SRI LANKA
SCIENCE & TECHNOLOGY INDICATORS

PART III

M.A.T. DE SILVA
K.K.G.V. WIJETILEKA
N.S. WETTASINGHE
M.Z.M.F. AMEEN
O.A. FOUZ

UNESCO

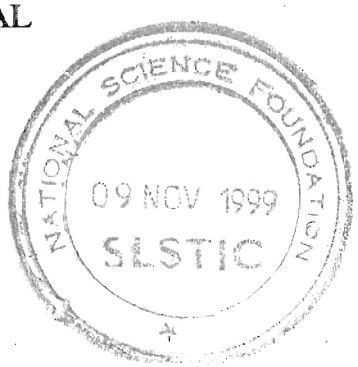
RESEARCH IS THE FOUNDATION OF KNOWLEDGE

sarec
SWEDISH AGENCY FOR RESEARCH COOPERATION WITH DEVELOPING COUNTRIES

DECEMBER 1991

SRI LANKA
SCIENCE & TECHNOLOGY INDICATORS

PART III - SCIENTIFIC AND TECHNO-ECONOMIC PERSPECTIVES FOR TECHNOLOGICAL AND INDUSTRIAL POLICY PLANNING



M. A. T. DE SILVA

K. K. G. V. WIJETILEKA

N. S. WETTASINGHE

M. Z. M .F. AMEEN

O. A. FOUZ

Natural Resources, Energy & Science Authority of Sri Lanka
47/5, Maitland Place
Colombo 7.

A study sponsored by UNESCO and
the Swedish Agency for Research Co-operation
with Developing Countries (SAREC)

December 1991

ACKNOWLEDGEMENTS

This study was initiated with a grant from UNESCO under contract Number 872.118.8. Subsequently further assistance was provided by the Swedish Agency for Research Co-operation with Developing Countries (SAREC), enabling us to widen the scope of the research study. We wish to acknowledge with gratitude the assistance provided by both UNESCO and SAREC.

Thanks are also due to Dr R.P. Jayewardene, Director General of Natural Resources, Energy and Science Authority of Sri Lanka for the encouragement and co-operation extended to the research team, to complete the study successfully.

The senior author wishes to commend the younger colleagues of the team for the contribution made to the technometric study of technology which was both intricate and time consumming. At the same time we wish to express our gratitude to proprietors, technical officers and the other staff members of the public and private sector commercial establishments which agreed to participate in the technology assessment study.

The study was also enriched by the critical and constructive discussions on issues of relevance at *Vidyartha,* the Centre for Science, Technology and Social Change.

Finally we wish to express our thanks to Mrs Chandra Fernandez and Mrs Shanaz Fernando for secretarial and word processing work on the report. Mrs Fernandez deserves a special word of thanks for her effort to transform and type-set the entire text for publication.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

F O R E W O R D

The Report on Scientific and Techno-economic Perspectives for Technological and Industrial Policy Planning, is the third in the series of studies undertaken under NARESA's Programme on Science Statistics and Indicators.

The financial assistance provided by UNESCO and SAREC, and the administrative backing of NARESA helped the project to progress in quality and depth.

Despite many constraints the research team advanced and completed the project successfully chiefly due to the determination of the project leader.

It is hoped that the results of this study would be of benefit to planners and policy makers, especially in the context of the current initiatives and programmes of the government towards industrialization.

R.P. Jayewardene

Director General

ABBREVIATIONS

APCTT	-	Asian and Pacific Centre for Transfer of Technology
ASEAN	-	Association of South - East Asian Nations
AUC	-	Affiliated University College
BTT	-	Business Turnover Tax
CAAS	-	Ceylon Association for the Advancement of Science
CAD-CAM	-	Computer-Aided Design and Computer-Aided Manufacture
CEB	-	Ceylon Electricity Board
c.i.f.	-	cost, insurance and freight
CISIR	-	Ceylon Institute of Scientific and Industrial Research
CKD	-	Complete Knock Down
CRI	-	Coconut Research Institute of Sri Lanka
DFCC	-	Development Finance Corporation of Ceylon
DMEC	-	Developed Market-Economy Country
EDB	-	Export Development Board
FDI	-	Foreign Direct Investment
FMRC	-	Farm Mechanization Research Centre
f.o.b.	-	free on board
GCEC	-	Greater Colombo Economic Commission
GDP	-	Gross Domestic Product
GNP	-	Gross National Product
LC	-	Letters of Credit
LDC	-	Least Developed Countries
MIS	-	Management Information System

NAITA	-	National Apprenticeship and Industrial Training Authority
NBRO	-	National Building Research Organisation
NDB	-	National Development Bank
NERD Centre	-	National Engineering Research and Development Centre
NIC	-	Newly Industrialized Countries
NIE	-	National Institute of Education
NYSC	-	National Youth Services Commission
PQLI	-	Physical Quality of Life Index
PTC	-	Presidential Tariff Commission
PVC	-	Polyvinyl Chloride
R&D	-	Research and Development
ROI	-	Return On Investment
RPRDC	-	Rice Processing Research and Development Centre
RRI	-	Rubber Research Institute of Sri Lanka
SAARC	-	South Asian Association for Regional Co-operation
SAREC	-	Swedish Agency for Research Co-operation with Developing Countries
S&T	-	Scientific and Technical or Science and Technology
SITC	-	Standard International Trade Classification
SLRI	-	Sri Lanka Rupavahini Corporation
TCA	-	Technology Content Added
TCC	-	Technology Contribution Coefficent
TRI	-	Tea Research Institute of Sri Lanka
TTC	-	Technical Training Centre
TTC	-	Tranferable Tax Credit
TVEC	-	Tertiary and Vocational Education Commission

UNCTAD	-	United Nations Conference on Trade and Development
UN-ESCAP	-	United Nations Economic and Social Commission for Asia and the Pacific
UNESCO	-	United Nations Educational, Scientific and Cultural Organization
USD	-	United States Dollars

Chapter 1

INTRODUCTION

1. 1 HISTORICAL PERSPECTIVES FOR TECHNOLOGICAL PROGRESS

Technology has been described as the Master Key for a prosperous society, yet it is undisputed that technology is not the panacea for all the social and societal dis-orders. Being largely a functional instrument for problem solving, the contribution of technology to progress is intimately linked with competence of its handlers, with the responsiveness of associated institutions, and with the receptivity and supportive nature of the environment.

Historically the transformation towards a technology dominated world is considered to have taken place sequentially through five different phases (1) as follows:

- Hunting and gathering
- Shifting and farming
- Agriculture and mining
- Manufacturing and processing
- Synthesizing and re-cycling

Nevertheless what the world has seen through the scientific revolution of the 16th and 17th centuries, and the industrial revolution of the 17th and 18th centuries, to the technological revolution of the 20th and 21st centuries, is the progressive telescopy and sophistication of this transformation process, rather than a progressive displacement or replacement of these phases. Much has been said and written about the motive force which generated this transition, especially the industrial revolution which occurred initially through artisans, craftsmen, metalsmithery, and then through a mastery of water and steam power, to engineering skills in the art of cutting gear wheels and machine making. Whether pure empiricism or science (natural philsophy, as it was then popularly known) was the cause and effect of this British-led industrial revolution in Western Europe, is not of concern today as history continues to repeat itself though at much quicker pace, as seen with the newly industrialized countries as well as several other nations approaching the launching pad for industrialization in the South Asian Region.

Undoubtedly the initial advantage gained by the Western World, enabled these countries to set a scorching pace in technological progress, creating in the process a substantial gap between the 'haves' and 'have-nots'. Although it may not seem

progressive or even plausible to admit that the so-called less developed countries should follow the sequence of events that led to the dramatic transformation of the west, the process does occur without much fanfare , and at a pace commensurate with the existing industrial environment and the sincerity of the political patronage towards societal upliftment.

It is to be noted that industrialization need not necessarily connote development. Development, as it is known today is a relative term linked more towards satisfying the materialistic needs and aspirations of the society and less towards the sophistication in life styles. Hence development need not necessarily result in a high technology society, neither does it imply the degree of industrialization or the competitiveness in industry.

In this context conventional indicators such as PQLI, per capita income, per capita energy consumption, trade balance, balance of payments, international reserves etc. which are not directly indicative of progress towards satisfying the materialistic needs and aspirations of society, are farthest from this concept of development.

1. 2 SCIENTIFIC BACKDROP TOWARDS INDUSTRIALIZATION IN SRI LANKA

The Sri Lankan economy at the turn of the present century had transformed from the typical subsistence agricultural system towards a bifocal outward looking plantation sector, and a traditional peasant feudal agrarian sector. The former naturally, was based on wage-labour and factory type system of large estates of tea, rubber and coconut, targetted towards foreign markets.

By 1930, still more than 60 percent of Sri Lanka's population depended on the traditional sector for its sustenance; whilst almost all the country's foreign trade was only with the plantation sector. However, during World War II, the link-up of the Sri Lankan economy to the British commercial centres weakened in many ways, largely because of the latters deep involvement in the world war, and consequent distraction from its hold on the colony. Consequently, Sri Lanka's income from its main export commodity tea, constrained by the operation of free market forces, began to decline resulting also with a drastic reduction of imports.

Nevertheless during the 1930's and also later on, the rise of nationalism prompted authorities to seriously consider diversification of the economy and the establishment of industrial units. However, the depression during this period and the out- break of the world war, prevented any positive measures in this direction (2). Despite these upheavals in the socio-political and economic structures it is significant that during the first quarter of the century, through the initiative of the British authorities, scientific research institutes emerged for the plantation industry. Their focus was mainly towards the British economic and trade interests, since research policies of these institutes were very much influenced by the activities of what were recognized as the "Scientific Advisory Committees" for tea and rubber, based in London (3).

Nevertheless the formation of the Chemical Society of Ceylon (as Sri Lanka was then known), in 1940 in an year of international turmoil, has been considered an epoch making event for more than one reason. For it is recorded that just two years after its formation, in December 1942, the then British Governor of the 'colony' had given formal recognition to the appointment of a "Scientific Advisory Committee" Although the main functions of this committee were to advise the government through the Ministry of Industry and Commerce, on matters pertaining to industrial development and research, it is not known how long it functioned, and how effective it had been as a scientific advisory body (3).

The Chemical Society also spearheaded the formation of the Ceylon Association of Science, which in July 1944 was then constituted as the Ceylon Association for the Advancement of Science (CAAS). The ability of the Chemical Society of Ceylon to bring together scientists, engineers, medical personnel and social scientists under an umbrella organization, the CAAS, has been considered as a remarkable achievement (3).

The manufacturing industry during the pre-independence period consisted of a traditional sector, comprising of basketware, pottery, agricultural tools, bricks, lime and other building materials, historically established on a caste-based division of labour. Almost all the tools and equipment required by this traditional manufacturing sector was turned out manually by the skilled village blacksmith. On the other hand the industrial needs of the plantation sector were imported mainly from Britain. Thus while the scientific and technological inputs were marginal for the traditional sector, substantial support was provided to the expatriate owned plantation sector.

Following independence, with the adversities and shortages of the World War II, still hovering over the economy, some initiatives for a rudimentary industrialization process were seen to emerge. These included the manufacture of products such as coir goods, leather products, glass, ceramics, paper and acetic acid in the public sector, and textiles, rubber goods, paper, matches and lacquered goods in the private sector. The quality of the products were sometimes of a low standard ,but the prevailing scarcity helped the industries to survive for sometime (2).

