying degrees, this may be offset for a time by using less productive techniques. It may thus be possible to use cheaper although less efficient machines at the warping and sizing stages, and at the drawing-in stage, automatic processes can be replaced, first by reaching-in mechanisms and eventually by hand methods. Because of the low capacity of individual spindles and looms, these processes are only affected at very low scales of output. Below 50 looms or so, however, staffing becomes difficult, and eventually shift work would have to be abandoned. Assuming that labour can be deployed uniformly so that an hour's work results in an hour's pay, the position at this low level of output, that is, about 1.75 million yd^2/a (1.45 million m^2/a) is shown for ordinary looms, together with that for the "standard" level of output, in table 7.

More use will be made of the data of table 7. Here, it suffices to note that moving to the smaller scale increases the PVC/yd^2 by 44 per cent, largely because of the cost increases in the first and last of the four stages covered in the table.

Below the level of output just discussed, capital costs would be unchanged

TABLE 7. ANNUAL PRODUCTION ON ORDINARY LOOMS AT TWO LEVELS OF OUTPUT IN A LOW-WAGE AFRICAN COUNTRY

(Thousands of dollars)

Stage or activity	*28.1 million yd^2*				*1.75 million yd^2*			
	Capital cost	*Operating cost*	*PVC ($/$yd^2$)*	*Number of employees (per million yd^2)*	*Capital cost*	*Operating cost*	*PVC ($/$yd^2$)*	*Number of employees (per million yd^2)*
Up to and including spinning	4 294	8 383	2.69	19.2	711	541	3.03	19.8
Preparation	1 662	194	0.12	9.7	126	22	0.18	17.8
Weaving	4 658	1 142	0.51	67.5	291	71	0.51	67.5
Administration	3 000	1 016	0.41	17.8	950	230	1.66	90.0
Total	13 614	10 735	3.73	114.2	2 078	864	5.38	195.1

and labour would be deployed on a single-shift basis. The PVC of \$5.38/yd^2 would then rise for an output of about 600,000 yd^2/a to \$6.67/yd^2.

For a small hand-spinning, hand-weaving operation of 26 hand looms and either 230 mechanized or 104 open-end spindles, the annual output at 30 picks/min is 78,000 yd^2 (65,200 m^2). Additional information is given in table 8.

TABLE 8. CHARACTERISTICS OF HAND SPINNING AND WEAVING: OUTPUT 78,000 YD^2/A

Stage or activity	*Capital cost*	*Operating cost*	*PVC ($/$yd^2$)*	*Number of employees (per million yd^2)*
	(Thousands of dollars)			
Up to spinning	7.2 to 8.9	75 to 80	11.4	1 330
Weaving and preparation	5.4			
Working capital	17.2		3.3	370
Administration		4.3	0.5	38
Total	29.8 to 31.5	79.0 to 84.0	15.2	1 738

As can be seen, costs would be about \$15/yd^2, compared with \$6.7/yd^2 on ordinary power looms and ring spinning. This assumes, of course, that an operative commands, in effect, an hourly rate which is such that the annual income is the same as that earned by an operative in a modern mill. It would not be unreasonable in rural areas to assume half this wage, so that hand operations would be competitive with ordinary looms at or below 500,000 yd^2/a. Employment would be much higher at 1,738 per million yd^2 compared with 195 on power looms.

One way in which account is often taken of employment is to calculate social rather than market costs, which in practice, with the usual over-valuation of the currency, low savings rates and high differentials between rural and urban earnings, means taking social wage costs at about one half the actual cost. If this is done, the hand operations become more attractive than before, and in power operations labour-intensive technologies are generally favoured.

Policy conclusions

At the beginning of this paper, emphasis was placed on the generation of an economic surplus from productive activities in developing countries. In particularly happy circumstances there would be no conflict between this and the pursuit of other objectives, such as those frequently implied by the basic-needs approach to development. That a single-minded approach to industrial development would serve a number of policy objectives equally well, however, is perhaps unlikely. A multi-purpose programme is consequently likely to entail compromise, and the challenge to policy is to obtain the best compromise possible. This formulation leaves open some difficult questions as to what might constitute the "best" compromise. Partly from conviction and partly to avoid long and inconclusive discussion, particular weight is attached here to minimizing the sacrifice of economic efficiency.

Other views on this matter are possible. It should be recognized, however, that economic efficiency and economic inefficiency are real phenomena, so that, in some circumstances a policy, for example, of maximizing employment at any cost would not be objectively sustainable. This said, another point to be recorded is that the data and conclusions of this paper are necessarily tentative. As a consequence, as much importance is attached to the methods used as to the results presented.

Having made these qualifications and clarifications, it is convenient in fairly dogmatic fashion to consider the policy options open to African countries in developing a textile industry. One way in which this can be done graphically is to suppose that the countries listed in table 1 expect their domestic markets to double in the next decade or so and wish to make provision for this on the further assumption that the entire expansion of demand will take the form of cotton cloth. To facilitate the discussion, it is useful to assume that the NPV of the optimal technology is such as to yield a margin of 10 per cent on costs.

On these assumptions, it may be noticed first that all but three of the African countries in question would need at least one integrated mill of a size capable of exploiting existing technical economies of scale. This being so, it is appropriate to proceed by considering alternative ways of satisfying this unit of demand[a] and to consider first the case where the demand is to be met by the setting up of a factory capable of producing 28 million yd^2 of cotton cloth per annum. Considering then the four technologies covered by table 6, the position in a low-wage country, using a 10 per cent rate of discount would be as shown in table 9.

Inspection of this table reveals that the optimal technology has the desirable properties of being the most profitable, the most employment-generating and the least demanding of investible funds. As has been seen, this result is not sensitive to a doubling of the discount rate. It is, however, sensitive to changes in the wage rate, and in a medium-wage country, the NPVs for technologies A, B,

[a]In countries where more than one "optimal" mill would be required, it is assumed that, whatever solution may be arrived at, it would hold for the relevant number of units. It will be obvious that the argument is not based on any fine analysis of potential market (segments), and that it ignores variations in transport and distribution costs that would result from different forms of industrial structure.

TABLE 9. NPV AND INVESTMENT EMPLOYMENT FOR FOUR TECHNOLOGIES IN A LOW-WAGE AFRICAN COUNTRY

(Millions of dollars)

Item	*Technology*			
	A	*B*	*C*	*D*
NPV	10	10	8.5	10.5
Investment	21.45	16.25	17.0	13.61
Number employed	1 245	2 274	2 432	3 209

C and D would be $9.5 million, $9.0 million, $7.5 million and $9.0 million respectively, so that the most capital-intensive, least employment-generating technology would be the most profitable one. The sacrifice in economic efficiency involved in staying with the most labour-intensive, lowest capital-cost technology would not, however, be inordinately great, amounting to about 5 per cent of optimal profits creating additional employment. These may be expressed in a number of logically identical ways as by an addition to investment cost, a decrease in NPV or an addition to PVC, and each of these can be expressed either absolutely or per additional job created. Table 10 shows, for a low-wage African economy and a 10 per cent discount rate, the cost of creating extra employment in 16 "modern" factories, as described above, and 47 factories, each producing about 600,000 yd^2/a of cloth and the hand-spinning and weaving sector producing about 78,000 yd^2/a. It would take 360 such units to produce the required amount of cloth, and these, it will be recalled, can defensibly be evaluated at two different wage levels. For simplicity, and in the light of earlier, recurrent emphasis on profitability, attention is confined to NPV.

TABLE 10. THE COST OF CREATING ADDITIONAL EMPLOYMENT BY ALTERNATIVE TECHNOLOGIES

Number of factories	*Loss of NPV (millions of dollars)*	*Number of jobs created*	*Loss of NPV per job (thousands of dollars)*
16	46.5	2 273	20.5
47	72.12	-303	
360 (High wage)	311.8	45 629	6.83
360 (Low wage)	72.12	45 629	1.58

Putting it differently, for a lower initial investment outlay and a doubling of employment compared to that generated by the optimal one, it would be possible to earn 95 per cent of the optimal profits.

It should be recalled that each of the four technologies just considered is capable of exploiting technical economies of scale, so that if it is thought desirable to meet the projected demand by means of smaller factories, some trade-off between profitability and other objectives must be expected. Here the magnitude of such trade-off would be critical. In the present context, this may be examined by combining the above assumptions with the data of table 9 and thus, in effect, comparing the single large factory just discussed with 16 smaller ones capable of producing the same aggregate output. Confining attention, for convenience of exposition, to the ordinary loom (that is, the optimal choice of table 6), data relevant to the contrast are presented in table 11. From this it can be seen that the trade-off between employment and profitability cannot be accommodated within the surplus indicated in the table, so that a decision to choose 16 factories rather than a single one would go beyond the sacrifice of positive profits into actual subsidy.

TABLE 11. NPV, INVESTMENT AND EMPLOYMENT FOR SINGLE AND MULTIPLE FACTORY PRODUCTION OF 28 MILLION YD² OF COTTON CLOTH PER ANNUM IN A LOW-WAGE AFRICAN COUNTRY

Number of factories	*NPV*	*Investment*	*Number of employees*
	Millions of dollars		
1	10.5	13.61	3 209
16	36.0	33.4	5 482

This is a disappointing result, the more so since it evidently applies *a fortiori* to the smaller-scale and hand-loom operations discussed above. It is consequently important to stress that it is sensitive to some extent to changes in the particular parameters used in the present calculations. The result is, nevertheless, plausible, particularly in the light of recent technical progress. Perhaps the most useful policy implication of this paper is consequently that of highlighting the need to determine systematically, and on an industry-by-industry basis, where sensible opportunities for decentralized, small-scale production exist.

In this regard, the present results can be used as a frame on which to hang some further illustrative discussion. The first point to be made is that any disappointment felt about the apparent economic undesirability of the smaller-scale production should clearly be tempered by the results of the evaluation of the large-scale alternatives which, as has been seen, suggest that the choice of the most labour-intensive technology is an attractive policy option. Indeed, even in medium-wage countries, some 95 per cent of the maximum surplus could be obtained if this choice were made, with an increase in employment of almost 160 per cent over that associated with the optimal technology, at a once-and-for-all cost of $255 per added job.

The employment gains from small-scale production would be very much greater than those resulting from a labour-intensive, large-scale technology. It is therefore worth probing further the costs of such production, although to do this fully would require much more macroeconomic and microeconomic data than are presently available. One thing which can, however, be said is that the scope for, or at least the desirability of, modifying choice in a small-scale direction depends greatly on the prices at which alternatives are evaluated. If the results presented above were based on shadow prices which accurately represented agreed development goals, then any move from the optimal technology would result in a distortion of resource allocation, and there would really be little more to be said. If, however, the prices were those thrown up by an imperfect market economy in which, for example, incomes were very unequally distributed, the situation could be very different, although it bears emphasizing that, strictly speaking, it would remain complex.

It is worth considering briefly, if rather sketchily, what policy options might be adopted (and at what cost) in such an economy. This may usefully be done by first considering costs, which are essentially those of providing additional employment beyond that associated with the optimal technology.

The first impression from table 10 is that, in the circumstances assumed, job creation would be expensive in that the loss of NPV associated with 16, 47 and 360 factories could finance between 3 and 24 factories, each capable of producing 28 million yd^2 of cloth per annum. If, nevertheless, it were felt that, perhaps to avoid undue concentration of industry in urban areas and to increase the spread and number of jobs, the single-factory option should be ruled out, then (provided the absolute cost is not an insuperable barrier) table 10 suggests that the hand operations would be preferable to small-scale variants of power technology. Here two things may be noted: the first is that the cost (loss of NPV) per job in the 16-factory option is considerably higher than the discounted value of the annual wage per operator, so that, in principle, it would be profitable to pay the additional workers the normal wage to stay away. In practice, there could be very serious administrative and political diffficulties associated with this method of subsidizing unemployment. The second thing to note is that, whereas the 47-factory option, because of the move to single-shift working, actually reduces employment, hand operations increase it very significantly at a cost per job that is considerably lower than the discounted wage. Indeed, a once-and-for-all expenditure of $1,580 per job does not at first sight seem excessive. When, however, it is recalled that this is 15 times the GDP *per capita* in many countries, it is clear that a subsidy of this magnitude could not be provided across the economy.

Another way of looking at the matter is to ask how the necessary subsidy would be raised. One obvious possibility would be to tax the consumers. The present assumptions imply a selling price of cloth of $4.10/$yd^2$. To enable the hand operators (at the high wage rate) to break even, this would have to be increased by more than 70 per cent. The increase need not fall on the cloth directly but could be levied on the final product made from the cloth. This would have several advantages. In particular, it would permit a discriminating impost to be made on products according to income levels, as expressed in demand, and give no incentive for an illicit trade in cotton cloth to develop.

Because of lack of knowledge and space, a number of important matters have either been ignored or drastically over-simplified in this paper. In many countries, notably in India, modern and traditional sectors already coexist, so that an explicit discussion of a mixed development might have been desirable. The present discussion has, however, offered some suggestions on how the relations between these two sectors might be organized. It has, moreover, given some insight into the reasons why in India the survival of the traditional sector cannot be left to the market.