The early post-colonial phase was also characterized by a revival and rapid expansion of science and technology. Spearheaded and lobbied by CAAS, the historical agitation to get politicians and administrators to recognize the role of science and technology in national development, was initiated in 1948. Their persistent pressure prompted the government to seek technical advice from the World Bank, which recommended the establishment of the Ceylon Institute of Scientific and Industrial Research (CISIR). It was the contention that the creation of such an applied research institute would resolve the main grievances of the scientists (3). This institution operating with a limited budget of Rs. 5.0 million spread over a five-year term, and with a small scientific staff, made a valuable contribution to the tea, rubber and coconut industries. It developed a very simple method for bottling of coconut toddy and also initiated a study on bottling of coconut cream in 1956, and later examined the possibility of producing edible proteins from coconut milk and poonac (coconut meal) (4). In 1958, it associated itself with the Tea Research

Institute in venturing into a technology on "Instant Tea" manufacture (5). In relation to the rubber industry the CISIR initiated work on new formulations of rubber products both from latex and dry rubber, which helped in the manufacture locally of slippers, play balls, soles, mats and erasers (6). But CISIR considers as its most important contribution during the early 1960's to the scientific and technical assistance provided to the bicycle tyre and tube industry, which led to the successful launching of the first tyre and tube factory in Sri Lanka (6). Its other important contributions during the period included preparation of waterless cleaners, sterilization of dessicated coconut, preservation and canning of fruits, and extraction and evaluation of properties of vegetable oil. (7,8). The CISIR in addition to its research functions also, provided services to industries, which included development of standards of manufacture etc. In 1964 with the establishment of the Bureau of Ceylon Standard, a major component of this work was transferred to the new institution.

The year 1960 stands as a landmark for product diversification in the tea industry, since ministerial sanction was granted for the establishment of an Instant Tea Industry in Sri Lanka. It is also recorded that as a result of concerted efforts in the breeding and management fronts, the tea industry during this period reached a peak production point of 6000 pounds of made tea per acre (9).

The early 1960's saw the rubber industry for the first time becoming exposed to a major challenge, with the introduction of synthetic polymers (synthetic rubber) to the market. Therefore the need to bring down the production costs of rubber and its products became imperative. In fact studies at the Rubber Researc Institute showed that cost of production could be trimmed by reducing the sulpher dusting levels from 96 lb. per acre to 32 lb. per acre, for control of leaf diseases.

The scientific backup for industrial development during the next two decades (1970-1990) continued to proceed in the same pattern as during the 1960's with the emphasis being on the development of agro-based import substituting technologies, as well as some efforts in product diversification. In 1973 however, the CISIR successfully went through the pilot plant stage for the manufacture of stabilized coconut milk, and in 1976, a proto-type of an extractor for coconut cream was constructed and tested (10, 11). In relation to the tea industry CISIR turned out a range of products including tea essence, tabloid tea and the so-called Earl Grey, an internationally famous scented tea. CISIR also prepared ebonite, a hardened rubber formulation which could be used for the manufacture of conduit piping to replace P.V.C. electrical insulations (12).

In the manufacturing technology of tea, the TRI made major advances to imporve the efficiency of production lines. Among these, the introduction of the "Fluid Bed Drier", to the industry, resulted in a significant saving in energy.

An important landmark in industrial research during the period was the establishment of the National Engineering Research and Development (NERD) Centre in 1974. Its main role was to foster technological research with the objectives of increasing the research capabilitis of various public and private sector industries. However, it was unable to undertake the activities prescribed for it until the

workshop and laboratories were established in September 1978, in the Ekala Industrial Estate.

On the other hand, the early 1970's saw the coconut industry threatened by an infestation of the Philippine coconut leaf miner, *Promecotheca cumingi* which spread rapidly, devastating an estimated 30,000 acres of coconut within a few months. The fear and tension that gripped the coconut growers then was probably reminiscent of a situation that existed about 125 years ago when the Island's thriving coffee industry was totally destroyed by a disease. However, due to the foresight and thoughtful action of the then government, in assembling almost the entire entomological talent in the country for a national cause, a major breakthrough in biological control of the diseases was achieved when it was found that two parasites, *Dimmockia javanic* and *Pediobus parvulus* were very effective in destroying the pest (13).

In the rubber industry, a major development was the finding by RRI scientists, of a simple method of removing proteins from rubber latex using the juice of pineapple, a technique which enhances the technological properties of rubber. In general industrial research has been largely directed towards product and process development through inhouse research programmes. The contacts with industry has been mainly to provide services and standards rather than for innovative research. The NERD Centre however, has ventured into areas such as low-cost construction and energy saving devices, some of which have been successfully commercialized.

1.3 RECENT TRENDS IN INDUSTRIAL AND ECONOMIC PROGRESS IN SRI LANKA

The political history since independence has been characterized by a rather regular alternation in political concepts and economic theory between centralistic and liberalistic policy frameworks which on the whole promoted a disarray of industrial activities through uncertainty and distrust.

Following the Parliamentary election of 1956, and the enactment of the State Industrial Corporation Act No. 49 of 1957, a crucial change was seen in the industrialisation efforts, with certain basic or strategic industries being reserved for the state sector, and the private sector being allocated others. Industries were categorised into three schedules: Schedule 'A' consisting of the basic and strategic industries like cement, fertiliser, steel, minerals etc., were reserved for the state. Schedule 'B' comprising 23 light consumer goods industries, took the organisational form of joint ventures of the state and private sectors, and Schedule 'C' consisting of 82 small scale industries like cycle tyres and tubes, blades, clips and pins, soap etc., were for the private sector (2).

A significant trend in the policies after 1956 was the strong emphasis on the state sector,as well as on attempts at planned industrial development. The Five-Year Development Plan of 1958 included a 20 per cent investment on industrial development, in contrast to about 5 per cent allocated for industries under the previous Investment Programme.

To encourage investment in the private sector, the government also gave a high degree of fiscal and tariff concessions to private sector industrialists. These concessions however, were given only after government approval of the project, which was based not only on commercial and economic feasibility,but also on whether the proposed industry fitted into national priorities. Many of the small scale industries that were started during the time were import substituting, and hence qualified for protection through the banning of imports.

Thus the ten year period 1956 to 1965 saw a rapid growth of import substituting industries in both the public and private sectors, operated under fairly rigid controls and restrictions. However, this political era was also marked by the creation in 1962, of a major technological organization, the State Engineering Corporation, which was to provide a strong technological back-up to the construction industry.

By the early 1960's with deteriorating terms of trade, further import restrictions were imposed, and by 1965, foreign exchange budgeting became a regulatory measure in the economy . Thereafter, imports of raw materials were based on licences, resulting in industries often operating below the installed capacity.

In 1965, a new government laid emphasis on the private sector, giving agriculture a key role as well, and hence the industrialisation that was to occur were those which were to "stimulate agricultural development" (2). The formulated policies favoured agro-based industries, dependent on local raw materials and indigenous technology, and also with a potential for export. Further, a large number of light consumer goods industries, which earlier depended on imported inputs were by then considered saturated for further investment. Thus the major policy thrust during the period 1965-1970 was the offer of a package of incentives to private industries, while at the same time keeping a low profile on large state enterprises. And in order to stimulate the new industrialization process, the government of the day also established the Industrial Development Board by Act No. 36 of 1969, as a supportive policy measure, to act as the promoter and "facilitator" of small and medium scale agro-based industries.

In 1970, again with the election of a new government, a reversal in industrial policy was seen, with the emphasis on the public sector being high, especially on heavy industries. The Five Year Plan that followed, emphasised investment with low capital intensity. Further the plan proposed that the regeneration of the rural sector should be through a programme of agro-based and other small scale industries, which thus constituted the major element in the implementation strategy.

A central emphasis was thus given to the small scale sector, where it was estimated that 77 per cent of employment and 40 per cent of value added in industry existed in 1970. It was acknowledged that small scale industry had been neglected in the past, although its contribution to employment and national production was considerable. The Plan proposed the doubling of the output of this sector during the planned period, with emphasis on handloom textiles, wood products, light engineering, rubber products and mining and quarrying, where annual rates of growth up to 15 per cent were projected. Thus by early 1977, there was not only a heavy emphasis on the small scale sector to combat unemployment, but a large part of the economy

comprising of the commercial plantations as well as the strategic industries were under state control (2).

1.4 AN OPEN ECONOMIC POLICY

In mid 1977, with another change of government, the winds of industrial progress swung again towards the private sector. In the manufacturing sector, the new policy directions included, (a) the establishment of a Free Trade Zone to promote foreign investment and large scale transfer of technology and capital goods towards export-oriented industries, (b) a scheme for liberalized imports of both raw materials and finished goods and fiscal tax concessions to lure investments in the private sector, and (c) use of tariff as an alternative to import restrictions to protect domestic industries. Other measures to re-orient the economy included the adoption of a floating rate of exchange, removal of price controls and market imperfections, interest rate reforms to encourage savings, shifts from consumer subsidies to producer incentives, and removal of excessive administrative controls. The response to these policy reforms had been both positive and significant, and was clearly evident during 1978 and 1979, which have been termed the "years of response". Thus the Gross Domestic Product (GDP) increased by 8.2 per cent in 1978 but dropped to 6.2 per cent in 1979, mainly due to the poor performance of the agriculture sector (14). In the years that followed a stabilization process occurred although somewhat distorted by the ethnic turmoil, which reached a climax in July 1983. Table 1.1 presents the structure and performance of the economy during the period 1970 - 1987.

The data in Table 1.1 shows that while the period 1971 - 1977 was characterized by a substantial growth in the mining and quarrying sector, the 1978 - 1983 period was marked by an enhanced growth in the construction sector. Evidently the economy during the former period was influenced by the lucrative gem trade, and the latter period by the head-works of the massive Mahaweli River Diversion Programme and the Housing and Urban Development Programme. During 1983 - 1987 there was again another structural change with the manufacturing sector recording the higher rate of growth. Table 1.2 shows that the percentage sectoral contribution to GDP during the period 1977 - 1984 at factor cost prices, had not been strongly influenced by the changes in the economic policies of successive governments.

During the early years of the economic revival, the major investment programmes were the Accelerated Mahaweli River Diversion Programme, comprising of five major irrigation, hydro-electric and human re-settlement schemes, the Housing and the Urban Development Programme, and the setting up of the Greater Colombo Economic Commission. (GCEC)

The GCEC was the key agency to set the pace for an export oriented economic growth. Its aim was to attract export oriented industries both local and foreign, into the Industrial Promotion Zones within its area of operation, and thereby promote transfer of new generation technologies, create more employment, and increase foreign exchange earnings. The incentives offered to industrial establishments included the following.

TABLE 1.1

CHANGES IN THE GROSS DOMESTIC PRODUCT
DURING 1970 to 1987 (Values in Rupees Million)

	At Consatant 1970 prices				At constant 1982 prices			Average growth rate (%)		
	1970	1977	1978	1983	1983	1985	1987	1971 1977	1978 1983	1983 1987
Gross Domestic Product	13,187	16,078	17,041	22,815	99,375	109,570	115,922	2.9	6.0	4.1
Agriculture	3,732	4,299	5,492	5,492	26,212	28,366	27,409	2.1	4.1	1.9
Mining andQuarrying	95	515	619	810	2,413	2,486	3,112	27.1	7.8	6.8
Manufacturing	2,197	2,357	2,541	3,014	10,995	12,971	15,408	1.0	4.2	7.5
Construc-tion	744	619	794	1,028	8,039	8,070	8,338	2.6	8.8	0.9
Services	6,419	8,288	8,915	12,548	49,001	54,455	58,315	3.7	7.2	4.9

Source: 1.Public Investment 1984-1988 National Planning Division, Ministry of Finance and Planning (1984)
2. Public Investment 1986 - 1990, National Planning Division Ministry of Finance and Planning (1986)

TABLE 1.2

SECTORAL CONTRIBUTION TO GDP AT CONSTANT 1970 PRICES (As%)

	1977	1978	1979	1980	1981	1982	1983	1984
Agriculture Forestry& & Fishery	26.9	26.0	25.0	24.3	24.6	24.0	24.1	22.8
Mining and Quarrying	3.2	3.5	3.5	3.5	3.4	3.4	3.4	3.4
Manufacture	14.8	14.6	14.4	13.7	13.6	13.6	13.0	13.7
Construction	3.8	4.7	5.1	5.4	5.1	4.9	4.5	4.3
Services	51.3	51.2	52.0	53.1	53.3	54.1	55.0	55.8
GDP	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Public Investment 1986 - 1990, National Planning Division, Ministry of Finance and Planning (1986)

(a) Tax holidays upto a maximum of 10 years

(b) An additional concessionary tax period following the tax holiday

(c) Duty-free imports of inputs and equipment

(d) Exemption from income tax of expatriates attached to projects, during the period of the tax holiday

(e) Exemption from tax on royalties during the tax holiday

(f) Exemption from taxes on all dividends paid to non-resident shareholders (14).