Basic problems of textile industries

*H. W. Sabhaney**

Most developing countries face similar basic problems in the textile industries. They include:

High cost of raw materials, complicated by irregular supply and shortages

Unreliable energy supply

Labour difficulties

Recent cutbacks in demand at home and abroad

Scarcity of working capital

Increasing overhead expenses

Declining productivity

Need for modernization and renovation of plant and machinery

The industrialized countries tackled these problems shortly after the Second World War, but similar efforts were not made in India and other developing countries, and they lost ground in the world textile market. The problems fall into two major groups: social or socio-economic, such as labour, management and financing; and technological, such as productivity and modernization.

The socio-economic problems are largely interdisciplinary, whereas the technological ones are both more specific and more basic. They are therefore more crucial, and it seems appropriate to concentrate here on the problems connected with the technology and the machinery corresponding to the appropriate technology required in a developing country.

Outline of industrial policy for developing countries

A close relationship between the agricultural and industrial sectors of the economy is basic to any industrial policy. Much industrial production is based on agricultural raw materials. Similarly, to increase agricultural productivity by the adoption of modern technology calls for important contributions from the industrial sector. For example, the highest priority must be given to the generation and transmission of electrical energy.

The prosperity of a country and the distribution of income arising from a broadly based growth of agriculture and related activities in the countryside is

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needed to provide the basic demand for a wide range of consumer goods produced by industry. It is only by such a process of interaction between the agricultural and industrial sectors that employment can be found for the large numbers of the rural population who cannot be absorbed in the agricultural sector.

Small-scale industries

The emphasis of industrial policy so far has been mainly on large industries, neglecting cottage industries and relegating small industries to a minor role. The main thrust of the industrial policy should, however, be on the effective promotion of cottage and small industries widely dispersed in rural areas and small towns. It could even be the policy of Governments, backed by legislation, that the production of whatever can be produced by small and cottage industries should be reserved for them alone. Care should be taken, however, to ensure that production in this sector is economic and of acceptable quality.

Promotional measures

The growth of the small-scale and cottage industries sectors has been slow, mainly for want of raw materials and satisfactory marketing arrangements for their products. Measures such as purchase preference, reservation for exclusive purchase by government departments and public-sector undertakings could also be used to support the marketing of these products.

Application of appropriate technology

The development and application of technologies appropriate to socio-economic conditions has not yet received adequate attention. Efforts should be made to ensure an effective and co-ordinated approach to the development and widespread application of suitable small and simple machines and devices for improving the productivity and earning capacity of workers in small and village industries. Additionally, there is also a definite role for large-scale industry, related to the programme for meeting the basic minimum needs of the population through wider dispersal of small-scale and village industries and strengthening the agricultural sector.

There should be an expanding role for the public sector in several fields. Not only will it be the producer of important and basic strategic goods, but it will also be used effectively as a stabilizing force to maintain essential supplies for the consumer. The public sector should be made responsible for encouraging the development of a wide range of supporting industries and contributing to the growth of decentralized production by making available its expertise in technology and management to the small-scale and cottage industry sectors. Each country should have a well-developed network of scientific establishments to help science and technology contribute to the improvement of living standards and the quality of life.

Location of industries

Governments should attach importance to the balanced regional development of their countries so that disparities in levels of development will be progressively reduced. It should be noted that most of the industrial development that has taken place in developing countries has been concentrated around large cities. The result has been a large-scale influx of rural people into the cities, with a consequent rapid deterioration in living conditions, especially for the working classes.

Pricing policies

A sound pricing policy must aim at a reasonable degree of price stability and parity between the prices of agricultural and industrial products. Price controls should ensure that the investor receives an adequate return. To speed up development, the Government must try to remove obstacles such as industrial approval procedures that impede industrial development.

Conclusions

By international standards, the textile machinery manufactured in the developing countries could be said to be ten years out of date. However, this is not a problem where there is an abundance of relatively cheap labour. What developing countries need is technology that would make the fullest use of available material and manpower resources. However, care should be taken that the technology adopted should prove to be adequately productive, economically viable and, at the same time, not inhibit the growth of employment opportunities. Developing countries need technology that is relatively cheap and that permits very wide application, so that workers without special training can be provided with gainful employment. Such a technology would be in an intermediate position between the highly productive technology used in industrially advanced countries and the very simple equipment and tools used in the least developed economies.

The aspiration of the Governments of the developing countries is to modernize their textile industries and increase their productivity. At the same time, however, they want to protect the domestic textile machinery industry because it cannot compete in product quality with some of the foreign manufacturers. Therefore, any textile machinery imported must fall into the group of machines that will increase productivity and yet be accepted by the import rules and regulations of the country in question.

Modernization should not be done for its own sake; it must meet the test of cost-benefit analysis, taking into consideration the economics and the return on investment.

The textile machinery manufacturing industry in the developing countries apparently is not producing the high-speed, modern, sophisticated, fully automatic machinery currently used by the developed countries. Nevertheless, it is filling the most important gaps and mainly producing machinery and equipment that is suited to the requirements of developing countries. Considerable attention must therefore be given to this sector by Governments, encouraging it to introduce technological innovations and, at the same time, produce machinery appropriate to the dispersed sector in most developing countries. The emphasis therefore may have to be on the manufacture of machinery for small-scale production that would be technologically efficient and economically productive.

Evaluation of appropriate technology for textile production

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The textile industry is one of the first to be established in many developing countries. In the last three decades or so, there have been rapid and many-sided advances in the techniques of textile manufacture, so that the choice of technology is difficult even at the purely technical or sectoral level. In developing countries, the choice of technology, however, will have to transcend sectoral considerations and be harmonized with national macro-economic plans.

This paper attempts to analyse the relevance to developing countries of some alternative technologies available for different stages of textile manufacture. Its scope is restricted to the main apparel fibres, namely cotton and man-made fibres. The discussion is based primarily on the profile of textile manufacture in India, where a wide range of technologies and scales of operation exist. Nevertheless, the observations and recommendations should have a degree of generality.

THE TEXTILE INDUSTRY IN INDIA: HISTORICAL SURVEY

The past, to 1946

India has a long and rich tradition in textile manufacture and is considered the birthplace of cotton textiles. The use of starch for sizing and of vegetable and mineral substances for coloration was well known before the Christian era. Special ornamentation techniques such as tie-and-dye and resist printing had been perfected. In more recent times, the Dacca muslins, calicoes and chintzes were world-renowned and highly prized. The manufacture was in the hands of master artisans whose knowledge and skill had been passed down from generation to generation.

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First the industrial revolution and then the regressive trade policies followed by the colonial government caused severe setbacks to traditional textile manufacture. Progressively severe restrictions were placed on the production and export of muslins and calicoes, while liberal imports of British textiles were permitted. Furthermore, the mechanization of textile manufacture within India itself added to the difficulties of the traditional textile industry.

Textile manufacture on an industrial scale started in India in the middle of the nineteenth century. Statistical details of the Indian textile industry from 1866 to the end of the Second World War (1946) are given in table 1.

TABLE 1. THE INDIAN COTTON TEXTILE INDUSTRY, 1866–1946

Year	Number of mills	Number of spindles (millions)	Number of looms (thousands)	Yarn production (million kg)	Fabric production (million m^2)		
					Mills	Hand looms	Total
1866	13	0.3	3.4	...	...	...	...
1901	178	4.8	40.5	259.9	...	...	...
1911	233	6.1	85.8	283.5	...	...	...
1921	249	7.3	133.5	314.8	1 307	1 052*	2 359*
1931	314	9.1	175.2	438.2	2 249	1 244*	3 493*
1941	396	10.0	200.2	715.3	3 548	1 509*	5 057*
1946	423	10.4	202.7	629.6	3 868	1 253*	5 221*

Sources: Indian Cotton Textile Industry, various volumes (Bombay, Gandhi and Co.).
*Estimated.

In the first few decades, the industry had concentrated on spinning coarse yarns, and there was a lucrative yarn trade with China and Japan. Fabric finishing was virtually unknown; grey fabrics were exported to Lancashire and re-imported in finished form. The industry was also not in a position to meet domestic demand, although fabric imports declined from 62 per cent of total consumption in 1901 to 15 per cent in 1936, with a corresponding increase in production within the country.

The history of the Indian national movement is closely interlinked with that of the textile industry. The rivalry between the Lancashire and the Indian industries resulted in the imposition of British protective tariffs against Indian textiles and of measures to counteract India's competitive advantages. These measures had an impact beyond the economic sphere; they were viewed in India as expressions of political dominance and were met with movements for the boycott of foreign goods, specifically British textiles, in India.

The resulting Swadeshi movement triggered increased fabric production in India. It also marked the beginnings of the *khadi* (hand-spun and hand-woven textiles) movement, although Mahatma Gandhi, its main advocate, viewed it in a much broader perspective. According to him, the resurgence of the spinning wheel in Indian villages has nothing to do with machinery or the propaganda for boycott of foreign cloth. It is purely and simply a question of the economic condition of the Indian masses [1].

The outbreak of the Second World War witnessed a further growth of the Indian textile industry. With India serving as an operational base in Asia for the allied powers, the textile industry was called upon to meet the sizeable military requirements, and domestic consumption had to be curtailed.

The past, 1947–1976

The partitioning of the subcontinent in 1947 seriously dislocated the textile industry. A substantial portion of the cotton-growing areas went to Pakistan, while most of the cotton textile manufacturing capacity remained within Indian territory.

Each of the two young independent nations had to take steps to stabilize its textile industry; India had to increase cotton cultivation, and Pakistan had to augment its textile manufacturing capacity.

The Government of India also decided, as a policy measure, to encourage the small-scale sector. The measures taken in pursuance of this policy included:

(a) Reservation of selected products solely for the decentralized sector;

(b) Fiscal incentives for setting up decentralized units;

(c) Relief in excise duties on yarn supplied to, and fabrics produced by, the decentralized sector;

(d) Restrictions on the use of filament yarn by the organized sector and on yarn exports to assure regular raw material supply to the decentralized sector;

(e) Establishment of agencies for the general promotion of these sectors (for example, the Khadi and Village Industries Commission and the Handloom Development Corporation).

This policy resulted in a pronounced growth in the production of woven cloth by the decentralized sector and in the number of spinning mills which supply yarn to this sector (table 2). The early 1950s also saw the beginnings of production of man-made fibres (regenerated cellulosics) in India, and this led to the establishment of a section of the decentralized sector concerned with weaving, the so-called art silk sector. The advent of other man-made fibres

TABLE 2. THE INDIAN COTTON TEXTILE INDUSTRY, 1950–1976

Year	*Number of mills*			*Number of spindles (millions)*	*Number of looms (thousands)*	*Yarn production (million kg)*	*Fabric production (million m²)*		
	Spinning	*Composite*	*Total*				*Mills*	*Power and hand looms*	*Total*
1950	94	268	362	10.5	191.5	533	3 351	911	4 262
1955	116	292	408	12.0	202.7	740	4 658	1 620	6 278
1960	186	293	479	13.5	200.3	788	4 616	2 013	6 629
1965	253	290	543	15.4	206.5	939	4 587	3 056	7 643
1970	366	290	656	17.7	208.3	965	4 157	3 692	7 849
1975	403	288	691	18.9	206.9	989	4 032	4 002	8 034
1976	409	289	698	19.5	207.7	1 006	3 881	4 064	7 945

Sources: Handbook of Statistics on Cotton Textile Industry, 9th ed. (Bombay, Indian Cotton Mills Federation, 1976); *Indian Textile Industry Annual*, various volumes.

(polyamides and polyesters) in later years resulted in an increased production of blended yarns and fabrics and also in the introduction of modern knitting machines, albeit on a small scale.

The present

A glance at the structure of the textile manufacturing industry in India today reveals several characteristic features. First, there is the segmentation of the industry into different organizational groups; the organized sector, comprising mills that can be further subdivided into the private, public and co-operative sectors; and second, the decentralized sector, consisting of hand spinning, hand looms, power looms (including art-silk looms), knitting, chemical processing etc. Within each of these sectors, the individual units span a wide spectrum as regards size, output, turnover, technical competence and, to some extent, the level of technology.

Generally speaking, India's textile industry has yet to adopt the most recent technological developments. Although India has a sizeable textile-machinery manufacturing industry, its production is generally restricted to conventional technology; machinery that incorporates the most modern advances must be imported. In view of the high cost of imported machines and the high levels of import duty, imported technology very often becomes prohibititive for most factories, although a number of them with specialized production patterns may find some imported technologies attractive. The upkeep and operation of modern machinery is also likely to pose problems in many mills, although there are sufficient units with the necessary competence and skills.

At the same time, the productivity levels in the organized sector are low, even when allowances are made for the overall level of technology and low machine utilization as a result of raw material shortages, power cuts and labour unrest. More important factors are the age and obsolescence of the machinery in many mills. Modernization is urgently needed in the textile industry. However, modernization does not imply the adoption of more advanced technologies only. The replacement or renovation of machines that are in poor mechanical shape, that is, the conversion of existing machines for higher productivity, is more realistic and feasible.

The decentralized sector is even more heterogeneous. The definition of the decentralized sector is largely based on the scale of production and does not always take into consideration the technological factors. In the knitting sector, for example, there are warp and circular knitting machines that represent a fairly high level of technology. Similarly, between the organized sector and the power-loom subsector of the decentralized sector, there is no basic difference in the level of technology. At the other extreme, the decentralized sector continues to employ techniques that have remained unaltered over decades, or even centuries. Hand spinning, hand weaving and block printing are some typical examples. Hence it would be erroneous broadly to equate the decentralized sector with outmoded technology.

Together, the various segments of textile manufacture play an important role in the economy of India. With annual yarn and fabric production of around

1,000 million kg and 9,000 million m^2, respectively, India has one of the largest textile manufacturing capacities in the world. Textile manufacture provides direct employment to several million persons and plays an important role in the Indian economy. The following sections describe the technologies currently employed by the different segments.

SPINNING TECHNOLOGY

General level of spinning technology

For the greater part of this century, the spinning operation was characterized by a number of separate processes with material handling between the successive stages. Developments in spinning technology in the last two decades eliminated some of the material handling and introduced an element of automation; direct chute feeding to cards and automatic doffing at ring frames are two examples of this type of development. The general trend towards higher productivity rates has asserted itself in spinning technology as well. Speed increases of 400 per cent and more have been achieved on machines such as cards and draw frames. The ring frame productivity has also registered an increase, though to a relatively modest extent of about 30 per cent. The adoption of mechanical and electronic devices has helped to maintain product quality despite the higher machine speeds and has in fact actually resulted in reducing the number of preparatory stages.

However, the most striking development in spinning technology has been the evolution of radically new methods of yarn formation such as open end spinning, self-twist spinning, and twistless spinning. These technologies use unconventional methods for imparting twist to the yarn or rely on methods other than twisting to provide inter-fibre cohesion. As a result, the inherent limitations to higher speeds encountered in ring spinning have been bypassed and appreciable increases in spinning productivity have been possible. Of these, open-end spinning has been accepted quite widely on a commercial scale. A total of about 0.9 million open-end spinning units (equivalent to approximately 2.4 million ring spinning spindles) are working at present in different parts of the world.

Spinning technology in India

Spinning mills account for 37 per cent of the total spinning capacity in India. Of the total of 413 spinning mills, 50 are co-operative enterprises formed by co-operative societies of either weavers or cotton growers. They are relatively small; nearly 35 per cent have fewer than 12,000 spindles. The composite mills, on the other hand, are larger and average 43,000 spindles. The production of blended yarns of cotton, viscose and polyester has steadily increased over the years. Their volume of production in 1975 was 40.5 million kg, or 14.5 per cent of the total.

The rising popularity of fibre blends and the availability of indigenous long-staple cotton have also led to a gradual but perceptible shift towards finer counts. Counts finer than 40s Ne (English cotton count) represented 12.5 per cent of the total production in 1976 as against 6.9 per cent in 1961.

These changes in raw materials and patterns of production have been absorbed without any major shifts in technology; the general level of technology in India can perhaps be best denoted as intermediate. Developments such as semi-high or high-production carding, high-speed draw frames, speed frames and ring frames have been adopted, to varying extents. However, more recent innovations such as chute feeding, automatic doffing and open-end spinning have yet to find their way into the Indian industry.

India is self reliant in conventional spinning machinery. As has been noted, however, machinery incorporating the latest technological advances such as open-end spinning machinery must be imported. The cost of such imported machinery outweighs its advantages in terms of higher productivity, lower wage costs or improved product quality. A techno-economic comparison of ring spinning and open-end spinning is given in table 3.

TABLE 3. COMPARISON OF ECONOMICS OF RING AND OPEN-END SPINNING YARN OF COUNT 10S-28S NE (DAILY PRODUCTION: 5,400 KG OF CARDED YARN)

	10s Ne		*16s Ne*		*20s Ne*		*28s Ne*	
Item	*Ring spinning*	*Open-end spinning*	*Ring spinning*	*Open-end spinning*	*Ring spinning*	*Open-end spinning*	*Ring spinning*	*Open-end spinning*
Total investment[a] (million Rs)	10.78	23.57	13.61	37.37	18.20	58.03	22.43	70.40
Conversion costs[b] (Rs/kg)	0.63	0.35	0.88	0.59	1.06	0.92	1.33	1.08
Annual profits after tax (million Rs)	1.95	2.16	2.17	2.39	2.39	2.50	2.57	2.75
Simple pay-back period[c] (years)	5.50	10.90	6.30	15.60	7.60	23.20	8.70	25.60

[a]Including investment in pre-spinning machines.
[b]Labour and energy.
[c]Gross investment divided by annual profit after tax.

It can be seen that the relative economic viability of open-end spinning diminishes steadily as the count becomes finer. There is also the further uncertainty whether this technology will be suitable for Indian cottons, which have a higher content of impurities and foreign matter.

The spinning wheel or *charkha*, which became a symbol of self-reliance, has continued to flourish in India. Approximately 500,000 of them are in operation today, with a total cotton yarn production of about 5 million kg/a. Much of this yarn is in the coarse count range and is produced all over the country.

In the mid 1950s a new hand-spinning technology, the Ambar charkha, was introduced. This machine incorporates the essential features of a conventional ring frame and has from 2 to 6 spindles per unit. The Khadi and Village Industries Commission has taken the initiative in refining and propagating the Ambar charkha. About 100,000 of them, with 500,000 spindles are in operation today, producing about 6 million kg of cotton yarn. The counts spun on the Ambar charkha are limited to approximately 20s Ne. A set of preparatory machines, which are essentially scaled-down adaptations of the mill technology, have also been designed for the Ambar charkha sector. One set of preparatory machines can feed about 25 charkhas. The hand-spinning sector provides employment to around 700,000 persons. Yarns spun on the Ambar charkha are, however, poorer in quality than those produced in spinning or composite mills. A shortage of trained workers and deficiencies in the design of the machines are two of the major causes for the low quality of hand-spun yarns. It should be possible to overcome these drawbacks. The Ambar charkha has the potential to provide employment with low capital investment.

A comparison of the productivity, labour input and capital requirements of four different spinning technologies is given in table 4.

TABLE 4. COMPARISON OF ALTERNATIVE SPINNING TECHNOLOGIES: COUNT 20S NE; CARDED; 1,000 KG/DAY

	Number of spinning units	*Investment*[c] *(million rupees)*	*Employment (persons)*	*Average monthly wages (Rs)*	*Labour cost (Rs/kg)*	*Capital cost per worker (Rs)*	*Capital cost (Rs/kg)*[d]
Box charkha[a]	11 100	2.85	11 600	125	58.00	245	1.97
Ambar charkha[a]	12 500	2.08	2 600	125	13.00	800	1.43
Ring spinning frame[b]	2 400	3.37	28	500	0.58	120 000	2.32
Open-end spinning machine[b]	800	10.75	10	550	0.24	1 075 000	7.41

[a]Single-shift operation.

[b]Three-shift operation.

[c]Including investment in preparatory spinning machines.

[d]Computed by dividing the investment, discounted at the rate of 16 per cent over 10 years, by the annual production.

Such a comparison presupposes that the product of each of the technologies is comparable, at least in a limited range. As indicated above, this assumption is not warranted at present. Design improvements for the Ambar charkha for improving yarn quality, for instance, are bound to increase the cost of the charkha to a certain extent, but the overall capital requirement per workplace is still likely to be lower than in the other technologies. The operation of the Ambar charkha by power would no doubt increase its productivity considerably, although this may not be feasible on a large scale immediately.

The model of centralizing the pre-spinning operations adopted by the Khadi and Village Industries Commission deserves further examination since it offers the possibility of combining the advantages of large-scale and small-scale operations. In spinning, the stages up to the roving frame can be conveniently and economically operated on a large scale. Here, the mill technology, with its higher productivity rates and adequate control of product quality, appears to be more efficient. The final stage of spinning can be decentralized, with each of the spinning units consisting of one or more manually operated Ambar charkhas.

Such an arrangement imposes restrictions on the physical location of the individual spinning units in relation to the central preparatory unit. The implications of material transport between the nucleus plant and the satellite spinning units must be studied in detail. This arrangement will require other facilities for efficient functioning. Provision should be made for machinery maintenance and the supply of spare parts. The proper training of operatives of the Ambar charkha should also help to enhance both productivity and quality.

Possibilities are being explored of introducing man-made fibres into the hand-spinning sector. The objective is to broaden the product range of *khadi* textiles. Taking into account the increasing popularity of man-made fibres, particularly polyesters, in India, a more serious examination of the various aspects of the scheme would be called for. The probable demand for blended khadi textiles will have to be assessed against the background of the high price of polyester fibres in India and the relatively high cost of hand-spinning production. Also, yarn quality would assume far more importance with the more expensive man-made fibres; waste levels and the proportion of substandard yarns would have to be kept to a minimum. Moreover, since the hand-spun blended yarns will be processed subsequently in the decentralized sector, the availability of required facilities in weaving and finishing must be examined carefully. The rough and natural texture of khadi textiles has a novelty appeal that cannot easily be matched by mill-made textiles. A planned and imaginative promotion of such features of khadi textiles in both the domestic and export markets might bring fruitful results.

TECHNOLOGY OF FABRIC PRODUCTION

As in the case of spinning, one of the main objectives in fabric manufacture development has been to raise productivity levels. A noteworthy development is the loss in dominance of weaving as a fabric manufacturing technology. Knitting has asserted itself as a viable alternative technology for manufacture of outerwear. Fabric manufacture without the intermediate stage of yarn formation has become a reality. Stitch bonding techniques, which can be viewed as a combination of knitting and weaving, have further extended the range of fabric manufacturing technologies. Knitting and stitch bonding offer production rates which are well above the levels attained by the conventional shuttle loom.

General level of weaving technology

Larger package sizes, electronic process and product monitoring, and engineering refinements of machine parts for higher speeds are some of the prominent features of modern machines in the preparatory stages (winding, warping and sizing) of weaving. Operating speeds in these stages have increased considerably.

After several decades of relative stagnancy, the loom has undergone radical changes in the last two decades or so. The conventional automatic loom developed in the early 1900s was used predominantly with only marginal changes in design. Alternative methods of weft insertion developed during the early 1950s brought shuttleless looms into the picture. Once the need to propel a heavy shuttle across the warp sheet was obviated, limitations on loom width and speed were eliminated. The most modern shuttleless looms operate at weft insertion rates of about 700 m/min with fabric widths of 330 cm. Still higher production rates are being aimed at in some of the new technologies such as multiphase weaving; however these are yet to be commercially accepted.

Weaving technology in India

The organized sector

The recent developments in pre-spinning operations have been introduced in Indian mills to a relatively larger extent than the developments in weaving itself. Automatic warp- and pirn-winding machines, high-speed warping machines and multi-cylinder sizing machines have been installed in a large number of mills. Many of these machines are manufactured in India.

On the other hand, weaving in the organized sector continues to be preponderantly on non-automatic shuttle looms that have remained unmodified in design for several decades. Of a total of approximately 208,00 looms in the organized sector in India, roughly 80 per cent are non-automatic; the rest are mostly conventional automatic shuttle looms. Very recently, shuttleless looms have been installed by some mills. The proportion of non-automatic looms is very high in India, even if the comparison is restricted to other developing countries. For instance, Brazil (45 per cent), Egypt (78 per cent), Hong Kong (100 per cent) and Pakistan (81 per cent), all have substantially higher proportions of automatic shuttle looms.

The conventional automatic loom does not facilitate higher production rates; its major advantage over the non-automatic loom is in the reduction of labour input. For example, one weaver can be put in charge of 48 automatic looms, as against four to six non-automatic ones, so the labour cost per unit volume of production is reduced. A second advantage of the automatic loom lies in the higher quality of its output, resulting from the various control and monitoring devices with which it is fitted.

As noted, despite these demonstrated benefits, the Indian textile mill industry has not introduced automatic looms on as large a scale as some other developing countries. The primary reason for this is that a change-over to the conventional shuttle automatic looms is not viable for many mills. Automatic looms of Indian manufacture are three to five times more costly than equivalent non-automatic looms. The general level of yarn quality in Indian mills does not permit the allocation of more than 16 automatic looms per weaver. As a result, the advantages of reduced labour cost per unit of output are not commensurate with the increased investment. While this analysis reflects the overall situation, automatic looms have been found to be appropriate and economically viable wherever fabric quality (that is, an absence of weaving defects) is a major criterion, as in high-priced fabrics meant for export.

The second-generation automatic shuttle looms and the shuttleless looms become even less attractive economically because of their still higher investment costs and the likelihood of added costs for preparatory processes before spinning and weaving to provide yarn of the required quality. The results of a techno-economic analysis of alternative weaving technologies in India are presented in table 5.

TABLE 5. TECHNO-ECONOMICS OF ALTERNATIVE SYSTEMS OF WEAVING IN THE ORGANIZED SECTOR[a]

	Type of loom			
Item	*Non-automatic*	*Conventional automatic*	*High-speed automatic*	*Shuttleless*
Total investment[b] (million Rs)	3.5	33.4	41.6	67.1
Conversion costs[c] (Rs/m)	0.65	0.64	0.61	0.60
Annual profits after tax (million Rs)	2.4	3.1	3.3	3.6
Simple pay-back period[d] (years)	1.4	10.8	12.8	18.6

[a]The values are based on an annual production of approximately 11 million metres of cotton fabric 48 × 26 reed picks/cm, 36s Ne in warp and weft.
[b]Including investment on weaving preparatory machines.
[c]Labour, energy and accessories.
[d]Total investment divided by annual profit after tax.