1:5 THE NEW INDUSTRIAL POLICY

In 1987, the Goverenment of Sri Lanka accepted in principle a statement on industrial development drawn up by a committee of officials. It was expected that this plan, described as the Industrial Policy Statement of the Government of Sri Lanka, would be implemented under the guidance of a Council of Ministers, which was set up by the then President, J.R. Jayewardene (15). The broad objectives of this policy were as follows:

(a) To provide employment and income opportunities to a growing population which can no longer continue to rely on agricultural pursuits, by utilizing industry to contribute to increasing the size of land holidings, and making of these land holdings economically viable.

(b) To make industry internationally competitive for import substitution and exports, and make the balance of payment viable through a reduction in the country's dependence on a narrow range of agricultural exports. Within the above broad objectives, the following issues were to be achieved.

"(i) In order to achieve more balanced regional growth, industries should, other things remaining equal, be dispersed widely throughout the country. It is necessary however, to safeguard against hapazard industrial location purely for the sake of regional dispersal. Optimisation of viability should be the paramount consideration.

(ii) Small and medium sized industries should be encouraged, given the capital and entrepreneurial endowment of the country. Here again due care must be exercised to prevent establishment of small industries, especially with their true costs distorted through government intervention, purely on a "small is beautiful" kind of approach. Viability is of paramount concern because that alone will give the required stability to industries.

(ii) Technologiocal advancement of the country for industrial growth is vital. Yet the country cannot afford to adopt technologies merely because they haveproved to be successful elsewhere. Technology must be adapted to the special needs of the country and the industry concerned" (15).

The main features of the Industrial Policy Statement may be summarized as follows:

I Assistance to import competing industries.

a. The phasing out of the few remaining import controls

b. The phasing out of export duties as soon as Government revenue considera tions permit.

c. The introduction of a four-tiered tariff structure over a four year period, with a targetted average level of assistance around 50 per cent, and with a greatly reduced dispersal of assistance among industries.

d. The assistance in determining this tariff structure, extended to the Presidential Tariff Commission (PTC), to undertake further work to assess the effect of different tariff scenarios on the average level of assistance provided to industry, the balance of payments, consumer welfare, tariff revenue and on the viability of firms which may be adversely affected by changes in the structure of the tariff.

e. The introduction of anti-dumping measures to prevent disruption in domestic markets resulting f rom the occasional sale of subsidized products produced in other countries,and from predatory dumping.

f. The extension of advisory and financial assistance to those firms and industries which require assistance to adapt successfully to the changes during the four-year phase in of the above policies. Some public enterprises, no longer eligible for grants or loans to cover their losses, will be similarly placed. A re-structuring unit will be established in the Ministry of Industries and Scientific Affairs to assist concerned line Ministries which provide advisory services about restructuring. The unit will be staffed by experts in the fields of finance, technology, marketing and management, and also recruit short-term experts. It will liaise closely with the PTC. Firm and sub-sector reports will be made detailing re-structuring programmes and, where necessary, phased financial assistance (15).

II Assistance to export industries

a. Duty free imports of material inputs and of capital equipment by exporters to continue, facilitated by the arrangements with GCEC, and improved customs duty rebate and bonded warehouse procedures.

b. To discontinue the present type of incentives based on value- added, and replace them with an incentive called Transferable Tax Credit (TTC). This will be a negotiable tax credit facility, usable to pay taxes, or sold at a slight discount for cash to any other tax payer, for settlement of taxes.

c. TTC assistance will be determined by the Export Development Board (EDB) and will be at least equal to the average level of assistance to value added per unit of output, granted to import-competing production by the tariff.

d. Exporters currently receiving income tax holiday benefit will continue to enjoy their entitlement until they terminate, or opt for TTC benefits in lieu of tax holidays (15).

III Special incentives:

a. Enterprises qualifying for "infant industry" status will receive additional assistance by a TTC, which will not exceed 100 per cent of normal assistance. This assistance will be phased out on a reducing basis over a five year period.

b. To encourage the regional dispersal of industry, additional assistance up to 100 per cent of the normal level will be provided by a TTC for industrial production in regions outside of areas already developed.

c. A TTC not exceeding 100 per cent of normal assistance will be provided as an export marketing incentive for the export of new manufactured products from Sri Lanka, as for the export of existing products to new geographic destinations.

The above special incentives are additive in the sense that a single establishment could qualify for all these additional incentives plus any normal incentive and thus at any given time, an industry could possibly be eligible for four times the normal assistance provided to the product. (15)

IV Income tax relief:

a. Investment in expanding manufacturing will be granted 100 per cent investment relief up to a limit of 50 per cent of assesable income

b. The tax in corporate income will be reduced to a level comparable with rates in countries in East and South-east Asia

c. The tax on distributed dividends in the hands of share holders will be offset against income tax levied on corporate income. In the meantime, this relief from double taxation will be given to exporters of non-traditional exports.

d. The 100 per cent tax on the transfer of shares from one foreign investor to another will be discontinued (15).

In addition to the direct incentives and facilities to the manufacturing sector, the governments industrial policy statement elaborates on a number of other promotional facilities which include banking and credit information, foreign investment climate, labour practices and legislation, research and development, land acquisition, mineral exploitation and provision of infrastructure.

More recently taking note of a new policy directive by the Head of State, which gave explicit priority to export oriented industrialization for restoring economic growth and creation of employment, "A Strategy for Industrialization in Sri Lanka" was formulated and accepted by the government in December 1989 (16). This document which reflected the concerns and vision of the government spelt out in the "Manifesto of Action for Investing in the People", was specifically an agenda for

action on a trajectory for industrialization. It outlined far reaching reforms, for investment promotion, financing of investments, fiscal incentives, tariff protection, marketing, manpower development, industrial labour relations, technology, infrastructure development, and the restructuring of public manufacturing enterprises. Among the key activities identified in this Strategy for Industrialization are the following:

(i) Abolition of the 100 per cent tax on transfer of securities shares to non nationals

(ii) Unifying and concentrating under one organization - the GCEC, all matters pertaining to foreign investment promotion work, and investment approvals

(iii) Establishment of Business Promotion Centres in key metropolitan centres abroad

(iv) Mobilization of local and foreign investment capital by setting up new financial structures such as Venture Capital Companies, and Unit Trusts, and inducing agencies such as the Employees Provident Fund, Employees Trust Fund and insurance companies to invest in investment capital companies, issue of Bearer Participating Preference Bonds, promoting a healthy and vibrant capital/stock market, and facilitating more companies to become public companies, with a broad-base share ownership

(vi) A waiver of tax on capital gains, tax holidays and investment relief for venture capital companies, unit trust and such pioneering financial structures

(vii) Double deductions from statutory income for 5 years for expenses on promotional activities such as trade fairs, exhibitions, literature, advertisements etc. of non traditional exports where local value-added is more than 40 per cent

(viii) Double deduction of expenditure on research and development (R&D), write off of payment for 10 years of manufacturing licensing fees, and provision of R & D grants for product development

(ix) Tarrif protection for infant industries during gestation period, which will be reduced progressively with gradual exposure for international competition; the existing 19 tariff band to be reduced to four bands.

(x) Ensure applicability of Sri Lankan standards to imported products and introduction of anti-dumping legislation, to prevent substandard goods at unrealistic prices of foreign origin, undermining local industry

(xi) Phasing out the Central Freight Bureau and permitting operation of pendulum sea freight services through Colombo, to ensure economic and rapid sea freight

(xii) All public manufacturing enterprises to be progressively commercialized and peoplised. The recently established Public Investment Management Board to overlook the affairs of commercialized enterprises (16).

Despite internal problems caused by heightening of the ethinic conflict, the government has not lost time in implementing the various provisions of the Strategy of Industrialization, with various activities already underway and the others being slotted into position.

In this study it is not proposed to review the wide ranging policy reforms introduced through the "Industrial Policy Statement" of 1987, and the Strategy for Industrialization in Sri Lanka" introduced in 1989. Since responses to many of the policy measures are likely to be transitional at this stage, and with further measures yet to be implemented, the current situation could only be considered as a transient phase in an economic, technological and industrial transformation. However, in the chapters that follow reference will be made to specific provisions of these policy documents especially those relating to R & D.

Chapter 2

TECHNICAL HUMAN RESOURCE POTENTIAL

2.1 ROLE OF SKILLED MAN POWER IN TECHNOLOGICAL TRANSFORMATION

Technology is the physical tool used in a technological transformation. Yet technology by itself is a nonplus entity, unless guided and managed by other functional components, which complete its utility package. One of these components is skilled manpower. The evaluation of this resource potential in terms of its contribution to a technological transformation process has been approached from several different angles. One such procedure was the model developed and tested by the Asian and Pacific Centre for Transfer of Technology (APCTT), based in Bangalore, India (17).

The model assumes that technology in its functional relationship, is composed of four vital components, referred to as Technoware (Production tools and facilities or object - embodied technology). Humanware (skilled manpower or person-embodied technology). Orgaware (organizational framework or institution - embodied technology and Infoware (production facts and information or document embodied technology). Accordingly, it is postulated that technology becomes an effective transformation tool only when all four functional components of technology, which are complementary to one another, are optimal or in their prime status. In fact, taking the Humanware component alone, APCTT, has shown that, even in a situation where a surplus of cheap labour is available, a labour intensive technology could falter against a capital intensive technology, if the correct quality of Humanware inputs are not available. Further, it has been shown that incompatibility or incongruency in the four components of technology in terms of the degrees of sophistication, may result in a transformation in which the degree of beneficiation of inputs would be too small to make the resulting products internationally competitive (17 a). These issues are discussed to some extent in Chapter 6 of this report.

In this context, it is critical that a policy on industrialization should take cognizance of the nature and quality of the human resource potential in the country, and devise means to match the needs of industries in relation to the quality of technologies available, or planned to be acquired.

2.2 WORKER ATTITUDES TOWARDS TECHNOLOGICAL CHANGES

Sri Lanka is proud of a high literacy rate, and its workforce is also considered highly productive, innovative and dedicated. These characteristics undoubtedly make the Sri Lankan labour force a highly cost-effective input to manufacturing industries, and thus an attractive proposition to foreign industrialists. However, recent technological advancements, especially in the fields of computer-aided designing and robotics, does not any longer make low-cost third world skilled labour an incentive for foreign equity participation and transfer of technology. Although there still exist conduits for large scale export of labour to oil rich countries and to a few newly industrialized countries, technological gains to the country are marginal, as a majority of the migrant labour fall into the unskilled and semiskilled categories.

On the other hand exploitation of the country's competent human resource potential by foreign entrepreneurs investing in Sri Lanka, has also not facilitated any significant transfer of technology in terms of knowhow, management skills or mastery of technology. This is because foreign equity participation and the accompanying capital goods in-flows have been either mainly in respect of turn key industrial technologies or in the form of simple assembly systems, which needed only the physical capabilities for tightening screws, nuts and bolts.

However, in recent times there have been a few public and private sector industrial concerns which have tried to bring about technological changes to maximize or optimize production lines. In the private sector, the ready-made garment industry, as well as the shoe manufacturing industry may be considered as front-runners with computer-aided designing and manufacturing facilities. Several other firms are now entering this field. In this context, what could be the response of workers for such technological changes.

The preliminary results from study undertaken by C.J. Amaratunga (18), a research student of the Open University of Sri Lanka, at the Kelani Tyre Corporation, are indicative of trends to be expected. The Kelani Tyre Corporation established in the mid 1960's, consists of a 4-stage manufacturing process comprising of a compound shop, calender shop, assembly shop and the vulcanizing shop. Over the years this facility had been subjected to several technological changes in keeping with needs of the time, and in responsiveness to the technical capability of the work force. One such change had been the introduction of Bag-O-Matic Pressers, which for one reason or other led to frequent breakdowns. The response of the workers to the new technological input, was a demand for specialized training, and when such training was provided, the study revealed that there were no further breakdowns.

An important technological change at the Tyre Corporation was the foreign collaboration (with BF-Goodrich), to manufacture radial tyres. In this instance, two of the assembly machines installed had the capability of manual as well as semi-automated operations. The research study (18) notes that the workers preferred the manual to the semi automated system, apparently because the latter was heavier than the manually-operated facility.

A third technological change was the computerizing of the valve system of sheer strip vulcanizers. In this instance the workers demonstrated their opposition initially, but changed their attitudes later, and co-operated with the management when they realized that the technological change was conducive and less exhaustive than the previous system.

In another technological change, a new bambary machine was installed in the compound shop. This introduction was also opposed by the workers, because apparently its installation affected production bonuses of workers. The management in this instance had agreed to comply with the requests of workers. It had been recorded by the researcher, that workers tended to be apprehensive of technological changes involving introduction of semi-automated assembly units sometimes even resorting to acts of sabotage to discourage such changes. One of the points made out by workers against semi-automation was the argument that they had no control over the operation of the machine. This study shows the variety of ways in which workers in a production facility may react to technological changes.

Thus management of technological change not only demands increasingly sophisticated organizational and management systems, but also highly innovative skills in labour relations. Amaratunge (18) in his study attempts to analyse attributes of workers to technological changes, through the interpretation of conventional and modern theories of management. According to him, while the early phase of the technological revolution was characterised by an alienation of man from his own labour, product, environment and even from his own species, the new technological changes tends to make the worker subservient to machines (18). Apparently the attitudes and responses of labour to technological changes as seen in the above study, are an expression of man's critique or repugnance towards a so-called machine dominated slavery. It is this human aspect of labour that needs the greatest sympathy and understanding in industrial labour management, since it is as much a critical factor as the skill structure of labour, in facilitating the production process of a technological transformation.

2.3 ORGANIZATIONAL FRAMEWORK FOR TECHNICAL, VOCATIONAL AND CRAFT LEVEL TRAINING

Although industrialization has been a much discussed topic, and a strategy for industrialization has been accepted and implemented, a technology policy is yet to be formulated.

In fact, little is known about the versatility and quality of technology currently in use, which makes technical manpower development and planning difficult and incongruous. The agenda for action of the Strategy for Industrialization in Sri Lanka, has taken note of this deficiency and has proposed the following steps (16).

a) The upgrading of the Technicians Training Institute at Katunayake, the Textile Training and Service Centre, the Foreman Training Institute at Ratmalana and other appropriate institutes.

(b) The setting up of an Institute of Industrial Arts, an Institute of Industrial Information, and provincial level institutes of technology

(c) The establishment of a Vocational and Tertiary Education Commission

(d) Establishment of a Business School by pooling the resources of the National Institute of Business Management and the Institute of Chartered Accountants

At present some 19 Ministries are said to be associated with technical, vocational and craftmens training programmes, with practically no accurate data on the current or future trained manpower needs of the country. This has indeed been a serious lapse in the national planning mechanism in the country. However, realizing the need for a co-ordinated effort on education and training towards a pre-conceived goal, the government, as a preliminary step, established the Co-ordinating Secretariat for Vocational and Technical Training under the Ministry of Youth Affairs. This was then followed up by the enactment of the Tertiary and Vocational Education Act No:2 of 1990, through which was established simultaneously a Tertiary and Vocational Education Commission (TVEC) and the National Apprenticeship and Industrial Training Authority. (NAITA). The latter was effectively the successor to the National Apprenticeship Board.

The objectives of the Tertiary and Vocational Education Commission are specified in the following terms.

(a) the planning, co-ordination and development of tertiary education and vocaional education at all levels in keeping with human resource needs of the economy;

(b) the development of a nationally recognized system for granting of tertiary education awards and vocational education awards, including certificates and other academic distinctions; and

(c) the maintenance of academic and training standards in institutes, agencies and all other establishments providing tertiary and vocational education.

The Commission consists of the Director General of the National Institute of Education (NIE) the Director of Technical Education of the Ministry of Higher Education and 4-6 persons appointed by the Executive Head of State.

The objectives of the National Apprenticeship and Industrial Training Authority have been set out as follows:

(a) planning, organizing and providing of vocational training

(b) specifying standards in relation to vocational training

(c) conducting of examinations and issuing of certificates and other awards in relation to vocational training

(d) conducting National Trade Tests;

(e) conducting research and development in vocational training

(f) holding of competitions to promote the development of various skills

(g) developing the training capacities of establishments and other institutions providing vocational training;

(h) to advise the Tertiary and Vocational Education Commission in regard to vocational training

(i) to establish links with institutions in Sri Lanka and abroad having similar objects and to equate and validate certificates, diplomas and degrees in allied subjects and courses

The Authority consists of a Chairman, a Vice-Chairman, the Director General of NAITA as an "ex-officio member" and upto twelve other members appointed by the Minister, representing government institutions, trade unions, commerce and industry, and/or, persons with special knowledge and experience in matters relating to vocational training.

With the creation of these institutions, as proposed in the Strategy for Industrialization in Sri Lanka, it is expected that eventually the present functions of the Co-ordinating Secretariat for Vocational and Technical Training, will be absorbed by these institutions.

2.4 TYPES AND LEVELS OF TECHNICAL TRAINING IN SRI LANKA

Higher technical education is currently provided by three institutions, the University of Peradeniya, the University of Moratuwa and the Open University. The trends in undergraduate admissions and turn-out of graduates for science, medical, engineering, dental, agriculture and veterinary sciences are given in the table below.

TABLE 2.1:

GROWTH IN ENROLMENTS AND TURNOUT OF GRADUATES FROM THE UNIVERSITIES OF SRI LANKA

Field of Science	1975	1980	1985	1986
Agriculture				
No. of enrolments	90	146	-	-
No. of graduates	92	103	147	118
Dental Sciences				
No. of enrolments	50	58	-	-
No. of graduates	50	32	42	63
Engineering Sciences				
No. of enrolments	310	476	-	-
No. of graduates	214	187	247	286
Medical Sciences				
No. of enrolments	247	403	-	-
No. of graduates	150	237	338	156
Natural Sciences				
No. of enrolments	579	739	-	-
No. of graduates	407	665	921	852
Veterinary Sciences				
No. of enrolments	NA	25	-	-
No. of graduates	25	27	24	20

Source: 1 .Liyanage, S. and de Silva, M.A.T. (1987 Science & Technology Indicators in Sri Lanka (Part 1 (19).

2. Statistical Pocket B ook, 1988, Department of Census and Statistics Ministry of Plan Implementation, Sri Lanka

Due to unsettled conditions that prevailed during the period 1987 to 1990, University examinations were postponed on three consecutive occasions, with the result that graduate outputs were not recorded for the years 1987, 1988 and 1989.

During the past few years, the former National Apprenticeship Board, with some 125 different categories of craft apprenticeship training programmes and several other technical and special engineering apprenticeship courses, played a vital role in technical and vocational training to serve the middle and lower middle categories of professions. Likewise the labour Department, through a wide ranging network of central, district and mobile training centres have provided basic craft level training as well as training of supervisory cadres. On the other hand the Technical Educational Programme of the Ministry of Higher Education is implemented

through a network of 25 technical colleges and five affiliated Technical Units providing largely Diploma level and certificate type of higher technical training. The overall student enrolment in technical colleges and affiliated units had increased from 7534 in 1970 to 21,771 in 1986, but has since been declining to 20,673 in 1988, to 19,094 in 1989 and to 18,342 in 1990 However, the demand for places at most technical colleges exceed the number of places available.

In addition to these three major training organizations are a number of other organizations provide in-service training as well as other specialized skills. Table 2.2 summarizes the currently available training programmes in different institutes, for technical, vocational and craft level skills. The table does not include the training programmes of NAITA, and also those in the fields of agriculture and health. Over 250 courses are listed here with an overall annual output of about 44,000 persons trained at technical vocational and craft levels. Unfortunately it has not been possible to determine their destinies and the effectiveness of their training in whatever capacity they are employed .

More recently with the inauguration of the Affiliated University Colleges (AUC) in the nine provinces, the government has opened a new avenue for academic training. However, the basic concern in developing this programme was to serve the large number of students who acquire minimum requirements for entry to universities through the General Certificate of Education (Advanced Level) Exam, but who are denied the privilege because of lack of space and facilities at the National Universities. The study courses provided by AUC's are free of charge, and therefore constitute a further expansion of free education at University level. Many of the courses offered by the AUC's are currently available at private educational institutions, for which high fees are charged. It is therefore the contention of the authorities that courses such as management studies, accountancy, hotel management, computer studies, English language, beauticulture, travel and tourism management etc. which were not within reach of the less privileged classes of the society would now provide new avenues for self employment in sub-urban and rural areas.

An interesting feature of the courses is the requirement for all students to read five compulsory core-course units to provide them the necessary knowledge, skills and versatility needed for a variety of day to day activities. These cores units comprise of computer studies, management studies. Sri Lankan studies, environmental studies and English. However, the courses are of shorter duration leading to a diploma or certificate level qualification, and hence comparable to similar technical courses provided by the Technical Education Division of the Ministry of Higher Education. Hence do these new AUC study course satisfy the demands and aspirations of an ambitious but frustrated category of youth, who have studied hard to enter the national universities for an academic career? Could they make up their minds to settle down to an educational programme which falls short of their expectation, especially when it is known that similar programmes are already available either free of charge or on payment of fees. These and many another questions will no doubt crop up in the testing years, for this new concept of higher education.

TABLE 2.2

TECHNICAL,VOCATIONAL AND CRAFT LEVEL TRAINING/EDUCATION IN SRI LANKA

Name of Institution & Training Course	Type of Training (Diploma Certificate etc.	Trade Certification Yes/No	Annual Turnout (1990)
SRI LANKA-GERMAN RAILWAY TECHNICAL TRAINING CENTRE			
Welders and sheet metal worker	Craft Level	Yes	18*
Engine and gear fitters	Craft Level	Yes	18*
Electricians-Locomotive Electronics	Craft Level	Yes	18*
UNIVERSITY OF MORATUWA			
National Diploma in Technology	Diploma	-	109
SLCTB VOCATIONAL TRAINING INSTITUTE BLAKE ROAD - BORELLA			
Automobile mechanism	Diploma	-	-
Tinkering welding	Diploma	-	12*
Auto Electricity	Diploma	-	-
Welding	Diploma	-	09*
CENTRAL TRAINING SCHOOL, SRI LANKA TRANSPORT BOARD, KALUTARA			
Motor Coach Driving Fulltime course	Certificate	Yes	1148*
Commercial vehicle	Certificate	Yes	2 413*
Jeep/van driving	Certificate	Yes	145*
Part-time/short-term	Certificate	Yes	90
Practical Tests	-	Yes	25*
Driver Instructor	Certificate	Yes	16*

LABOUR DEPARTMENT			
(a) Central Vocational Skills Development & National Trade Testing Inst. Orugodawatte			
Electrician, Radio & TV Technician, Refrigeration Technician, Welders, Metal Work, Motor Mechanic, Tractor Mechanic, Plumbing & Pipe fitting	Craft Level (1 year)	Yes	Twelve courses of 30 train-ees each
District Vocational Skills Development Centres at 13 District Training Centres			
Engine operators, motor mechanic mechanics, metal, fabricators, juki	,Craft Level (1 yr)		Six courses of 30 each
(c) English Typing Training Centres	Certificate (4 mths)		30 per course
(d) English Stenography Training	Certificate (6 months)		30 per course
(e) Mobile vocational skills development centres			
Cutting & sewing at 175 locations	Basic craft level (9 mths)		4375
Carpentors at 71 locations	Basic craft level (1 year)		1775
Masons at 64 locations	Basic craft level (6 mths)		1600
Weevers at 3 centres	Basic craft level (6 mths)		75
Juki Sewing at 24 centres	Basic craft level (2 mths)		280
(f)Foreman Training Institute			
Diploma in Foremanship	Diploma	Yes	84
Welding & Metal fabrication techhhnology	Diploma	Yes	23
Machining technology	Diploma	Yes	22
Building construction	Diploma	Yes	25
Carpentry	Diploma	Yes	-
Plumbing and pipe fitting	Diploma	Yes	11
Repair maintenance of automotive	Diploma	Yes	42