The non-automatic loom can be improved in several ways for added efficiency. Some of the more important features of automatic looms such as the warp-stop motion, individual drive and floating swells can be advantageously incorporated into the non-automatic loom. There is also scope for an increase in speed of the non-automatic loom. Developmental activity along these lines has largely been completed at the Ahmedabad Textile Industry's Research Association, and it is expected that non-automatic looms of an improved design will become available shortly. The changes should help to improve the technology of the non-automatic loom without offsetting its economic advantages.

The decentralized sector

Accurate information on different aspects of the decentralized sector such as production capacity and volume and employment is not available. The figures cited in the following sections are therefore estimates drawn from various governmental and other agencies.

Power looms. There are approximately 200,000 power looms in India working on cotton yarns, with an annual output of roughly 1,800 million m^2. In terms of technology, this sector is hardly distinguishable from the mill sector; the looms in the power-loom sector are almost identical in design to non-automatic looms installed in mills. It is thus evident that power looms can produce the same range of fabrics as the mill sector. The major differences are in the scale of operation and in the organizational set-up.

The units are small, with an average of 4 to 20 looms per unit. Very few of them have facilities for pre-weaving activities. They procure yarn from mills; warp yarns in the form of sized beams and weft yarn in packages. Pirn winding is generally carried out within the units themselves, but they depend on outside establishments for fabric finishing. Most usually, traders acting as intermediaries purchase cloth from the power-loom units and arrange for its further processing as well as for marketing. This system has given rise to a sizeable small-scale sector in fabric finishing.

Art silk. As its name implies, this sector is concerned with the weaving of art silk or man-made fabrics and is comparatively recent in the decentralized sector. Established in the early 1930s with imported viscose rayon as raw material, this sector received a stimulus in the 1950s and 1960s when plants were set up in India, first for the production of regenerated cellulosics and then for other man-made fibres.

The art-silk sector today has a capacity of 111,000 power looms that are basically similar to those in the mills or in the cotton power-loom sector except that some details have been adapted for weaving man-made fibres. The industry uses both cellulosic and synthetic fibres and produces a variety of textiles of which shirtings, saris and dress materials are important items.

Most of the art-silk weaving units are small, with one to six looms. There are only three units in the country with more than 300 looms. The smaller units produce only grey fabrics; a few of the larger ones have their own facilities for dyeing and printing. A group of separate chemical processing units has been established that caters to finishing requirements of man-made fibre fabrics and also frequently takes over the marketing function.

Hand looms. Hand-loom weaving has a long tradition in India and is the oldest of all the textile sectors. The design of hand looms and the process of hand weaving have remained essentially unaltered over centuries. It is estimated that there are 3.5 million of them in India, spread all over the country, employing several million persons. Both throw-shuttle and fly-shuttle looms are in operation.

The output of hand looms is around 2,300 million m^2/a, which is roughly 25 per cent of India's total fabric production. The main products are saris, shirtings, furnishings and other items of household linen, with a fair amount of product specialization among the different regions. Hand-loom fabrics and garments have a significant place in India's textile exports as well; their share in the total value of exports in 1976 was around 30 per cent.

Hand looms draw their supplies of yarn in the form of hanks from spinning mills. A considerable amount of yarn bleaching and dyeing is carried out in the hank form, again on a small scale. The need for fabric finishing is relatively less with hand-loom fabrics than with power-loom fabrics.

Its small scale of operation constitutes one of the major strengths of hand-loom weaving. Short runs can be handled without any loss in efficiency or increase in cost or waste. Hand weaving, therefore, lends itself well to the production of fabrics with woven-colour patterns. At the same time, the manual operation imposes several limitations on the product range. Fabrics wider than about 150 cm are difficult to weave on hand looms, as are fabrics of high thread density in either warp or weft. There is no inherent limitation to the range of yarn counts that can be used; nevertheless, because of the difficulties in producing a dense fabric, only yarns of coarse and medium counts are employed.

There has been a vigorous co-operative movement in the hand-loom sector; nearly one half of the total number of hand looms is now in the co-operative fold. The co-operative societies provide centralized services in raw materials procurement, financing and marketing, and they have gradually replaced the master weaver, who had traditionally discharged these functions.

Comparison of technologies

The various technologies of weaving have been compared with respect to production rates, investment and employment potential (table 6). There are inherent limitations to an analysis of this type, since the product ranges of the various sectors differ markedly. As mentioned earlier, hand-loom fabrics have a relatively low thread density and are produced from coarser yarns. At the other extreme, the art-silk sector produces lightweight fabrics, employing fine yarns and a high thread density. The power-loom and organized sectors cover the entire range, so any comparison on the basis of a common product is rendered difficult. Moreover, if fabrics with elaborately coloured patterns are considered, the manufacturing costs in the mill sector will rise considerably. The results therefore should be viewed mainly as broad indicators.

TABLE 6. COMPARISON OF ALTERNATIVE WEAVING TECHNOLOGIES[a]

Loom type	*Number of looms*	*Investment[b] (million Rs)*	*Employment[b] (persons)*	*Average monthly wages (Rs)*	*Labour cost[b] (Rs/m)*	*Capital cost per worker (Rs)*	*Capital cost (Rs/m)[c]*
Hand	3 300	3.96	4 900	175	1.65	808	0.13
Power (cotton)	255	2.51	506	300	0.29	4 960	0.08
Non-automatic (mill)	205	2.39	262	500	0.25	9 122	0.08
Conventional automatic	150	8.92	192	550	0.20	46 458	0.30
High-speed automatic	102	10.78	154	550	0.16	70 000	0.37
Shuttleless	70	50.57	120	600	0.14	421 416	1.72
Power (art silk)[d]	416	10.4	586	600	0.70	17 750	0.35

[a]Single-shift work in hand looms; three-shift work in others. Production: 20,000 m^2/day.
[b]Including weaving preparatory stages.
[c]Computed by dividing the investment, discounted at the rate of 16 per cent over 10 years, by the annual production.
[d]Not comparable with other technologies because of product differences.

General level of knitting technology

One of the most striking developments in fabric production in the last decade has been the growth of knitting technology as an alternative to weaving. From a technology traditionally restricted to the production of underwear, foundation garments, and sportswear, knitting has emerged as a serious competitor to weaving in the manufacture of outerwear.

Several factors have been responsible for the growth of knitting technology. Firstly, there had been the increasing use of man-made fibres in the form of normal and texturized filaments, and knitting can handle these without difficulties. Secondly, preparation of yarn for knitting is less elaborate than for weaving, and hence comparatively shorter runs are economical in knitting and the technology can respond better to the rapidly changing demands of the fashion trade. Lastly, knitted fabrics are more elastic because of their structure and have better easy-care properties than woven fabrics.

The recent advances in knitting technology show the same basic features as in spinning and weaving. Improved design features of knitting machines permit much higher production rates, particularly in warp knitting. Highly sophisticated electronic devices are a common feature especially for patterning on circular knitting machines. There have also been attempts to increase the versatility of knitting machines so that products such as pile fabrics, men's suitings, and furnishings which were once reserved for weaving, can be knitted today.

In spite of these trends towards higher production, automation and complexity of design, knitting technology is relatively more labour intensive than weaving technology.

Knitting technology in India

In India knitting has always been a small-scale or even cottage industry. It has been estimated that there are about 5,000 knitting factories in India, using cotton, woollen and synthetic fibres. About 100,000 people are employed by the industry, either directly or in such associated operations as bleaching, cutting and making up [2]. As shown in table 7, the Indian knitting industry uses a wide variety of machines.

TABLE 7. ESTIMATED NUMBERS OF KNITTING MACHINES OF VARIOUS TYPES

Type of machine	*Number of machines*
Sock knitting	
Hand-operated	9 000
Single-cylinder	1 500
Double-cylinder	350
Flat knitting (mostly hand-driven)	8 550
Circular knitting	26 450
Warp knitting	844

Source: J. G. Parikh, Knitting in India, *Man-made Textiles in India*, December 1977.

The knitting sector consumes 30 million kg of cotton yarn and about the same amount of man-made fibre yarn per annum. It should replace its machinery, much of which is old. Lack of finance, reluctance on the part of owners to diversify and modernize and difficulties in procurement of new machinery appear to be the major factors that impede modernization.

The simpler types of knitting machines are produced in India. However, the knitting machinery industry is also fragmented, and its product quality is poor. Greater attention must be paid to the selection of appropriate raw materials and fabrication techniques, closer adherence to specifications and interchangeability of parts. Modern knitting machines (warp and circular) must now be imported, and their high cost puts them beyond the reach of many knitting units.

Very few knitting units have qualified technical staff. Since they are small, they find it uneconomic to recruit qualified supervisors. In any case, there is a dearth of qualified knitting technologists in India.

Similarly, more extensive facilities are required for training operatives. The level of mechanization in knitting is relatively high; even a simple knitting machine is more complicated in design and construction than, for instance, a non-automatic loom. The availability of trained operatives and technologists is thus of importance.

Information on investment requirements, production rates, and employment for different knitting technologies is given in table 8. A comparison of alternative technologies is even more difficult in knitting than in weaving, since product differentiation is more pronounced. Sock knitting and hosiery manufacture are quite distinct from flat, circular or warp knitting of outerwear. Within the latter group, flat knitting differs from the other two in that it employs much coarser yarns. The figures given in table 8 should thus be interpreted within these limitations.

TABLE 8. COMPARISON OF KNITTING TECHNOLOGIES

Technology	*Machine cost (Rs)*	*Production rate (kg/machine-shift)*	*Employment (persons/machine-shift)*	*Average monthly wages (Rs)*	*Wage cost (Rs/kg)*	*Capital cost (Rs)*	
						Per worker	*Per kg*[d]
Sock knitting (power)[a]	100 000	1.4	0.75	400	8.33	44 400	17.52
Flat knitting (manual)[b]	2 000	8	2	250	2.50	1 000	0.17
Flat knitting (power)[a]	3 000	10	2	300	2.40	500	0.07
Circular knitting[a]	20 000	20	0.6	400	0.50	11 100	0.25
Circular knitting (Jacquard)[a]	68 000	20	0.6	400	0.50	37 800	0.83
Warp knitting[a]	500 000[c]	70	1.5	500	0.43	111 100	1.75

[a]Three-shift operation.
[b]Single-shift operation.
[c]Including warping machine.
[d]Computed by dividing the investment, discounted at the rate of 16 per cent over 10 years, by the annual production.

FINISHING TECHNOLOGY IN INDIA

Organized sector

Many of the composite mills have their own processing facilities. In addition, some of the spinning mills bleach and dye yarn on a limited scale. In recent years there has been an appreciable increase in the volume of finishing, particularly in dyeing and printing.

Most of the mills process only their own fabrics; the processing of fabrics from other mills is not common, even though surplus machine capacity is generally available. Large and independent process houses with modern machinery that buy cloth for finishing or undertake contract finishing are a relatively new phenomenon in the Indian textile industry.

The organized sector has been quicker to introduce the more recent developments in finishing than in spinning and weaving. Some of the recent developments such as high-pressure continuous bleaching, jet dyeing and rotary-screen printing are in regular use in a number of mills. As the value added in finishing is substantially greater than in spinning or weaving, a versatile range in finishing enhances the profitability of mills. This consideration perhaps explains the relatively quick adoption of more recent developments. The textile machinery manufacturing industry in India has also been prompt in establishing the production of several modern machines.

The introduction of man-made fibres, and particularly of the non-cellulosics, has had a major impact on the development of the finishing technology in India. The cotton-type machinery in spinning, weaving and knitting can be used for man-made fibres or blends with few or no modifications, but finishing fabrics from man-made fibres or blends calls for vastly different technologies and chemicals. This transition has been accomplished with relative ease by the organized sector.

Production runs are comparatively short in dyeing and printing. An average composite mill in India produces around 50,000 m^2 of fabric per day. This total production is fragmented into several different sorts in finishing, with the result that lot runs of 5,000 m^2 or less are not uncommon in dyeing and printing. This production pattern should, strictly speaking, rule out the use of high-speed machines which are most advantageous in processing long runs. Nevertheless, such machines are in operation in the mills either because they enhance product quality or because they extend the range of finishing styles. Such considerations are no doubt important in catering to the export or fashion markets.

The decentralized sector

The traditional styles of dyeing and printing have been preserved over several centuries, and there are several centres in different parts of the country that specialize in particular techniques. The decentralized sector has also extended its range of operations; fibres other than cotton are handled; almost the entire class of dyes available is used; and roller and screen printing have been added to block printing.

Very little finishing is done on hand-loom fabrics; bleaching and dyeing are carried out on the yarn itself prior to weaving. Each of the other sectors in decentralized fabric production (that is, the power-loom, art-silk and knitting sectors) has more or less its own finishing sector, specializing in the particular type of fabric. Finishing units for knitted or man-made fibre fabrics are situated in or near the centres of fabric manufacture; in contrast, units that handle power-loom cotton fabrics show a wider geographical dispersion.

In terms of volume of production, the sector for power-loom fabrics is the most important. With the exception of dhotis, the entire production on power looms is dyed or printed. This sector can best be illustrated by an example. Jetpur is a town with a population of about 55,000, situated about 250 km south-west of Ahmedabad. Nearly 80 per cent of the working population in the town is directly or indirectly connected with cottage-scale textile finishing.