Electrical engineering	Diploma	yes	60
Maintenance of plant & machinery	Certificate	yes	11
Supervisory management	Certificate	yes	12
Leadership training	Certificate	yes	07
SRI LANKA TELEVISION TRAINING INSTITUTE			
Workshop on TV for development comniunication	Certificate of participation	No	10
Provincial Correspondents workshop	"	No	25
Teledrama writing	"	No	18
Animation and graphics in motion	"	No	20
Use of Time code in TV Production	"	No	06
Scripting for Video presentations	"	No	05
Orientation for scripting for TV	"	No	09
Workshop for video programme - Production for Public Sector Video	"	No	11
Scripting for Video Production	"	No	14
Orientation for News Presenters	"	no	13
Animation and Graphics in Motion	"	No	24
Workshop for puppetry for TV	"	No	12
Third Country Training Programme on colour TV Engineering -	"	No	12
Orientation Workshop for newly - recruited technical officers of SLRC	"	No	12
Workshop on Public Sector Video Production Personnel	"	No	09
Workshop on Power and - AC Practice for TV studies	"	No	11
Orientation for provincial correspondents of SLRC	"	No	13
Special workshop for ENG/EFP staff of SLRC	"	No	28
Digital Electronics and Microprocessors used in Broadcasting (Module 1)	"	No	17
Workshop on Video ProgrammeProduction for Public Sector Video Personnel	"	No	18
Television Scripting Workshop - for English Language Teaching	"	No	15

Workshop on Script Writing for Teledrama	"	No	19
Digital Electronics and Micro-Processors used in Broadcasting (Module II)	"	No	13
Exercise on TV News reading for news presenters (Sinhala) SLRC	"	No	11
TV/Audio sound balancing & mixing with special emphasis on musical programmes	"	No	12

NATIONAL YOUTH SERVICES COUNCIL

Maintenance of Agricultural Equipment	NYSC Certificate	No	30
Agriculture	"	No	107
Motor mechanism	"	No	82
Welding	"	No	123
Electrician	"	No	209
Metal fabrication	"	No	18
Metal welding	"	No	42
Ornamental	"	No	33
Gem Cutting	"	No	99
Wood craft	"	No	09
Repair of agricultural machinery	"	No	18
Radio & T.V. repairs	"	No	66
Masons	"	No	18
Machining	"	No	33
Motor cycle repair	"	No	90
Catering & Cookery	"	No	97
Cutting & Sewing	"	No	205
Beauty culture	"	No	39
Carpentry	"	No	147

Field Training:

Professional Training Course	"	No	2192
Training in services for women	"	No	7200

SRI LANKA PORTS AUTHORITY
MAHAPOLA TRAINING INSTITUTE

Machine shop practice	Certificate	Yes	13*
Bench Fitting	"	Yes	-
Manual metal Arc & Gas welding	"	Yes	-
Domestic & Industrial wiring	"	Yes	-
Skills updating course for welders	"	Yes	07
Skills updating course for electrical wiremen	"	Yes	17
Spur & Helical gear cutting	"	Yes	04
Prime Mover operators	"	Yes	34
Fork lift truck operators	"		75
Gantry crane operators	"	Yes	05
Transfer crane operators	"	Yes	13
Mobile crane operators	"	Yes	-

INSTITUTE OF COMPUTER TECHNOLOGY
UNIVERSITY OF COLOMBO

Postgraduate Diploma in Computer technology	Post-graduate Diploma	No	17

CIVIL AVIATION TRAINING CENTRE
KANDAWALA ROAD, RATMALANA

Air traffic services	ICAO Certificate	No	08
Communication operations	"	No	-
Communication engineering	"	No	08
Aviation security	"	No	55
Aviation fire services	"	No	19

TECHNICAL TRAINING CENTRE, CEYLON
ELECTRICITY BOARD, CASTLEREIGH DICKOYA

Training in linesman work for CEB unskilled/semi-skilled employees		No	30

Re-development training course for detainees conducted under the auspices of the Comm.General of Rehabilitation	-	Yes	46

EDUCATION & TRAINING BRANCH CEB

Systems training programme for engineer in construction units	-	No	05
Induction training for newly recruited electrical Engineers	-	No	05
Systems training programme for area engineers		No	14

EDUCATION & TRAINING BRANCH T.T.C CEB PILIYANDALA

System training for depot electrical supdts	Certificate	No	24
Systems training for power station electrical supdts.	"	No	16
System training for power station mechanical supdts	"	No	12
Switch board operators	"	No	-
CEB draughts men	"	No	-
Meter readers	"	No	-
Consumer education Assts	"	No	-
Lift operators and E.SS	"	No	-
Co-ordinating officers in provincial offices	"	No	-

COLOMBO TECHNICAL TRAINING CENTRE, CEB, PILIYANDALA

Electronics	Familia	No	15
Electrical Supdts. (depot)	rization	No	03
Electrical Supdts. (generation)	"	No	10

Mechanical supdts.	Familiarization	No	12
S.B.00 (P.S.)	"	No	23
S.B.00(S.Y.)	"	No	25
Meter readers	"	No	72
E.FF (Generation)	"	No	22
E.FF (switch-yard)	"	No	05
M.FF (generation)	"	No	08
M.FF (Switch-yard)	"	No	10
Cable joints	"	No	07
Engine drivers	"	No	12
Linesman (construction)	"	No	14
Linesman (Depot)	"	No	54

TECHNICAL TRAINING CENTRE, CEB, PALLEKELLE

Electrical installation of blgds. and repair home appliances	For Janasaviya recipients	No	25

SRI LANKA AIR FORCE

Technical

Air Frame Adv. Course	Certificate	Yes	10
Aero Engine Adv. Course	"	"	16
Aero Inst. Adv. Course	"	"	03
Aero Electrical Adv. Course	"	"	05
Safety Equipment	"	"	04
M.T.M. Adv. Course	"	"	09
Armament Fitter Adv. Course	"	"	18
General Fitter Adv. Course	"	"	06
A/C welder	"	"	20
Surface Tech. Adv.Course	"	"	19
Air Radio Adv. Course	"	"	-
Teli Fitter Adv. Course	"	"	-

Vocational

Fire Fighter Adv. course	"	"	12
O.M.T. Adv. Course	"	"	17
Supplier Adv. Course	"	"	16
Air Com. Adv. Course	"	"	12
Telephonist	"	"	05
Plumber Adv. Course	"	"	18
Dog Handler	"	"	08
Mucian Adv. Course	"	"	

MINISTRY OF HIGHER EDUCATION
TECHNICAL EDUCATION DIVISION

Accountancy (2 Courses)	Diploma	Yes	1619
Commerce	"	"	889
Civil Engineering	"	"	102
Mechanical Engineering	"	"	96
Electrical Engineering	"	"	103
Business Studies (11 Courses)	"	"	1162
Agriculture	"	"	104
Home Economics	"	"	182
English	"	"	265
Jewellery	Design Manuf.	"	24
Secretarial Practice	"	"	84
Labour & Tax Return	Certificate	"	0
Stenography	"	"	1746
English Commerce & Industry	"	"	1076
Sales Marketing (2 courses)	"	"	0
Civil Engineering Technology	"	"	1482
Mechanical Engineering Technology	"	"	619
Electric & Electronic Eng. Tech.	"	"	838
Quantity Surveying	"	"	695
Draughtsmen Apprenticeship	"	"	676
Gem Industry	"	"	21
Accounting Technicians (2 courses)	"	"	1619
Marketing	"	-	153
Public Administration	"	-	44
Machining	"	"	216
Plumbing (3 courses)	"	"	269
Electrical wiring (2 courses)	"	"	538
Radio Servicing	"	"	52
Refrig. & Air Conditioning	"	"	0
Fitting (General)	"	"	83
Tractor Mechanics	"	"	31
Motor Vehicle Electrician	"	"	63
Welding Practice	"	"	23
Agriculture	"	"	24
Automotive Mechanic	"	"	328
Textile & Furnishing	"	"	17
Elect.Installation in Building	"	"	153
Building Trade	"	"	8
Radio & Electro Mech.	"	"	37
Craft Metal work	"	"	165

Radio & Electronics	"	"	12
T.V. Technology	"	"	13
Craftsman Auto Trade	"	-	113
Craftsman Elect. Trade	"	-	191
Craftsman Building Trade	"	-	9
Gas & Arc Welding	"	Yes	23
Wood Machinist	"	Yes	44
Refrig. & Air Cond. Mech.	"	Yes	26
Electrical Trade	"	-	24
Wood Carving	"	-	39
Welding Practice	"	-	133
Tailoring	"	-	52
Batiks & Textile Print	"	-	13
Art. Flower & Doll Making	"	-	14
Repairs to water pumps	"	-	0
Motor Cy. & Scooter Rep/Maint	"	-	13
Anthurium & Orchid Culture	"	-	13
Owner Drives	"	-	0
Prod. of Leather Goods	"	-	11
Dress Making	"	-	9
Steel fixing and Bar Bending	"	-	53
Repair/Manuf. of Boat Engines	"	-	30
Lathe Practice	"	-	11
Woodwork (3 courses)	"	-	876
Electrician	"	Yes	38
Automotive mechanics	"	Yes	102
Mechanical Craft	"	-	167
Fitting	"	-	0
Building Trade (2 courses)	"	-	1021
Supervisory Training	"	-	126

Note: Data summarized in this Table are based on a survey carried out during October - November 1991

*Courses with Dual Training

2.5 FINANCIAL RESOURCES FOR TECHNICAL EDUCATION

The total budgetary expenditure on education as a percentage of GDP during the period 1978 to 1984 had been only 2.7 percent as compared to 3.4 percent during the period 1970 to 1977. However in the preparation of the Public Investment Programme for 1988 to 1992, the government had decided to increase the budgetary allocation for education to 3.5 percent of GDP, which would thus be slightly higher relatively, than the average recorded for the period 1970-77 (19).

The financial resources allocated for the Education sector had increased from Rs. 1344 million in 1979 to Rs. 5202 million in 1987 indicating an annual growth rate of 36 per cent. However, appropriation of resources for technical education had been less than 2.5 per cent of the total allocation for the sector. The Table 2.3 below shows the trends in the allocation of funds for technical education with 1981 recording the lowest percentage, and 1985 the highest, during the period 1979 to 1987.

TABLE 2.3

ALLOCATION OF FINANCIAL RESOURCES IN THE EDUCATION SECTOR (in Rs. million)

Year	Funds allocated for Education	Funds allocated for Technical	Funds for Technical Education as %
1979	1344.9	29.7	2.21
1980	1719.4	29.6	1.72
1981	2075.7	22.2	1.07
1982	2538.8	38.4	1.51
1983	2907. 1	50.1	1.72
1984	3329.4	73.0	2.19
1985	4183.3	94.1	2.25
1986	5034.8	100.4	1.99
1987	5202.4	100.2	1.93

Source: Communication from the University Grants Commission

Chapter 3

INDUSTRIAL RESEARCH AND DEVELOPMENT

3.1 RESEARCH FUNDING :

Sri Lanka's expenditure on research and development (R&D) increased from Rs. 45 million in 1975 to Rs. 257 million in 1984. However, in real terms, this increment had been only from Rs. 45 million in 1975 to Rs. 78 million in 1985. It is significant that 93 per cent of the gross national expenditure on R & D had been from the State Sector, and only 7 per cent had come from the private sector (20). In general, this had been the trend throughout the past several decades. These figures indicate the strong influence of the State on the role and direction of science and technology in the country. It has also been observed that 15 major state research institutions account for nearly 80 percent of the total R & D expenditure in the country. The data presented in Table 3.1 shows the sectoral share of research funds accounted for by 15 major research performers.

TABLE 3.1

R & D EXPENDITURE OUTLAY OF 15 MAJOR RESEARCH ORGANIZATIONS TO THREE SECTORS (1984) (in thousands of rupees)

Sector	Recurrent		Capital		Total
	wages	other	equip	other	
Agriculture & Animal Husbandry-	59,002	43,496	14,440	14,968	131,906 (71%)
Forestry & Fishery	2,445	1,269	1,526	7,475	12,715 (7%)
Industry	13,987	5,216	15,284	7,346	40,386 (22%)
TOTAL	73,987	49,981	31,250	29,789	185,007

Source : Liyanage, S & De Silva, M.A.T. (1987) Science and Technology Indicators in Sri Lanka, Part I

Table 3.2 shows the distribution of R & D expenditure in terms of basic, applied and experimental development research, while Table 3.3 shows the breakdown of expenditure by source of funds.