There are around 500 units in Jetpur for dyeing and printing, most of which concentrate on the screen printing of saris. A number of dyes–reactives, naphthols, indigosols and rapidogens–are used for printing; the volume of printing with each of these dye classes naturally changes with market demands.

Much of the printing is done on a contract basis; traders place orders on the basis of printed samples prepared by the units, supply the bleached fabric and undertake marketing. A few of the larger units buy the fabric and sell it after printing.

Each unit prints about 150 saris (approximately 750 m) per day. Thus, the annual volume of production (assuming 300 working days in a year) for all the units taken together, works out to around 100 million m, which is roughly 10 per cent of the volume of printing in the organized sector. This is a remarkably high figure for a small town.

An average-sized factory has three printing tables and employs eight to nine people, working in groups. Wages are on a piece-rate basis, and the average daily earnings of a textile printer are roughly Rs 20, which compares favourably with those of a printer in a mill.

Runs are generally short: the print length for each design is normally around 500 m, and four to five different colour combinations are used in each design. As such the run for each design and colour combination is around 100 m. Such a small scale of operation would be manifestly uneconomic in the organized sector. The designs are fairly intricate; on an average, there are six to eight colours in each design. The printing coverage is quite high. The quality of printing is generally satisfactory in terms of clarity and wash fastness.

The units have been set up with very little capital outlay. In addition to printing tables, which are the major equipment, the units have very simple devices for steaming. Printed fabrics are air dried and washed in the nearby river. Washing, pressing and folding are carried out by separate groups working for a number of units.

The printing units have formed an association that acts as their spokesman, takes part in arbitrations between printers and traders and arranges for the supply of scarce dyes and chemicals.

The vigour and growth of the decentralized printing sector in Jetpur are indeed significant. However, the development appears to have been carried beyond the optimum level already. For example, the town is facing a severe water-pollution problem; even the ground water seems to be affected by the continuous discharge of effluents in open spaces over a prolonged period. Skilled workers are becoming increasingly scarce, and wage levels are rising. It would be desirable to take these factors into account in planning for development of similar centres elsewhere.

Comparison of technologies for printing

The alternative technologies for printing have been compared in respect to various socio-economic aspects. The results are reproduced in table 9.

TABLE 9. COMPARISON OF ALTERNATIVE TECHNOLOGIES FOR TEXTILE PRINTING (PRODUCTION: 50,000 M/DAY)

Technologies	*Number of machines*	*Investment[a] (million Rs)*	*Employment (persons)*	*Average monthly wage (Rs)*	*Labour cost (Rs/m)*	*Capital cost (Rs)*	
						Per worker	*Per metre[b]*
Hand-screen printing[c]	–	2.00[d]	600	350	0.17	3 300	0.03
Roller printing (6 colours)[e]	3	1.80	63	400	0.02	28 600	0.02
Flatbed screen printing[c]							
Semi-automatic (domestic)	18	8.28	486	450	0.16	17 000	0.11
Fully automatic (imported)	12	14.40	216	450	0.08	66 700	0.20
Rotary screen printing[e]							
Domestic	2	4.40	60	475	0.02	73 300	0.06
Imported	3	12.00	90	475	0.04	133 300	0.15

[a]Cost of rollers and screen not included.
[b]Computed by dividing the investment, discounted at the rate of 16 per cent over 10 years, by the annual production.
[c]Single-shift operation.
[d]Cost of tables.
[e]Three-shift operation.

The problems in comparing different technologies are less difficult with printing than with spinning, weaving or knitting. Although the various methods differ with respect to styling possibilities, intricacy of pattern, clarity and the like, there is adequate common ground for comparison. It can be seen in table 9 that hand-screen printing compares favourably with the other technologies in terms of labour cost. The advantages of hand-screen printing are even greater in short runs, as mentioned earlier. This technology is also labour-intensive. It should be noted, however, that the space requirements for hand-screen printing are considerably higher than for other techniques. The cost of land and buildings will add to the capital requirements; these have not been included in the present analysis because they vary significantly from region to region.

THE GARMENT INDUSTRY IN INDIA

Garment-making as an organized activity has not yet struck deep roots in India. The industry came into existence during the Second World War in response to the demand for military uniforms and subsequently changed over to civilian needs. In the 1950s and early 1960s, garment-making was more or less at the cottage industry level. Between 1963 and 1970, a number of large and medium-scale factories were set up, primarily as a result of the expanding international trade in garments. The schemes introduced by the Government of India for the promotion of garment exports stimulated the growth of the industry.

Comprehensive information is lacking on the capacity, production, employment and other aspects of the Indian garment industry. It has been estimated that approximately 500,000 persons are engaged in the industry. Available data have been analysed to obtain an indication of the size of the garment-making units (see table 10).

TABLE 10. DISTRIBUTION OF GARMENT-MAKING UNITS IN INDIA, ACCORDING TO SIZE

Number of machines	*Number of units*	*Percentage of subtotal*
Fewer than 10	26	8.5
11 to 50	137	45.1
51 to 100	73	24.0
101 to 500	60	19.8
More than 500	8	2.6
Subtotal	304	100
Data not available	286	
Total	590	

Source: Indian Clothing Directory, 1977 (Bombay, Clothing Manufacturers Association of India).

Capacity utilization in the Indian garment-making industry is relatively low, amounting to an overall average of 65 per cent (single-shift) according to a survey carried out in 1970–1971 [3]. Generally speaking, the smaller and medium-sized units concentrating on exports have higher capacity utilization.

The garment industry represents a combination of a fair degree of mechanization and labour intensiveness. For instance, the investment on machinery required for a unit with a capacity of 500 garments per shift at a level of technology fairly common in India today would be approximately Rs 0.35 million. Such a unit would provide 120 work places, so the investment per work place would be about Rs 3,000. On a cottage-industry level, the investment per work place would be even less; each pedal-operated sewing machine costing approximately Rs 800 would employ one person. In such a set up, centralized facilities for buttonholing, overlocking and the like will have to be provided, so that the total investment per work place may come to about Rs 1,500.

Labour productivity in the Indian garment-making units is lower than in many other countries, particularly Western ones. Units employing manually operated sewing machines have an inherent limitation with respect to labour productivity. Streamlining the operations and the systematic adoption of industrial engineering techniques would help to increase labour productivity. Despite the lower output per worker, India enjoys distinct cost advantages over the Western countries because of its lower wage level.

CONCLUSIONS AND RECOMMENDATIONS

Vastly different technologies exist side by side at almost all stages of textile production in India. This situation results from the interplay of history, tradition, economic forces and social conditions. The two sectors–organized and decentralized–are interdependent; each has its rightful place in the Indian economy.

The organized sector has the advantages of low labour cost per unit volume of production and better co-ordination of individual operations, arising out of its technology and process integration, respectively. The size of the unit and scale of operations also confer on the organized sector significant marketing and financial strengths. On the other hand, the technology of the organized sector is relatively capital intensive and offers fewer employment opportunities.

The new highly capital-intensive and labour-displacing technologies cannot be justified socially, nor are they economically viable for most mills in the organized sector. This situation is likely to persist as long as factors such as parity of capital and labour costs, quality expectations and technological adaptability remain unchanged.

While it appears that conventional technology will dominate in the organized sector in the foreseeable future as well, it must be more efficiently utilized and modified for increased productivity, reduced costs and improved quality. Simultaneously, there is a case for selective adoption of advanced technology to meet the needs of special domestic and export markets.

The decentralized sector in India, apart from holding a major share in fabric production, fulfils the important social objective of providing employment. It has the advantage of being better equipped to cope with small volumes of production. Its strengths are therefore in products or markets where short runs of distinctive designs are in demand. The forging of closer local linkages between production and consumption will add to the viability of this sector. Because of the favourable capital:employment ratio, the decentralized sector has social value.

The non-integrated nature and the small-size of the operations pose several technical and organizational problems in the decentralized sector. The small size of the units makes them particularly vulnerable to market fluctuations. Lacking the organizational, financial or marketing strengths of the larger units in the organized sector, they are the hardest hit when there is a shortage of raw materials or a fall in the demand for the fabric in question.

Lack of flexibility in handling different varieties of yarns and fabrics is a limitation in some of the decentralized sectors. For example, cottage-scale finishing, in its present stage, will be unsuitable for processing fabrics from non-cellulosic fibres or their blends. Such fabrics require fairly high and closely controlled temperatures in dyeing, printing and heat setting, which is possible with the present methods currently in use. Yarn dyeing in the hand-loom sector also presents problems.

While the investment per work place in the decentralized sector is very much lower than in any of the technologies of the organized sector, the decentralized sector technology does not compare as favourably with the intermediate technologies of the organized sector in terms of the total investment for a given volume of production. In other words, the present technologies of the decentralized sector are highly labour intensive and at the same time require a fairly high level of capital investment. This aspect must be recognized, especially in the context of the general scarcity of capital.

It should also be pointed out that the competitiveness of the decentralized sector as against the organized sector now rests largely on the product reservation and preferential excise duty structure. The low labour productivity and, consequently, the high labour cost per unit of output would make the decentralized sector economically unviable in the absence of the present incentives. The application of narrow economic yardsticks to the exclusion of broader social considerations can be justifiably questioned. The need for continued government support in the near future is undisputed, but there is a strong case for encouraging increased self-reliance in the decentralized sector as a long-term goal.

Although the wage cost per unit of output is high in the decentralized sector, the wage levels are low in absolute terms. They are acceptable only against the background of widespread unemployment in the country. Only a higher level of output can offer any meaningful increase in the earnings of the labour force in the decentralized sector. Therefore, narrowing the technological gap between the organized and decentralized sectors without seriously disturbing the capital-employment components of the decentralized sector becomes an urgent task.

The fiscal and development policies of the Government are the most powerful tools in shaping the future pattern of growth. A clear enunciation of a comprehensive long-term policy is necessary. It should cover raw material supplies, production targets, time schedules, alternative approaches and the roles of different manufacturing sectors and other agencies. Linkages between the textile and other industries should be identified.

The supply of raw materials in adequate quantities and at reasonable prices is vital to all sectors of textile production. A parity in prices of raw materials and finished products is a prerequisite for economic viability of production and its growth. Further utilization of the existing capacity in the organized sector is imperative. Judicious renovation and modernization, correction of imbalances in the present capacity and stricter attention to machinery maintenance are all steps which, by themselves, would generate the substantial volume of additional production required to meet increasing consumption. Therefore, these aspects should receive priority over capacity expansion.

The technology in the decentralized sectors must be improved. The objective should be to enhance labour productivity and product quality with only marginal increase in capital costs. Favourable features of the more advanced technologies can be adapted to suit the requirements of this sector.

The Ambar charkha, which is a striking example of such amalgamation of technologies, can itself be further improved. Similarly, a combination of selected stages of the more advanced technology, in miniature if necessary, with labour-intensive cottage-scale operations, can also be the basis for an appropriate technology. The concept of *Lok Vastra* (people's cloth), which is still in an experimental stage, is based on this approach. The textile research institutions, the textile machinery manufacturing industry and other agencies should jointly take up this challenging and rewarding task.

Institutionalized arrangements should be strengthened to extend on-the-spot consultancy, training and technical services to the decentralized sector. The store of knowledge built up by textile research associations in optimization, cost reduction and quality improvement is largely relevant to the decentralized sector as well. A more extensive transmission of this know-how is called for, to raise the overall level of technological awareness and capability. In parallel with this, centralized facilities should be set up for machinery maintenance and the supply of spare parts.

The formation of co-operatives should be encouraged to reduce the present vulnerability of the decentralized sector as regards raw material procurement, finance and marketing. The structures of several such co-operatives that are functioning successfully can be used as guidelines.

Technologies of knitting and garment-making, which combine a fair degree of mechanization with labour intensiveness, can be used advantageously for meeting both domestic and export demands. Facilities for expanding these segments should be created.

There is scope for regional co-operation, particularly among countries which, because of similarities in their factor endowments, are guided by broadly identical considerations in the choice of technology. The Indian experience, with its blend of intermediate and cottage-level technologies, can serve as a model for other countries where the textile industry is of comparatively recent origin.

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Appropriate technology for cotton yarn spinning in rural areas

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The introduction of mechanization has had a serious effect on the cottage textile industry. Hand spinning has almost completely disappeared, and hand-loom weaving, where it survived, has done so only at a subsistence level where other employment was not available. However, the manufacture of cloth remains, after agriculture, the industry with the highest employment potential and is thus a valuable asset for developing countries, especially those with large resources of rural labour. The major problem, meanwhile, in initiating a programme of cottage or small-scale cloth production in rural areas on a decentralized basis or for any upgrading of existing hand-loom weaving is the lack of the proper technology for decentralized cottage spinning.

The necessary weaving technology spans a wide spectrum. Many types of looms, from traditional to semi-automatic power looms, together with dobby and Jacquard arrangements to weave more complex cloths, are available.

If economic and technologically sound decentralized cottage spinning could be evolved, the textile industry could be decentralized in cottages in developing countries. The economic conditions of the cottage weavers where they still exist, as in India, could be considerably improved.