TABLE 3.2

R&D EXPENDITURE BY TYPE OF RESEARCH (1984)

(In thousands of Rupees)

Field of Science	Basic Research	Applied Research	Experimental Research
Natural Sciences	5,254	21,720	3,765
Agricultural Sciences	11,841	111,95	30,118
Engineering Science	117	20,619	12,031
Medical Science	6,056	6,788	455
Social Science	1,485	24,535	520
Total	24,753	185,157	46,889
As% of Total	10	72	18

Source : Liyanage, S and De Silva M.A.T. 1987 Science and Technology Indicators in Sri Lanka, Part I.

Tables 3.1, 3.2 and 3.3 clearly demonstrate the dominance of the Agriculture sector in scientific research. It obviously shows the priority and importance given to this sector in the economy of the country. On the other hand, scientific activity in the industrial sector, as evident from the patronage given to industrial research as well as to the engineering sciences as a whole, has been marginal. However, in the context of the current policy directives of the government with a massive thrust towards industrialization, this structure of scientific activity will have to change, and a major transformation towards technology and experimental development will have to take place to sustain an industrial base. Although plans are being drawn up to bring about a transformation , it is clear that such a change cannot be brought about overnight. Among the activities proposed include the amalgamation of some of the industrial research organizations, establishing direct links with the industry, making research organizations commercially viable through contract research and/or research directed towards process and product development. Incentives are also being provided to industrialists through tax concessions for R & D Expenditure, and building allowances for construction of buildings used for research.

TABLE 3.3

R & D EXPENDITURE BY SOURCE OF FUNDS AND FIELDS OF SCIENCE (1984) (In thousands of Rupees)

Field of Science	Local funds	Foreign funds	Total
Natural Science	30,111	628	30,739
Agricultural Science	135,824	17,630	153,454
Engineering Science	25,025	7,742	32,767
Medical Science	7,221	6,078	13,299
Social Science	16,779	9,761	26,540
Total	214,960	41,839	256,799
As % of Total	84	16	100

Source :Liyanage, S and De Silva, M.A.T. (1987) Science and Technology Indicators in Sri Lanka, Part I

There is little doubt that the proposals contained in the government's Strategy for Industrialization are revolutionary and outward looking. Its vision is towards making Sri Lanka, yet another of the newly industrialized countries. Yet its success will depend on a number of factors which should be set in the correct perspective using correct policy decisions and instruments. Among the factors that will have a bearing on the result is the environment or the climate for investment, industrialization, and acquisition and transfer of technology. This climatic factor comprises of a variety of physical, invisible and moral issues, inductive of investment, supportive of industrialization, and promotive of technology transfer. Among such facilitating issues are the administrative flexibility, status of physical infrastructure (including quality and reliability of energy supply, telecommunication, transport and informatics), the effectiveness of services such as insurance and shipping, the state of Science and Technology and the strength of the academic base. While the Strategy for Industrialization has been quite eloquent in its presentation of the administrative, fiscal and financial incentives, and to some extent on physical infrastructure, its outlook on science, technology and the academic scene are grossly inadequate. In fact, when one considers the rate at which efforts in Science and Technology have been declining over the past two decades (measured in terms of the fall in gross expenditure on R & D as percentage of GDP - see reference (20)), it is difficult to see how Sri Lanka's dream of being a newly industrialized country could be realized.

The reason for this is clear and simple; because an industrial super - structure, inevitably made up of a range of generic technologies from intermediate to state of the art technologies, could hardly be sustained on the type of academic and scientific profile that has characterized Sri Lanka during the past few decades. The 1990's does not appear any better with a critical shortage of specialized personnel, constrained by the lack of a S & T planning framework, or even the political awareness of its needs, and more seriously, the lack of an appreciation of the role that scientists and technologist could play in technological development.

3.2 DEPLOYMENT OF SCIENTIFIC AND TECHNICAL WORKFORCE

Although studies have shown that scientific and technical manpower employment in scientific institutions had been steadily increasing with an annual growth rate of about 10 percent, from 4567 in 1978 to 8253 in 1985 (20), the present indications are that this growth rate has declined during the latter half of the last decade (ie. from 1985 to 1990). This is due to, (a) the closure of the institutes of higher education for nearly two years, and (b) the displacement and massive migration of the educated youth following the turmoil in the North and South of Sri Lanka during 1983 to 1989. In fact, judging by the current manpower strengths in the scientific organizations in the country, it is very likely that a negative growth rate would have occurred between 1985 and 1989.

The total scientific and technical (S & T) human resource potential has been estimated to be around 21,500 of which scientists and engineers comprised of 10,579 and technicians 3908. Tables 3.4, 3.5 and 3.6 illustrates the structure of S & T personnel in 1985.

TABLE 3.4

ECONOMICALLY ACTIVE S & T PERSONNEL IN 1985 BY MAJOR CLASS AND SEX

	Scientists	Engi-neers	Archi tects	Medical scientists	Social Scientists	Technicians
Males	2802	4165	268	244	1448	3419
Females	640	315	63	133	501	489
Total	3442	4480	331	377	1949	3908

Source : Liyanage, S, and De Silva, M.A.T. (1987) Science and Technology Indicators for Sri Lanka, Part I

TABLE 3.5

EMPLOYMENT IN THE PUBLIC AND PRIVATE SECTOR INSTITUTIONS DURING 1985

	Public Sector			Private Sector		
	Males	**Females**	**Total**	**Males**	**Females**	**Total**
Scientists	2584	623	3207	217	18	235
Engineers	3681	310	3991	484	05	489
Architects	126	47	173	12	16	158
Medical Scientists	228	132	360	16	01	17
Social Scientists	1410	499	1909	38	02	40
Technicians	3088	485	3573	331	04	335
Total	11117	2096	13213	1228	46	1274

Source : Liyanage, S. and De Silva, M.A.T. (1987) Science & Technology Indicators for Sri Lanka, Part I

The main features of the S & T human resource structure may be summarized as follows:

(a) In all sectors, the S & T personnel comprise of 85 per cent of males and 15 percent of females.

(b) The female population is highest among medical scientists (35%) and lowest in engineering sciences (7%)

(c) The proportion of S & T personnel in the private sector is only 9 per cent of the total.

(d) Among private sector S & T personnel, only 3.8 per cent were females as against 18.9 per cent in the state sector

(e) Among scientists and engineers, 24.6 per cent had post graduate qualifications.

TABLE 3.6

EDUCATIONAL LEVELS OF THE S & T WORKFORCE DURING 1985/86

Category of personnel	Bachelors Degree	Postgraduate Diploma	Master Degree	Doctoral Degree
Scientists	1919	100	488	336
Engineers	2987	125	320	81
Architects	89	27	33	21
Medical Scientists	223	34	59	25
Social Scientists	1352	122	116	256
Total	6570	408	1016	719

Source :Liyanage, S. and De Silva, M.A.T. (1987) Science and Technology Indicators for Sri Lanka, Part I

The number of S & T personnel engaged in scientific research was enumerated to be 4108 during 1985/86 (20). Out of these, 3117 were found to be engaged in full time research and others on a part time basis. The table below gives the structure and time-equivalence of the number of S & T personnel engaged in R & D.

3. 3 INSTITUTES FOR INDUSTRIAL RESEARCH

Although a number of research organizations are involved in industrial research, the two main institutions fully committed to serve the manufacturing industry are the Ceylon Institute of Scientific and Industrial Research (CISIR), established in 1955, and the National Engineering Research and Development Centre (NERD Centre) established in 1974. The other research organizations associated with the industrial sector include the plantation research institutes TRI, RRI and CRI, and organizations such as National Building Research Organization, (NBRO), Rice Processing Research and Development Centre (RPRDC) and the Farm Mechanization Research Centre (FMRC) at the Maha Illuppallama Research Station. These latter institutions are specialized in specific fields and are mandated to function within these fields.

TABLE 3.7

R & D PERSONNEL BY TIME EQUIVALENCE AND FIELD OF SCIENCE 1985/86

Field of Science	Full time		Part Time		
	Total	Female	Total	Female	Fulltime Equivalence
Natural Science	1503	400	169	47	1559
Medical Science	195	67	40	21	208
Engineering Science	229	22	191	17	293
Social Science	599	116	394	102	730
Technicians	645	181	143	21	693
Total	**3171**	**786**	**937**	**208**	**3483**

Source : Liyanage, S. and De Silva, M.A.T. (1987) Science and Technology Indicators for Sri Lanka, Part I

The CISIR is a statutory body under the Office of the Subject Specific Minister of Science and Technology. Its main policy making body is the Governing Board, which lay down the main guidelines for scientific activities of the organization, based on the advise of the Research Planning Council. The organization is headed by a Director and three Deputy Directors. The 16 sections of the CISIR comprise of 13 research divisions (Applied Physics and Electronics, Rubber and Plastics Technology, Natural Products, Industrial Microbiology, Agro-industries, Food Technology, Wood Cellulose, Pilot Plant and Design, Analytical Chemistry, Minierals Technology, Industrial Economics, Environmental Science and Technology, and Engineering Services), and 3 service divisions (Information, Instruments Centre and a Workshop).

The objectives of the CISIR are as follows :

- To undertake testing, investigation and research programmes in such a manner as the institute may deem advisable, with the object of improving the technical processes and methods used in industry, of discovering processes and methods which may promote the expansion of existing or the development of new industries or the better utilization of raw materials or waste products.

- To advise on scientific and technological matters affecting the utilization of the natural resources of Sri Lanka, the development of its industries and the proper co-ordination and employment of scientific research to achieve those ends.

- To foster the training of research workers.

- To foster the establishment of associations of persons engaged in industry for the purpose of carrying out scientific and industrial research.

- To undertake or to collaborate in the preparation, publication and dissemination of useful technical information.

- To co-operate with departments of government, universities, technical colleges and other bodies in order to promote scientific and industrial research, and the training of investigators in pure and applied science and of technical experts.

- To assist otherwise in the advancement of scientific research and technical training.

- To undertake, or to collaborate in, the surveying and monitoring of environmental pollution with the object of devising remedial measures to reduce or eliminate such pollution.

- To engage in technology transfer activities and to offer services in respect of technology transfer to the Government or to other institutions in Sri Lanka.

Like the CISIR the NERD Centre is a statutory body under the purview of the Office of the Subject-Specific Minister of Science and Technology. Its main policy making body is the Board of Management, whose Chairman is also the Chief Executive. It has nine research and development divisions (Machine Development and Fabrication, Electrical and Electronics, Civil Engineering, Chemical Engineering, Solar and Wind Energy, Biogas, Process Plant and Agriculture, Techno-economics, and Energy Management), and 3 service sections (Workshops, Computer Centre, and Library).

The objectives of the NERD Centre are as follows :

- To provide for the institutional mechanisms needed for the progressive development of indigenous technology by encouraging, recognizing and developing innovative and creative talent in Sri Lanka.

- To provide facilities to co-ordinate the technological engineering and research capabilities of various public and private sector industries and institutions in a productive manner through a co-operative endeavour.

- To ensure by adoption and adaptation the choice of technologies that would be consistent with the country's resource endowments and national planning objectives.

- To examine the direct and indirect mechanism of technology transfer and offer counsel to appropriate government and private institutions in Sri Lanka, when required to do so.

- To promote the optimal exploitation of the country's human and material resources by promoting the growth of suitable technbology.

- To design, manufacture and test prototype machinery, pilot plants as demanded by industrial, commercial organizations and others.

- To provide for continuous monitoring of technological data and documentation relating to engineering designs and research through the co-operation of international and national agencies.

- To offer sustained consultancy services to public and private sector enterprises and undertake research and promote training activities to broaden the base of the country's engineering, industrial design and research capabilities.

The great majority of the research projects carried out by CISIR and NERD Centre are in-house initiated. In the case of CISIR, these have been estimated at about 90 per cent of all R & D projects; while in NERD, they account for 75 percent of all projects. The criteria for the selection of in-house initiated projects differ in the two institutions. At CISIR, projects proposed by the various R & D sections are submitted to the Research Planning Council for discussion, evaluation and formulation of an advisory opinion to the Governing Board, which has the authority for final approval. In the case of the NERD Centre, project documents prepared by the section or subsection proposing the research project, are submitted to the Chairman of NERD for approval, and subsequently reviewed at executive staff meetings.

3.4 REVIEW OF INDUSTRIAL RESEARCH

Both CISIR and the NERD Centre, progressed through a period of adjustment and orientation since initiation, before getting off the ground. For instance, in the CISIR, after the establishment of the institute, no new recruitment was done until 70 when most of the older scientists were close to retirement. When a new group

of scientists and researchers was finally recruited, there was a gap in the experience and expertise available at the institute. It therefore took sometime before the new group could develop the skills and expertise necessary for the execution of R & D projects. The NERD Centre also took almost four years to enter into the main stream of activities entrusted to it. Indeed, between 1975 and 1977 the NERD Centre contracted out research work to other institutions or to individuals.

However, after the initial orientation phase, considerable progress has been made by both institutions in their mandated fields of activities. The activities presently being carried out by CISIR and NERD Centre are broadly of three types : (i) R & D activities leading to the development of new products or processes, (ii) Non R & D activities mainly consisting of services provided to industry, such as analytical work consultancy, waste management, metrological services, quality testing, and repair and maintenance of equipment, (iii) providing opportunities for training.

The R & D activities undertaken by CISIR and the NERD Centre during the 1960's and 1970's have been reviewed in chapter I of this report. However, after 1977, a general shake-up in the scientific and technical activities in the country became necessary, with the introduction of wide - ranging economic reforms including the liberalization of imports of essential as well as non-essential consumer goods. The

new policies not only facilitated the large scale import of raw materialss for existing industries, but also paved the way for the import of finished goods, some of which were later to compete with locally manufactured goods. There was also a large scale transfer of technology through Foreign Direct Investments and joint venture agreements. In such circumstances, it was evident that some of the earlier scientific and technical programmes were no longer compatible with the new thrust towards a market economy.

A specific example of such redundancy was in the piece of adaptive research undertaken by the NERD Centre from 1978, to 1980, under the auspices of the Commonwealth Science Council, in developing indigenous competence in design and manufacture of low-cost prime movers (21). Under this international collaborative programme, the NERD Centre, functioning as the national counterpart research agency, undertook to collaborate with India and Bangladesh, to develop competence and mastery in the manufacture of small engines of 3.5 hp capacity using locally available material. Accordingly the NERD Centre having acquired a popular engine, stripped it into its various components. Thereafter barring three components (piston assembly, magneto assembly and valve assembly), the NERD Centre researchers tested casting and moulding methods on the other components. Using permanent moulds, the cylinder head, crank case and flywheel were turned out without much difficulty. However, items such as the cylinder block, cam shaft and crank shaft, which had to be turned out outside the NERD Centre workshops, proved difficult. At this stage, as a result of the new import policy of the government, a range of popular models of engines became freely available in the open market. Hence the incentive and desire for the manufacture of engines locally dimmed out, and the project to acquire competence and mastery of the manufacturing technology of small prime movers was discarded (21).

Such reversals in the search for import substituting product manufacture and process technologies, were not limited to state institutions. In fact the few private sector organizations which had in-house research capability, and had initiated programs for identifying and developing alternative industrial raw materials, components and ingredients, were quick to abandon these programs in favour of the less troublesome and less costly alternative of direct import of the required raw materials and intermediates.

The data presented in Table 3.8 shows the types of projects undertaken by CISIR during 1982-1986. It is clear that out of 39 projects, 19 were for product or process development, while the rest constituted largely non - R & D activities (22).

During the 1980's CISIR's main focus of R & D was in the following areas :

- Post harvest technologies for village level application

- Prolonging storage life of fruits and vegetables

- Cultivation and preservation of straw mushrooms

- Composite flour preparations for bakery products to substitute the imported wheat flour

- Cultivation and processing of *Catharanthus roseus* which is a source of vincristine, and hence has a high export value

-Rubber products in relation to solid tyre manufacture development of latex - based products

- Products of coconut (preservation of kingcoconut water, white fibre manufacture and increasing ethanol content of toddy)

- Kelani River pollution studies

- Starch-based products (starch hydrolysis, glucose and alcohol production)

- Cinnamon bark oil distillation

- Processing and upgrading vegetable oils (palm oil, castor oil, mee oil)

TABLE 3.8

PROJECTS UNDERTAKEN DURING 1982-1986 BY CISIR

Year	Product/ process develop ment	Development of Informa- tion	Development of expertise studies	Commercial feasibility studies	Total
1982	3	2	0	4	9
1983	0	1	0	0	1
1984	4	0	1	1	6
1985	2	3	1	1	7
1986	10	2	3	1	16
Total	19	8	5	7	39

Source : The Role of R & D Institution in Technological Innovation: A case study of Sri Lanka - UNCTAD/TT/95 (United Nations NY (1988)

The NERD Centre's activities have been mainly in the engineering fields of civil, mechanical, electronic and chemical. Its research focus in the 1980's have been in low cost building technology, non-conventional energy sources, biomass gasification, biogas technology, wind and solar energy, electronics, energy management and agricultural engineering. Their services include, trouble shooting and quality improvements in mechanical, electrical, and electronic aspects in industry. Its major findings and developments include, (a) a model house incorporating all the low cost techniques developed in the Centre, featuring slipform walls and precast concrete doors and windows, (b) a novel bio-gas unit utilizing straw, grass etc.,

involving no daily feeding or maintenance, with continuous gas production for a period of six months to one year, (c) gassifiers built to international standards for thermal and shaft power application, (d) an energy efficient clay stove with a steel cage, (e) a low-cost F.M. receiver (f) a low-cost rural electrification scheme (Prashakti) and (g) establishment of a rural battery charging unit (for Prashakti), using two wind mills to serve 60 families in a fishing village. It has however, been pointed out that in relation to the number of research programmes undertaken by the CISIR and the NERD Centre during the period 1982-1986, a relatively few have been commercialized (see table 3.9) (22).

TABLE 3.9

PROJECTS UNDERTAKEN FOR PRODUCT/PROCESS DEVELOPMENT BY NERD AND CISIR DURING 1982-1886 (NUMBERS)

R & D Institute	Projects undertaken	Products/ processes commercialized	Projects completed but not yet commercialized	Projects at development stage
CISIR	19	2	5	12
NERD	36	3	16	17

Source : The Role of R & D Institutes in Technology Innovation : A case of Sri Lanka UNCTAD/TT/95 - United Nations N.Y. (1988)

Thus out of 19 projects undertaken by CISIR during this period only 2 had reached the commercialization stage, and at NERD Centre out of 36 projects only 3 had been commercialized. The UNCTAD case study on the Role of R & D Institutes in Technological Innovation in Sri Lanka (22), in its survey of 25 major industrial organizations, identified the diffuse character of linkages of R & D institutions with the Production Sector as a major defect in the R & D system.

The table 3.10 summarizes the views expressed by of 20 commercial organizations in relation to the relevance of Sri Lankas R & D Institutions output to their firms technological needs. And Table 3.11 summarizes the reasons adduced by these organizations to the apparent lack of effective linkages between R & D institutions and industry.

TABLE 3.10

RELEVANCE OF R & D INSTITUTES OUTPUT TO THE TECHNOLOGICAL NEEDS OF THE RESPECTIVE FIRMS
(No. responding)

Relevance of R & D Institutes output to technological needs of firms	SECTOR			
	Chemical Industry	Agro-food Industry	Metal working and machine building industry	Total (out of 20)
No relevance	2	1	3	6
Little relevance	3	2	1	6
Some relevance	1	2	-	3
Highly relevant	2	3	-	5

Source : The Role of R & D Institutes in Technological Innovation : In case study of Sri Lanka UNCTAD/TT/95 United Nations NY (1988)

TABLE 3.11

REASONS FOR APPARENT LACK OF EFFECTIVE LINKS BETWEEN R & D INSTITUTES AND INDUSTRY
(No. responding)

Reason	Total (out of 20)	Chemical industry	Agro-food industry	Metal working and machine buiding Industry
Lack of knowledge of industrial problems	4	1	2	1
Absence of effective liason and extension activity	7	4	2	1

Lack of a market which understand or needs research service	3	-	2	1
Lack of information on R & D Institutes activities	4	2	1	1
Others	2	1	1	-

Source : The Role of R & D Institutes in Technological Innovation : A case study of Sri Lanka, UNCTAD/TT/95 United Nations NY (1988)

The findings of this survey are in line with the general expectations on the issue. Accordingly, the Report states that the failure of R & D institutes to commercialize many of the projects undertaken, were due to (a) the apparent lack of orientation of R & D towards real or actual needs of the productive sector, and (b) the absence of functional linkages with the industrial sector in Sri Lanka. While it is true that the research activities of CISIR and NERD Centre were not demand oriented, it has to be noted that neither the past nor the current State policies and measures on science, technology, and industrial development, have been supportive in ensuring linkages between users and producers of R & D in the industrial sector. Thus any linkages between industry and the industrial research system in the country are *ad hoc* and purely the result of personal contacts, and interests of individual researchers and the industry. In this context it is relevant to note that the most recent official document on industrialization - "A Strategy for Industrialization in Sri Lanka" , very briefly enumerates the tax concessions, to be provided for investing in R & D , and the incentives for research services. Unfortunately, as seen from the experiences of other countries, financial incentives of this type have little or no impact on innovative industrial progress. It is obvious that a distinction has to be made between investment in R & D and innovation in R & D, since concessions and guarantees for investments does not necessarily result in innovation, instead may only serve as alternative opportunities for tax rebate benefits. Also investment in research need not necessarily mean in-house research. Incentives for research investment could also take the form of direct contracts to R & D institutes, or even contributions for a central research foundation. All these proposals need appropriate policy initiatives, adequately supported by financial, legal and fiscal instruments, to create the necessary environment for innovation and mastery of technology. This should be the launching pad for international competitiveness in products and processes, that has been so eloquently spelt out in the Strategy for Industrialization in Sri Lanka. The failure in the policy document to provide guidance on not only the expected thrust of scientific and technological research in industrial and technological progress, but also on measures for evaluation and granting of rewards for elements of invention, innovation, and adaptation of technology, is thus considered a major short coming.

Chapter 4

THE BUSINESS SECTOR OF SRI LANKA

4.1 THE STRUCTURE OF COMMERCIAL ACTIVITY

A survey by the Central Bank of Sri Lanka estimates the total number of companies in the country, in 1986, to be 6941 comprising of 461 (or 6.6 per cent) public limited liability companies, and 6480 (or 93.4 per cent) private limited liability companies (23). This is said to be an increase of 12.4 per cent over the number enumerated for 1985. The increase had occured both in the public companies (15.8 per cent), as well as in the private companies (14 per cent). The Table 4.1 shows the sector-wise distribution of commercial companies in Sri Lanka.

The table shows that the highest number of companies (28.6 per cent of the total), are in the manufacturing sector, and this again spreads to both the public and private firms, with the former enjoying a bigger share than the later.

The estimated share capital of all companies was Rs.35.22 million of which about 32.7 per cent was in the Transport, Storage and Communication sector, while about 22.0 per cent was in the manufacturing sector. However, when disaggregated between public and private companies, the latter appeared to have committed 45.4 percent of their share capital to the manufacturing industries, and only 8.3 per cent in the case of public companies. Nevertheless the public companies had contributed 46.6 per cent of the share capital to transport, storage and communications. The employment structure in the commercial firms is shown in Table 4.2.

The total number employed in business activities in Sri Lanka was estimated to be 321,652 in 1984/85 which was a reduction of about 44.4 thousand (or a negative growth of 12.1 per cent) from the estimated number for 1983/84. Of the total employed in business activities, 16.9 per cent were in public companies and 83.1 per cent in private companies.

Of the total number of employees, significantly the highest number (69.4 per cent for public companies and 56.5 per cent for private companies), was in the manufacturing sector. Each of the other sectors accounted for 10 per cent or less of the total number of employees.