Situation of the cottage textile industry in India

In India, the strength of the decentralized cottage weaving industry, particularly among the self-employed, is demonstrated by the fact that 50 per cent of Indian cloth production comes from it. The weakness of the industry is in its yarn supply. The cottage weavers, being at the end of a long distribution chain, frequently suffer problems of irregular supply and high costs. The weavers' associations claim that they pay between 25 and 30 per cent above the ex-mill price for their yarn; a figure which has been verified by Government investigations.[1]

Cottage weavers also have problems in obtaining adequate working capital. The total number of persons employed in the large-scale textile industry in

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[1]*Powerloom Inquiry Commission Report, 1964.*

India, both spinning and weaving, is about 1 million, while the cottage weaving sector, based on the number of installed hand looms, is estimated to employ 7 million. Wages range from about Rs 15 a day in large-scale industry to between Rs 3 and Rs 5 a day in the self-employed cottage weaving sector.

The Government of India has initiated a number of schemes to ease the financial and marketing problems of the hand-loom weavers. A number of co-operative spinning mills have also been established to supply yarn to the weavers, but prices have remained similar to those of commercial mills. There has been some improvement in the availability of yarn, but the efforts have fallen short of upgrading most hand-loom weavers from starvation or subsistence levels.

If these weavers could be supplied with yarn at the same price as the mills, with greater surety of supply, their income would increase and they would be in a position to take care of their future development.

The only solution appears to be to develop a spinning technology in villages, preferably within the weavers' families, so that much of the marketing and transport expense in the yarn price could be avoided. It is estimated these efforts could create approximately 1 million jobs in rural areas in India.

The movement to revive hand spinning and other village industries in India began in the early 1920s, in response to concern at the collapse of traditional village industries in the face of competition from large-scale industries set up at the end of the nineteenth century. The movement advocated the revival particularly of the manufacture of hand spun and hand woven cloth later known as khadi.

Ashrams were set up all over the country to produce yarn on hand spinning wheels (charkha). The technology was cheap and simple, but the khadi cloth was coarse and uneven. It became the clothing material symbolic of the national movement, but as it was more expensive than mill cloth, it was not accepted by the mass of the people as usual daily wear.

In 1950 development work was started on the charkha and the spinning frame. In hand spinning, the right hand is used for giving motion to the spindle and the left hand is used to draw, twist and wind the yarn on the spindle. Considerable skill is required, but even so the quality of yarn is not uniform and the strength is low. The ring-spinning frames used in the mills do this work mechanically; one worker can control over 200 spindles. Productivity per person is therefore very high, although the output per spindle is only about 2½ times higher.

To increase the productivity and to improve the quality of yarn, a textile mechanic designed a four-spindle wooden charkha, later known by his name as the Ambar charkha. This charkha, or spinning frame, was still hand operated but the drawing of yarn, twisting and warping on the spindle were done automatically, leaving the operator's other hand free. The quality of the yarn improved, but despite the use of four spindles, productivity did not rise in the same proportion and working the four-spindle Ambar charkha by hand was very tiring for the operator. Efforts were then made to design machinery for processing the cotton before spinning. Two types were developed.

Further improvements came when the four-spindle charkha was developed into a six-spindle model incorporating many features of standard mill machinery. Later a 12-spindle charkha was built, with a treadle drive. The quality and productivity of khadi yarn improved, but it was still inferior to mill-spun yarn. The Appropriate Technology Development Association (ATDA) helped in the final stages of design to achieve almost the same amount and quality of yarn as that produced by large-scale spinning units. Trials to produce 20-count yarn[a] have resulted in a quality of yarn almost identical with that of large-scale mills and it has found acceptance with the hand-loom weavers. Projections based on the trials indicate that the yarn will be up to 15 per cent cheaper to the weaver if the spinning is carried out in cottages by individual artisans. If the spinning can be done within the weaver's family, the yarn can be 22 per cent cheaper. It may therefore be concluded that it is possible, with the adoption of newly developed machinery, to set up an appropriate technology for cottage spinning in rural areas and to operate such an industry efficiently in developing countries. In India, the hand-loom sector is already well established in cottages in rural areas. Developing the cottage spinning technology will go a long way to improving the conditions of the weavers. It should also be possible to extend cottage spinning and weaving systems into new areas.

Efforts at improvement

Need for infrastructure

A suitable infrastructure is as important for industrial production as product selection and efficient technology, especially in ensuring the supplies of raw materials for the marketing of goods and the provision of finances.

The traditional rural industries in India had their own infrastructure but, owing to the development of mechanized large-scale technology, it broke down. The rural artisan-entrepreneur obtained better returns from working for large-scale technology. Fiscal policies led to a shift of capital to urban areas to meet the growing demand of large-scale industry. There are now hardly any facilities available for rural artisans. Capital costs are high, and the raw material supply is from urban areas, mostly on credit at high rates of interest. This has led to large-scale migration of rural artisans to urban areas. Many skills and abilities have thus been lost. Any proposals for developing rural schemes for cotton yarn spinning, in India, will therefore have to include the following:

(a) Introduction of suitable technology and its extension by providing the technological know-how and operational advice;

(b) Assistance with production activities that cannot be scaled down to the cottage or individual artisan level;

(c) Product development and diversification;

(d) Training and demonstration programmes;

(e) Research and development (R and D).

[a]English count system.

Progress to date

A review of the schemes and programmes being carried out for rural industrialization by the Government and other organizations reveals the lack of a comprehensive coverage of the needs outlined above. These schemes mostly provide financial and marketing facilities on a co-operative basis (only recently have individual financial facilities been given to individual craftsmen), limited to urban or semi-urban areas. Technological research and product development have not been exploited because of lack of finance and readily available technical advice. The impact of these programmes has therefore been limited.

Other schemes have been more successful. Gandhi Ashrams have a more comprehensive coverage of needs and, despite lower technology, are producing 1 per cent of the total cloth production in widely dispersed rural cottages. The organization is in two parts, the service centre and the cottage units. The centre supplies the raw materials, arranges pre-processing and marketing, and provides finance on a co-operative basis. ATDA, in India, has adopted the same organizational pattern for its cottage spinning projects, which has proved its effectiveness in establishing technology. There are, however, problems of extending this work, for which a large number of service centres would be needed. It would have to be decided who would own and operate them, and who would provide the financing. Statutory bodies gradually tend to overlook the interests of the craftsmen, and voluntary organizations need dedicated teams of workers, which may not always be available.

Co-operatives, at least in their present forms, have failed to improve the conditions of the rural artisans. They have been formed without proper assessment of needs or the certainty that they can provide a meaningful increase in incomes. Small co-operatives cannot afford the right type of managerial skills needed for efficient organizations. The members of co-operatives, being themselves weak and dependent, are rarely in a position to exercise control over the managements, so outsiders often take control of them and run them for their own benefit. Finally, the loan obtained by the society must be paid back at high rates of interest and within a short time, sometimes leading the management of the society to increase service charges, and the artisans find themselves with a lower net income than they had before they joined.

In some cases, once a productive activity has been well established, a private entrepreneur gets interested in it and manages to take it over. This can also be unsatisfactory because, in both the case of the co-operative societies and that of organizations run by the private entrepreneur, there is usually a large difference between the financial conditions of the craftsman and the entrepreneur, and this leads to complete dependence of the artisan on the entrepreneur.

This weakness is often exploited. J. W. Powell, a visiting professor from the Technical Consultancy Centre, University of Science and Technology, Kumasi, Ghana, who spent four months with ATDA and helped in designing and planning a decentralized spinning project, felt the project should aim at raising the income of the artisans to a level where, besides providing decent wages to meet daily living expenses, some reserves might be built up to help deal with private entrepreneurs or to exercise or share some control over the organization of the co-operative.

An analysis showed that, by working with a 24-spindle spinning frame, the worker would be able to have only a subsistence-level daily wage rate of between Rs 5 and Rs 8 after deduction for share capital. When working with a 72-spindle spinning frame, the wage rate would be about Rs 20 net after meeting the cost of the spinning frame and other expenses, which would be an adequate rate. As a start, the 24-spindle frame is being introduced in cottages but, gradually, successful cottages will be upgraded to operate frames of between 48 and 72 spindles.

ATDA pilot project

ATDA, in co-operation with the Intermediate Technology Development Group in the United Kingdom, and with funds provided by Christian Aid, has set up a pilot project on decentralized cottage spinning. Its objectives are as follows:

(a) To use cottage spinning technology in field conditions to demonstrate its technical feasibility and economic viability;

(b) To demonstrate that rural cottage spinning can give higher incomes to cottage weavers, preferably through joint spinning and weaving arrangements;

(c) To provide pre-weaving facilities for increasing the output and quality of the cloth, thus also improving the economy and income of the cottage weavers;

(d) To diversify the product of the cottage weavers by developing varieties of cloth with improved designs and patterns;

(e) To organize training programmes in both spinning and weaving;

(f) To carry out R and D to increase efficiency in plant and machinery for cottage spinning and cottage weaving;

(g) To develop a co-operative organization to take over the activities and operate them on a self-financing basis.

With the achievement of the first objective the project would create about 1 million jobs throughout India.

The pilot project should make available two kinds of integrated plant. The first would introduce decentralized spinning technology into areas where cottage weavers are already working; the other would establish cottage textile complexes in rural areas in family groups in developing countries.

The project has been located at Kushmi Kalan in the district of Ghazipur. There are about 200 hand looms within 8 km of the project; the capacity of the centre will be sufficient to supply all of them. It is proposed to extend the activities to other areas later.

The project is divided into three sections:

Service centre

Cottage units

Co-operative organization for supply and marketing

Service centre

The service centre will supply the following needs of the cottage units:

(a) Pre-spinning. The cotton will be brought and processed into rovings. These rovings will be supplied to the cottage units through a co-operative society on a cash or credit basis;

(b) Pre-weaving section. Costs can be saved for cottage weavers if pre-weaving facilities for warping and sizing are made available. The hand warping carried out by weavers does not stretch the yarn properly, so weak yarns are often passed to the hand looms. This leads to breakages at the loom, and the productivity of the weaver is reduced. In mechanized warping, weakened yarn is exposed and rectified. Similarly, hand sizing is uneven and also leads to frequent breakages. Mechanized warping and sizing can increase productivity by 12 to 15 per cent, and the quality of cloth is better. The higher costs of mechanized warping and sizing can be covered by increased productivity, still leaving 7 to 10 per cent extra income for the weaver.

An efficient sizing machine does, however, require steam for its operation. At first, kerosene burners were used but were replaced later by electric heaters;

(c) Training. Training will be carried out on the same type of spinning frames as will be installed in the cottages. The trainees will be drawn from rural areas, preferably from weaving families. Yarn produced by them will be sold. The cost of training will be met as far as possible from the earnings of the service centre;

(d) R and D. The centre will carry out R and D as outlined in the objectives above.

Cottage units

The cottage units will be of two types, mechanized and integrated with the cottage weavers or as separate spinning units, or non-mechanized as separate spinning units in areas where khadi cloth is produced.

In the mechanized units, there will be electrically driven 24-spindle ring frames. Later, the number of spindles will be increased to reach, within three to five years, a total of 72 spindles per cottage. In the non-mechanized units, a foot-driven 12-spindle ring frame will be installed. The increase in the number of spindles in these units may not be possible unless the number of operators in a family working on a shift basis is increased, or more machines are owned and operated by a family group.

The finance to meet the capital cost of the cottage units is being arranged from the nationalized banks on loans at a 4 per cent rate of interest. From the daily earnings of the units, deductions will be made to repay the loan. A handicap is that the repayment period is only five years, and the deductions will reduce the earnings of the cottage spinners to a level where there may not be sufficient incentive for them to take out loans. Attempts are being made to have the repayment periods increased.

Co-operative groups

A co-operative organization is being set up in which each of the cottages will have a share capital of Rs 100. This amount will be raised later to Rs 1,000 for each cottage. ATDA is buying shares for about Rs 5,000 each. Negotiations are also being held aimed at persuading the Government to buy shares.

The marketing of cloth will be handled at the risk of the weavers, who will give the cloth to the society for marketing at whatever price is available. The society will deduct a service charge. However, when weavers demand immediate payment, cloth may also have to be bought and sold at the risk of the society.

The operation and control of the society will be with the development agency, Organization of Rural Poor, with the help and advice of the ATDA. Attempts will be made to build up the capital of the society by service charges and raising the share capital of each worker gradually so that, within three to five years, the co-operative group might be able to take over the service centre.

Dualism and technological harmony for balanced development of the textile industry

*G. K. Boon**

Economic and technological dualism

Developing countries are commonly characterized by a duality of development. That is, they promote both high technology from developed countries and traditional methods. The effect is often to establish pockets of economic and industrial development that resemble a country more advanced than the one in which the pockets are located. This dualism, consisting of a small modern sector, usually concentrated in and around a number of big cities, and a large, virtually unaffected part in the semi-urban and rural areas, creates several important imbalances.

One cannot ignore the industrial development that has already taken place in the third world, which, in certain countries, has been occurring for three or four decades. The modern industrial sector in developing countries is a reality. It is dependent on first-world technology, and it is safe to assume that this dependence will continue in most modern, high-technology production areas for many years to come. New semi-urban technology or existing adapted technology should be produced in the third world. Although there are economies of scale in the production of machinery, some decentralization in production would be possible.

Instead of creating a third-world technology distinct from that originating in the developed world, one could aim for technological harmony: the third, second and first worlds applying the same basic technology in the modern, high-technology, large-scale production areas that originated in the first world. Consequently, any technological contradiction would not be between the third and first worlds but rather between the modern sector in the first and second worlds on the one hand and the semi-urban and rural sectors in the third world on the other. There is little doubt that a more balanced development in the third world could be accomplished by upgrading the technology of the semi-urban rural areas instead of downgrading the technology of the modern sector. Such a technology could satisfy the most fundamental need of this area, that is, employment.

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The role of a semi-urban textile industry

To decide the economic feasibility and usefulness of semi-urban textile industrialization in developing countries, it is necessary to distinguish four cases:

1. No textile industry
2. Cottage textile industry only
3. Modern textile industry only
4. Both modern and cottage textile industries

Case 1. No textile industry

In the first case, semi-urban textile manufacturing is almost certain to be preferred to modern-sector textile or rural textile industrialization. Although a country without a textile industry of any kind has no skilled labour, a labour-intensive textile industry creates employment and the need to develop skills which are, however, of a relatively simple type. Naturally, the choice should be for a simple technology with which the labour force could easily become acquainted. Every country's textile needs include a considerable amount that could be produced within the capabilities of the simpler textile technology. Nevertheless, technology of this type, although relatively simple, is seen as being fully modern. For example, in the case of weaving machinery, it concerns fully automatic shuttle looms.

In the textile industry, the technology in the final stage of spinning and weaving is not characterized by economies of scale, at least not as far as the capital invested in the equipment is concerned. The technology is therefore suitable for decentralization. It is thus possible to apply modern, sturdy equipment in relatively small production units. There are, however, certain economies of scale in overheads and in the textile finishing processes such as dyeing and printing, and a certain concentration of textile industrial activities may be worthwhile, although the actual production can still take place in a relatively large number of units. Such a concentration could help with vocational training centres, raw material production and, ideally, buying and selling the raw materials and final products. As small-scale industry implies a restricted economic power of the producing units, the possibility of exploitation by more powerful sellers and buyers is a problem, which can, however, be reduced by co-operatives or unified bargaining with third parties.

The start-up of a textile industry in a country without any such activity calls for some protective measures. Certain materials can be produced competitively within the country; for other materials, the country may have to rely on imports such as yarn of the coarser types and polyester staple or filaments.

Should a country start a textile industry if no industrial activity of this kind exists? Obviously, a country can always import textiles; to do so would be a perfectly rational decision if the country in question specializes in outputs where its comparative production advantage is stronger. Nevertheless, few countries want to be completely dependent on imports for such a basic need as textiles.

Case 2. Cottage textile industry only

When a country has only a cottage textile industry, the development of a semi-urban textile industry is again preferable to a modern, more capital-intensive textile industry. The reasons are basically the same as those provided above for the first case.

Case 3. Modern textile industry only

When the country already has a modern centralized urban textile industry, the justification for a semi-urban industry seems less strong. By means of certain incentives, expansion of the existing firms in the semi-urban centres may be induced. To initiate an independent semi-urban textile industry that, in a market economy, would have to compete with an existing modern industry may or may not be feasible, depending on the particular market and other relevant conditions.

Case 4. Both modern and cottage textile industries

In the fourth case, where the country has both a modern textile industry and a cottage textile industry, an intermediate, semi-urban textile industrial development may be possible, but whether it is feasible depends again on the situation. Incentives may be given to the existing industry for reallocation to semi-urban areas or to expand into those areas. Also, cottage industrial textile activities can be stimulated, and certainly many cottage industrial entrepreneurs would have the chance to move up into a semi-urban type of production.

Interrelation of textile industrial activities

Whether there is a real need for semi-urban textile industrial activity and whether such a development is feasible depends very much on local conditions. The possibility always exists, but the need and feasibility cannot be discussed meaningfully in general terms.

When the development is feasible, what should be the interrelation of such a semi-urban textile industry with the already existing textile activities?

When the existing industry is only of the cottage type, the interrelation is of minor importance, as both types of activity largely produce different outputs for different markets. Nevertheless, industrial yarns produced in the semi-urban centres might become an input for the cottage textile-weaving industry, enlarging its output and improving its quality.

In case 3, where the country already has a centralized modern textile industry, the interrelation with the semi-urban textile industry is stronger, because it is likely that the existing industry will be involved in the more decentralized textile activities. Again, in case 4, a strong interrelation between the urban textile centres and the semi-urban centres is envisaged, possibly with certain links to the cottage textile industry.

Appropriate technology for the semi-urban textile industry

In general terms, the technology should be easy to operate, maintain and repair. The skills required should be relatively easy to acquire. The requirement of the equipment is not to minimize operating, maintenance and repair time. Although modern equipment should be used, it must be relatively more labour intensive than capital intensive. Although the equipment must be of intermediate quality, its technical lifetime could still be long, with proper maintenance and repair services. The equipment should be of restricted versatility; specialization in output should be by firm. Reducing the output versatility simplifies the machinery, making it cheaper to produce. Automatic greasing and other automatic maintenance options should be eliminated. Although the equipment should have about the same level of mechanization and automation in its basic performance as the technology for the modern sector, all other automatic features should be eliminated.

What the source of the technology should be depends on whether a semi-urban textile technology is already in existence or whether it must be designed, manufactured and supplied. Generally speaking, for most developed countries, manufacturing a semi-urban textile technology is not profitable. Nevertheless, in this area some relatively simple modern equipment is available that is excellent for application in the modern textile sector of the third world. Brazil, China, India and Japan are sources. This type of textile machinery is usually produced under licence as "frozen technology", that is, a technology that is no longer used in the first world and therefore no longer subject to R and D. Although its price is attractive, this equipment has some disadvantages, particularly in that after-sales service is often deficient. Another major problem is that the firms making this equipment are rarely well represented in the developing countries and so, although it is theoretically available, in practice it often cannot be acquired.

An important factor is that the reputations of the first-world suppliers are so good that developing countries often prefer their technologies to cheaper alternatives. This preference also explains why other suppliers may have difficulties in building up their marketing and after-sales services. The problem with frozen technology is that it embodies technological know-how that is possibly 25 years old and is therefore not necessarily the best technology for developing areas any longer. It might be better to develop a fully up-to-date technology that makes use of the latest know-how while being basically simple and labour intensive.

It is possible that the third world has sufficient talent and expertise in textile technology to work out the design principles of the various required production techniques and to build the prototypes. To implement such an idea it would be necessary to employ new or existing nationai or supra-national third-world research institutes. The R and D work on new technologies could be financed by a third-world R and D bank to which each country would contribute, according to an agreed formula.

There is another way to attain appropriate semi-urban technology. Some reputable first-world technology designers, manufacturers and suppliers are, in principle, interested in designing a semi-urban textile technology. At the same time, they have no wish to manufacture this equipment but are, in principle, willing to help in setting up factories in developing countries.

Naturally, these first-world technology producers, whose business is the design, manufacture and sale of technology, must be compensated for their work on the basis of normal commercial practice. The R and D work might be done on contract for a third party, or they could hold title to any resulting patents. This possibility has some attractive aspects. Use is made of the best know-how available. If the name of a well-known first-world technology producer is linked to a certain machine design, it would help to sell this technology in the third world.

The semi-urban textile technology should be commercially supplied by the third-world manufacturers to neighbouring third-world countries and, on the basis of a common export-promotion plan, be marketed in the first world for possible use in a decentralized, small-scale, labour-intensive textile branch for speciality inputs. It is hoped that, in the future, an international trade in technology might develop which would change the technological dependency of the third world on the first world into an interdependent relationship. At present, there is an enormous trade in textiles, particularly from the developing to the developed world, while technology flows almost exclusively from the first world to the third world.

Generally speaking, a semi-urban textile industrialization in developing countries would seem to be both useful and feasible. Some appropriate technology for this is produced in the second and third worlds, sometimes under licence from a first-world supplier. However, under present conditions, its actual availability in the third world is strictly limited because of deficiencies in the marketing, distribution and after-sales service of the suppliers.

It might be worthwhile, therefore, to investigate the possibility of a specifically designed third-world, semi-urban, fully modern textile technology, making use of the know-how of the first world's most prestigious designers—a simple but fully modern textile technology.

Appropriate technology in the textile industry of Sri Lanka

*I. Afzal**

Background

The cotton spinning and weaving industry in Sri Lanka has been in existence for so long that its origin cannot be dated. Whether or not there were local perennial cotton plants is uncertain, but the Portuguese who occupied the country in the seventeenth century must have introduced the New World cottons there, as indeed they did in their territories of Daman and Goa on the Indian mainland [1]. These cottons, however, failed to take hold. In any case, traditional trade could account for the import of raw cotton from southern India where the perennial *Razi* cotton had been well established.

In pre-colonial times, home spinning and hand-loom weaving were the rule. The industry must have been small, as the local production of raw cotton was very limited and utility textiles could be easily brought from India. It should be remembered that India was the dominant manufacturer of cotton textiles from about 1500 B.C. to 1 500 A.D. [2]. The local spinning and weaving industry in Sri Lanka seems to have developed into the production of specialities, of which batik-printed cloth is still produced.

The modern textile industry in Sri Lanka began in the 1930s. In 1978, the private sector included nine mills with 269,740 spindles and 2,650 looms. In addition, there are 5,133 power looms operated by the Government Department of Small Industries and various co-operatives. There are more looms in the dispersed sector, of which about 100,000 are hand looms devoted to the production of cheap cloth with no quality control and 1,308 looms for weaving nylon sari and suiting cloths.

Although well dispersed, the Sri Lanka textile industry cannot meet the domestic demand for textiles, which is of the order of 12 yd^2 (9 m^2) of cloth per person per year. Huge quantities of piece goods are imported, which constitutes a very serious drain on foreign-exchange resources. The need for expansion is clear.

The machinery in the public-sector mills ranges from good to obsolete and is only slightly better in the private-sector mills. A programme of balancing, modernization and replacement of obsolete machinery is called for. Spare parts are either unavailable or in short supply. Appropriate technology can play a role

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in this regard in selecting the spare parts which could be advantageously manufactured or fabricated locally. Domestic production of quality and durable spare parts would need to be developed.

Raw material

At present, a small amount of raw cotton (about 1,000 bales per year) is produced in the Uda Wallawe tract in the south of the country, where rainfall is about 500 cm. This area has two rainy seasons, the summer and winter monsoons. Such a climate is unsuitable for cotton cultivation, which requires a dry season during the maturation of the bolls.

It is anticipated, however, that cotton will be an important crop in the Mahaweli Diversion Scheme in the northern, comparatively dry part of the country. When additional mills are set up, priority should be given to this area. It is thought that there will ultimately be about 30,000 acres (12,000 ha) under cotton. Even then, domestic cotton production will be insufficent, but it will be a good beginning. It is suggested that experimental work on cotton should emphasize the production of extra-long-staple cottons. In latitudes and climates similar to those of Sri Lanka, Sea Island cotton is grown in the West Indies, particularly in St. Vincent, and in certain islands of the Pacific. If Sea Island cotton can be established, Sri Lanka will have a ready supply of the best cotton in the world, which it could also export to great advantage.

Technological alternative

The level of appropriate technology envisaged for a country will determine the appropriate type of machinery. The minimum technology would be the hand loom, which has only one operator, and automatic shuttleless weaving machines, also tended by one operator. The other extreme would be a fully automated plant with chute feed, cross-roll cards, shuttleless looms and a continuous finishing process. This would mean a very high level of technology but a minimal labour input. If the level of technology and the level of employment were weighed against each other it would probably mean that Sri Lanka should compromise with simple power looms with a few automatic stop motions. With its high production rate, knitting can be and is an alternative to weaving. The market for knit fabrics, however, is limited, and once again the installation of knitting machines will depend upon the level of technology, coupled with the levels envisaged of both employment and demand.

The choice of a suitable line of machinery for the new cotton textile mills offers an excellent chance to improve the industry and adapt it to present needs. It must be mentioned, however, that the cotton textile machinery has evolved from the mule to open-end, sliver-to-yarn and twistless spinning. Most of the preparatory processes such as the blow room, cards and draw frames have also undergone many changes. There are spinning frames without spindles and looms without shuttles, and there are also textured yarns. The raw material has also undergone a transformation from the coarse and harsh Asian *Gossypium* *arboreum*, half-and-half types of *G. hirsutum* to fine and extrafine *G. hirsutum* and *G. barbadense* cottons and a bewildering variety of man-made fibres. This wide choice of raw materials offers an excellent chance to improve the industry.

Blow room

Over recent decades, opening and cleaning machines have been improved, along with the spinning machines. From scutcher lap, the industry has progressed to the chute feed. Few technological alternatives are available in this area.

Card room

Choice can be made between the ordinary low-production card, the high production card, the tandem card, or the card fitted with crush rollers. Careful study of quality and appropriate technology in this section is advocated. If an existing mill is being expanded, the modification of the existing cards, together with the installation of the crush rollers, would mean that the existing cards would be enough to satisfy the increased spinning capacity of the mill, which would save considerable foreign exchange. The training of production workers and of the maintenance staff would be necessary. It is recommended that a technical training institution for the required skills be set up as a matter of priority.

Draw frame, comber and roving frames

The range of alternative technologies is limited here. It is essentially reduced to the selection of speeds, drafting systems and package sizes. To some extent, the drafting system would depend upon the choice and quality of raw materials.

Spinning

The choice of appropriate spinning technology is quite wide. It can be made from small lift to high lift, from low draft to super-high draft, from ordinary to live ring and finally between ring spinning and open-end spinning.

The choice of appropriate technology will be dictated by the level of employment required, the level of yarn quality required, the availability of suitable back-processes, the availability of skilled operators and maintenance staff and of facilities for training them.

The open-end yarn, although slightly inferior to ring-spun yarn in strength, is less irregular and thus more suitable for knitting. Open-end yarns sell at a premium, and the number of workers employed and the power used are much less than required in ring spinning. Moreover, the mechanical and dyeing properties of open-end yarn are quite different from those of ring-spun yarn. However, the comparatively higher unit cost of open-end machines should be kept in mind.

It is suggested that an in-depth analysis be carried out by taking into account such factors as the back-processes and the quality required before deciding on the level of appropriate technology and thus the level of sophistication of the yarn-forming systems.

Blends of cotton and man-made fibre

The mass market requires a quality fabric that is durable, comfortable, fast in colour and low in price. Synthetics could answer the above requirements but would be uncomfortable in the hot and humid climate of Sri Lanka. The choice of appropriate technology in this case should be the cotton-polyester blends. The most common blending ratios are 35/65 and 20/80. Appropriate technology would be required to process the blends, especially in finishing them.

Hand looms

Conditions in Sri Lanka now clearly favour a higher degree of technology than that of hand looms, which require long hours of hard toil and at best yield a poor return.

Most hand looms should be replaced with power looms, with perhaps weft and warp stop motions. However, a sufficient number should be retained to produce special fabrics for export. Before such a decision is made the following questions must be answered:

(a) What employment level is envisaged?

(b) Are there foreign markets for the product?

(c) Are the levels of education and skill of the labour force high enough to warrant a higher technology in the form of power looms with few stop motions and perhaps automatic weft replenishment?

(d) If the level of education of the workers is high enough, are facilities for training them in the new technology available?

(e) Is the conversion capacity large enough to absorb the increased fabric production that would result from the introduction of higher appropriate technology?

Reliable production figures for the hand-loom sector are not available. It is clear, however, that the bulk of production goes to local markets and only about 1 to 5 per cent is contributed to the export market in the form of batiks. An in-depth study would reveal the weaknesses of this sector. Some of them are the following:

Growth without due attention to future market requirements

Lack of quality control and resultant difficulties in maintaining any quality level or knowledge of market requirements

Limited technical knowledge

Poor financial condition of the hand-loom owners

Until now, this sector has been able to survive only because of import restrictions on foreign cloth, which resulted in a sellers' market; the hand-loom industry could sell whatever it produced without regard to quality or price. The situation has recently changed with the liberalization of imports of certain categories of piece goods, so these weaknesses have become more evident. Under free trade, the hand-loom sector might well cease to exist.

Power looms

The replacement of hand looms by power looms will reduce the number of workers in this sector. The total output will increase manifold, and subsidiary facilities such as warping, sizing, calendering and dyeing would develop with some government help. This will be all to the good, as the day of the hand-loom weaver has really passed.

The installation of power looms would mean a slightly higher technology and the power-loom industry will therefore attract better-educated workers who would be more amenable to the institution of an elementary form of quality control. On the whole, higher appropriate technology would mean higher production, better quality, lower prices and the establishment of subsidiary facilities. The reduction in employment caused by the change to higher technology would be compensated for by the creation of additional employment opportunities in the subsidiary facilities. The subsidiary industries themselves would also require a study in appropriate technology. In the end, all this may mean a sustained chain reaction of studying and adopting appropriate technology for the entire textile industry.

In order to make the power-loom sector competitive and efficient, the following recommendations have been made:

(a) An institute should be established where operators could receive training in appropriate technology, thus upgrading their skills;

(b) A booklet on how to operate and maintain a power loom should be prepared in Sinhala and Tamil. It should contain basic information regarding technology, quality control and the like;

(c) A strategy of growth should be planned for the power-loom industry. Tax incentives should also be considered;

(d) The possibility of buying yarn in bulk should be explored;

(e) Facilities to set up ancillary facilities should be provided.

Dyeing and finishing

In bleaching, dyeing and finishing, several options are available. Batch dyeing or continuous bleaching and dyeing can be chosen. Similarly, screen, roller, transfer or other printing systems can be employed.

For Sri Lanka, both low and higher technologies are recommended. For hand-loom or power-loom production, batch-bleaching and dyeing, even in cement tanks, is recommended, while for mills a higher technology is recommended, Transfer printing is becoming popular and, surprisingly, relatively less skill is needed at a higher level of technology.

Training and R and D

Training is essential even at a very low level of technology. In Sri Lanka, it has been established that very many middle-level technicians are needed. The University of Sri Lanka, with the help of UNDP and UNESCO, which have provided 36 man-months of fellowships and testing equipment worth $85,000 and expertise, has started a three-year diploma course of textile technology. It involves two years of theory and one year of in-plant training. Students who successfully complete the course are awarded the National Diploma of Technology (N.D.T.).

The N.D.T. course is tailored for middle-level management. However, industry also needs higher technology and hence also more highly qualified technologists. The educational system of Sri Lanka is well poised to produce them. It is therefore recommended that the diploma course be suitably upgraded. Educationally, Sri Lanka has a unique position in the third world. The Government should take advantage of it and provide enhanced facilities for technical education.

R and D are essential for solving the day-to-day technical problems of the industry. The Government of Sri Lanka has indicated its desire to set up a textile research and training institute. It should not engage in fundamental research but concentrate on practical problems. It should also provide consultancy services to the textile industry to raise its productivity and efficiency. A design centre for the textile industry is also recommended. It has been reported that the textile industry of Sri Lanka is operating at about 40 per cent efficiency. The proposed institute and the design centre could help to correct this situation.

Quality control

Quality control does not mean constant upgrading but maintaining standards. Quality standards should be established to satisfy local or export demands. Appropriate technology can help in selecting appropriate standards. Routine testing, as for yarn number, strength and twist, should be standardized. For instance, is ordinary Uster per cent checking adequate or should it be advanced to where spectrograms are needed?

The quality control department should establish procedures to enable top management to monitor the various departments of a textile mill. It should also institute procedures for materials handling, inventory control, maintenance and the like. All these require rather high technology and rigorous training. However, each mill would have to determine the level of technology it needed.

Market research

There are a few organizations in Sri Lanka that protect the interests of the textile industry. It is suggested that the proposed Textile Research and Training Institute establish a market research department which should:

(a) Identify marketing problems and suggest solutions for them;

(b) Provide information regarding market trends;

(c) Provide advance information regarding fashion trends;

(d) Advise the industry on product development;

(e) Bring about an interaction between the raw-cotton producer or importer, the user and the teaching staff of the Department of Textile Technology, Katubedda Campus of the University of Sri Lanka;

(*f*) Provide effective and reliable information channels between trade and industry, research and education.

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Problems of the textile industry in Ghana

*B. K. Kuma**

The textile market

The Ghanaian textile market is one of the largest in West Africa. Ghana, the Ivory Coast, Nigeria and Senegal account for about 65 per cent of West African consumption of textiles.

It is estimated that today Ghana consumes about 250 million yd^2 (21 million m^2) of textiles per year, or about 25 yd^2 (21 m^2) *per capita.* Available statistics suggest that, over the past 10 years, only about 60 per cent of Ghana's total textile consumption was locally produced. However, because of poor supplies of raw materials, only a relatively small percentage of domestic production capacity is used. Also, a large proportion of both imports and exports enters and leaves the country illegally, thus distorting the figures.

An analysis of the Ghanaian textile market according to the various fibres used is not easy, since many statistics do not distinguish between fibre types. There is little doubt, however, that cotton fabrics account for the largest part of consumption. The demands for rayon and other synthetic fabrics and for woollens are relatively small, since these fabrics are unsuitable for clothing in the Ghanaian climate.

Virtually all the dyes used in printing of textiles are now imported.

Demand structure

The Ghanaian textile market falls into four sectors: piece goods, garments, other textiles, and yarn and thread. By far the largest demand is for piece goods, which are used to make traditional types of clothing. The existing domestic production capacity could meet the demand for piece goods, except that a lack of raw materials makes output low. Officially, imports of yarn and thread constitute the bulk of the textiles entering Ghana, although there has been a steady growth in the unofficial (illegal) import of garments.

Most of the demand is for cotton fabrics, but the demand for blends is increasing. It is estimated that, in 1977, imports that were not officially recorded accounted for over 30 per cent of consumption. Exports, again according to official figures, make up some 10 per cent of the Ghanaian textile trade, but it is estimated that, in certain goods, unregistered exports account for as much as 25 per cent of the market.

*Chairman and Managing Director, Tesano Textiles Ltd., Accra, Ghana.

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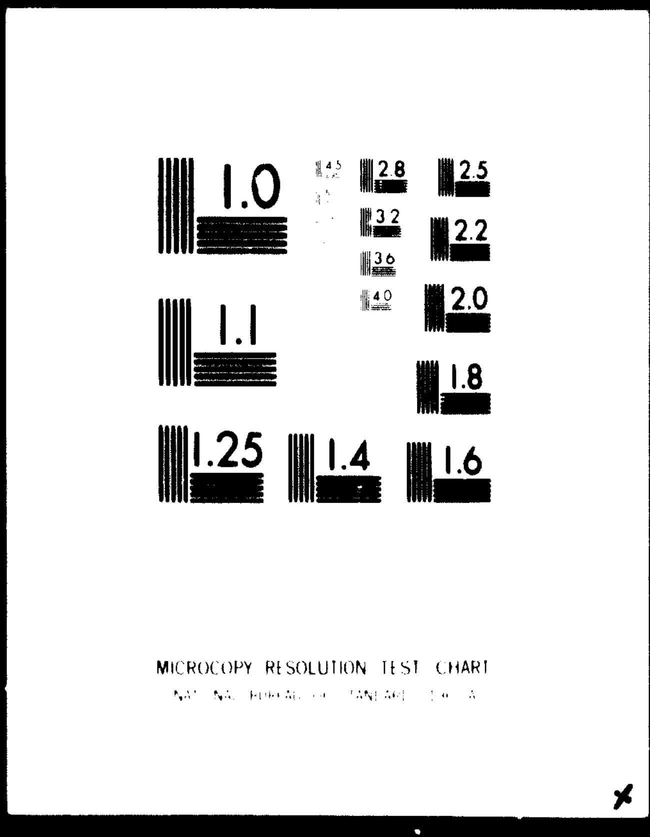

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Prices and tariffs

The price of textiles is high in Ghana–sometimes as much as four times as high as in industrialized countries. On the black market, goods are often sold for up to 10 times their real value. This applies not only to imported items but also to locally produced textiles. Among the reasons for the inflated cost of textiles are high training costs, the high salaries paid to foreign advisers, the relatively small size of most textile factories and the under-use of labour because of the under-use of plant capacity.

The textile industry

Weaving

Woven piece goods dominate the textile market in Ghana. This industry used to be largely controlled by foreign-owned companies, but recent Government economic policies in Ghana have led to increased state participation.

The bulk of material produced by these companies is printed cloth, used for traditional wear, and dyed piece goods. Weaving mills in Ghana, for various reasons, produce a large percentage of waste. During sizing, for example, the end yarn on the drums is cut off and thrown out as waste. This could be avoided by sizing the entire drum load. As much as 60 to 100 yards (55 to 90 m) of good dyed, white or grey yarn on the used weft pirns is thrown away. This yarn could be reeled out on a big revolving drum and supplied to *kente* weavers in hank form. A shortage of cotton yarn is forcing many of these weavers out of their traditional industry.

Efforts are being made to reduce wastage. One firm has already succeeded in producing experimental table mats from waste cotton yarns on hand looms. Waste also occurs with synthetics such as imported knitted nylon and polyester fabrics, which are collected and burnt. This waste could be exported for reprocessing and thus bring much-needed foreign exhange into the country.

Spinning

Spinning is relatively new to the modern Ghanaian textile industry. To date, there is only one factory producing sewing thread. There are, however, about 22 textile firms in Ghana which depend on imported cotton yarn, a fact which highlights the need for the domestic production of cotton yarn on a large scale.

Need for industrial training

The experience of the textile industry in Ghana has shown the necessity of having technically trained and qualified personnel to manage the companies now operating in the country. There are only two institutions involved in the training of textile workers, and unfortunately neither puts much emphasis on keeping students in touch with new fabrics, dyestuffs and their applications. The courses are highly theoretical, with little attention given to cotton-processing machinery. Above all, Ghana lacks textile research facilities.

Summary

The problems of the textile industry in Ghana have their origin in the following deficiencies:

Limited supply of spare parts and raw materials because of foreign exchange regulations

Shortage of skilled technicians for the maintenance and repair of textile machinery

Lack of machinery for high-quality finishing of products

Scarcity of experienced managers

Lack of local raw materials and high duties on imported raw materials

Absence of a textile institute and adequate training facilities

Overly high standards and quality control specifications for locally consumed products

Lack of organized information relating to textiles and of back-up research services to help manufacturers

Unreliable financing facilities

Annex I

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Roof-cooling system, p. 46.

Swell release motion, p. 48.

Fibre length tester, p. 49.

Fibre fineness tester, p. 50.

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Annex II

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