Table 4.1

DISTRIBUTION OF COMPANIES BY SECTORS OF ECONOMIC ACTIVITY

Sector	Estimated Number of Companies					
	All companies		Public companies		Private companies	
	No. of companies	Percentage	No.of companies	Percentage	No.of Companies	Percentage
Agriculture Forestry and Fishery	312	4.50	13	2.82	299	4.61
Mining and Quarrying	16	0.23	0	0.00	16	0.25
Manufacturing Industries	1986	28.61	157	34.06	1829	28.23
Construction	227	3.27	6	1.30	221	3.41
Electricity,Gas water & sanitary services	94	1.35	0	0.00	94	1.45
Transport Storage and Communication	382	5.50	19	4.12	363	5.60
Wholesale & Retail Trade	1382	19.91	42	9.11	1340	20.68
Banking Insurance & Real Estate	345	4.97	61	13.23	284	4.38
Hotel services	503	7.25	93	20.17	410	6.33
Other	1694	24.41	70	15.19	1624	25.06
All sectors	6941	100.0	461	100.00	6480	100.00

Source: Report on the Survey of Business Activity and Planned Investment in Sri Lanka 1984/85 to 1986/87. Central Bank of Sri Lanka.

Table 4.2

ESTIMATED NUMBER OF EMPLOYEES IN COMPANIES BY SECTOR OF ECONOMIC ACTIVITY - 1984/85

Sector	All companies		Public companies		Private companies	
	Number	percentage	number	percentage	number	percentage
Agriculture Forestry and Fishery	25,042	7.79	445	0.82	24,597	9.21
Manufacturing Industries	188,818	58.70	37,831	49.42	150,987	56.51
Construction	6,563	2.04	186	0.34	6,377	2.29
Electricity Gas Water & Sanitary Services	3,196	1.00	-	-	3,196	1.20
Transport, storage & communication	14,699	4.57	589	1.08	14,110	5.28
Wholesale & Retail Trade	26,229	8.15	1683	3.09	24,546	9.19
Banking, Insurance and Real Estate	5,003	1.56	2668	4.90	2,335	0.88
Hotel Service & Tourism	17,380	5.40	9290	17.05	8,090	3.0
Other	34,772	10.79	1801	3.30	32921	11.32
All Sectors	321,652	100.00	54493	100.00	267159	100.00

Source: Report on Survey of Business Activities and Planned Investment in Sri Lanka 1984/85 to 1986/87. Central Bank of Sri Lanka

The distribution of the work force in the business sector, according to the occupational categories shows (Table 4.3), that the highest number of employees,comprising 34.5 per cent of the total employed in all companies, were in the category of unskilled workers **(23)**.

TABLE 4.3

ESTIMATED NUMBER OF EMPLOYEES IN 1984/85 BY OCCUPATIONAL CATEGORIES

Occupational Categories	All companies		Public companies		Private companies	
	Number	Percentage	Number	Percentage	Number	Percentage
Manager and Administrators	17,163	5.34	2,673	4.91	14,490	5.42
Scientists, Engineers	4,105	1.28	826	1.52	3,279	1.23
Clerks, Cashiers & Translators	26,913	8.37	4,840	8.88	22,073	8.26
Typists, Stenographers & Punch Card Operators	7,156	2.22	1,354	2.48	5,802	2.17
Middle-Level Technicians and Skilled workers	71,769	22.31	16,791	30.81	54,978	20.58
Messengers, Peons and Drivers	17,499	5.44	1,985	3.64	15,514	5.81
Security Officers & Store Keepers	8,355	2.60	1,424	2.63	6,921	2.59
Sales Staff	11,199	3.48	1,329	2.44	9,870	3.69
Unskilled workers	111009	34.51	14,739	27.05	96,270	36.04
Other	46484	14.45	8,522	15.64	37,962	14.21
All categories	321,652	100.00	54493	100.00	267,159	100.00

Source: Report on the Survey of Business Activities and Planned Investment in Sri Lanka 1984/85 to 1986/87. Central Bank of Sri Lanka.

TABLE 4.4

RATIO OF INVESTMENT TO EMPLOYMENT IN THE COMMERCIAL SECTOR OF SRI LANKA DURING 1984/85

Sector	Estimates issued share capital (Rs.1000"s)		No. of employees per block of 1000 issued shares*	
	Public Companies	Private Companies	Public Companies	Private Companies
Agriculture, Forestry and Fishery	70,332	352,663	15.8	1.4
Mining and Quarrying	-	149,856	-	-
Manufacturing Industries	1,849,31	5,879,384	4.9	3.9
Construction	432,723	24,231	232.7	0.4
Electricity, Gas, Water & Sanitary Services	-	330,363	-	10.3
Transport, storage and commu nications	10,373,791	1,153,835	1761.3	8.2
Wholesale & Retail Trade	239,032	1,013,434	14.2	4.1
Banking, Insurance & real estate	1,152,634	1,030,510	43.2	44.1
Hotel services and Tourism	5,612,406	716,601	60.4	8.9
Other	2,534,280	2,307,152	140.7	7.0
Total/Overall	22,265,127	12,958,029	40.9	4.9

* A block of 1000 shares is assumed to be at the par value of Rs.10,000/=

Source: *Extracted from the "Report on the Survey of Business Activities and Planned Investment in Sri Lanka, 1984/85 to 1986/87, Central Bank of Sri Lanka*

The category next in importance, in terms of numbers is the middle level technicians and skilled workers, who made up 22.3 per cent of the total. The senior managers were 5.3 per cent, while scientists, engineers and doctors comprised only about 1.3 per cent. Disaggregagted figures however, show that in the public companies, middle-level technicians with 30.8 per cent, out number the unskilled labour, which comprise 27.1 per cent (23).

The data presented in Table 4.4 shows the distribution of the issued share capital of companies by sector of economy, as well as its relation to the employment structure.

TABLE 4.5

ACTUAL AND PLANNED INVESTMENT BY TYPE OF ASSETS 1984/85-1986/87 (Rs. million)

Type of Assets	1984/85		1985/86		1986/87	
	Amount Rs.Mn	%	Amount Rs.Mn	%	Amount Rs.Mn	%
Public Companies	9699	100.00	5030	100.00	7597	100.00
Land & Land Improvement	340	3.51	139	2.76	306	4.03
Building (Residential &Non-residential)	1943	20.03	2798	55.63	4588	60.39
Machinery & Equipment	930	9.59	860	17.10	1523	20.05
Office Equipment & Furniture	696	7.18	286	5.69	309	4.07
Transport Equipment	1630	16.80	291	5.78	269	3.54
Other	4160	42.89	656	13.04	602	7.92

Private companies	5730	100.00	7203	100.00	7550	100.00
Land & Land Improvement	1165	20.33	818	11.36	952	12.61
Building (Residential & Non Residential)	646	11.27	1568	21.77	2830	37.48
Machinery & Equipment	1922	33.54	2458	34.12	1594	21.11
Office Equipment and Furniture	261	4.56	246	3.42	252	3.34
Transport Equipment	490	8.55	469	6.51	444	5.88
Other	1246	21.75	1644	22.82	1478	19.58

Source: *Report on the Survey of Business Activities and Planned Investment in Sri lanka 1984/85 to 1986/87 Central Bank of Sri Lanka.*

The total issued share capital of all companies stood at Rs.35,223.1 million during 1984-85, which had been an increase of 43.0 per cent over the estimated share capital of 1983-84. However, the issued share capital of private companies had declined by Rs. 5,307 million. It had been shown (23) that the overall increase in the share capital was mainly due to an increase in the number of companies. The per capita share capital was also shown to have increased from Rs.4.1 million per company in 1983-84 to Rs.5.1 million per company in 1984-85 (23).

A highly significant structural transformation in relation to deployment of capital, is the sharp increase in issued share capital in the transport, storage and communications sector which rose from a negligible share of 0.8 per cent in 1983/84 to 33 per cent during 1984/85. This phenomenon has been attributed to a rapid increase in the number of companies, especially public companies servicing this sector.

Table 4.4 also attempts to evaluate the impact of the capital deployment strategies on employment. The overall outlook points to the fact that public limited liability companies had almost a ten fold greater commitment to employment than private limited liability companies. While the ratio of capital to employment shows no marked disparity between public and private limited liability companies, in respect of the economic sectors of manufacturing industries, banking, insurance and real estate, in all other sectors there appears to be a substantial difference with very high ratio for the latter class . These very large gaps may be indicative of the higher

utilization and or efficiency of manpower, or a gross exploitation of labour, by the private limited liability companies .

Table 4.5 illustrates the pattern of actual investments by Sri Lankan companies during 1984-1985 and planned investments for 1985 to 1987.

It is significant that while private limited liability companies have in general deployed one third of their investment on machinery and equipment, public companies have contributed less than 10 per cent on such technology-related material during 1984- 85. On the other hand public companies have planned progressively increasing levels of investments on machinery and equipment during the period 1985 to 1987, while private companies have planned for decreasing levels of investments for these items during the same period. The increasing levels of technology related inputs in public companies may reflect the growing awareness of these firms of on-going technological changes, for which replacement or upgrading of existing technological hardware becomes necessary. On the other hand the decreasing levels of technology related inputs in private companies could mean a disinclination to make major commitments in an uncertain economic environment.

The Central Bank survey which covers many other aspects in the operation of business establishments in Sri Lanka, provides a good insight to the commercial activities in the country.

Chapter 5

SRI LANKA'S REGIONAL PERSPECTIVE IN ECONOMIC GROWTH, TRADE AND TECHNOLOGY FLOWS

5.1 SUB REGIONAL SETTING:

Sri Lanka's economy and international trade are inevitably linked and influenced by the role played by neighbouring nations, either individually or as members of sub-regional economic communities. Sri Lanka is a member of one such group, the South Asian Association for Regional Co-operation (SAARC).

SAARC unlike its more senior South-East Asian rival ASEAN, comprises of a highly diverse group of countries ranging in size from the tiny land-locked Kingdom of Bhutan and the 1190 odd microscopic islands comprising the Republic of Maldives, to the massive sub-continent of India (see Table 5.1). Also amongst its members is one of the most thickly populated nations, Bangladesh (721 inhabitants per sq.km) at one end, and a thinly populated nation, Bhutan (30 inhabitants per sq. km) at the other extreme.

Economically SAARC also has amongst its members, four countries (Bangladesh, Bhutan, Maldives and Nepal) falling into the category of Least Development Countries (LDC's), while the other members (India, Pakistan and Sri Lanka) are at the lower end of the scale of Developing countries.

Thus apart from proximity, and historical and cultural ties, there appears to be very few commonalities amongst the member-countries of SAARC. On the other hand ASEAN, comprising of Brunei Darussalam, Indonesia, Malaysia, Philippines, Singapore and Thailand are either in the category of Newly Industrialized Countries (NIC's) or on the threshold of acquiring NIC status. It has amongst its members a small island nation Singapore with little or no natural resources, and Brunei with substantial fossil fuel resources, both countries enjoying per capita income levels comparable to Development Market Economy Countries of the Western Hemisphere. Obviously therefore ASEAN countries are several steps ahead of SAARC nations in economic progress, and hence their influence and comparative advantage as front runners in regional and international trade has to be recognized.

Unfortunately geographical proximity among SAARC nations has not implied, easy communications and travel with practically no direct air links among its capital cities. Bilateral relations which are not mandated for review within the SAARC conventions, are at times under stress, making the group vulnerable and less stable against external economic and trade pressures.

5.2 SRI LANKA IN RELATION TO ITS NEIGHBOURS IN ECONOMIC ACTIVITIES

Though Sri Lanka is a small island nation, its economy is not constrained by the type of debilities which characterize countries such as the Republic of Maldives (24) and Seychelles. Its geographic characteristics are such that it does not suffer from isolation, remoteness, fragmentation and insularity. Its geological structure is such that its soil, water and the ecosystem in general, are not prone to natural hazards or disaster. Its natural resources base, manpower potential and indigenous technological capability more than matches the scales of the economy, unlike for example, in the case Bhutan and the Maldives (24, 25). Though deeply ingrained in the fabric of social and cultural traditions typical of South Asian countries, its value systems are rational and characteristically adaptable.

TABLE 5.1

STATUS OF SRI LANKA IN SOUTH ASIA THROUGH SELECTED GEOPHYSICAL AND ECONOMIC INDICATORS

	Population ('000s)	Population growth % 1980/87	Land area (Km^2)	Population Density Persons Per Km^2	Total GDP (1987) (million US$)	Per-capita GDP (1987) (US $)
ASEAN Countries	301,809	2.20	3,054,669	99	208,385	690
SAARC Countries	1,029,660	2.36	4,481,397	302	311,278	279
Bangladesh	102,560	2.4	144,000	721	17,603	172
Bhutan	1,424	1.8	47,000	30	252	117
India	786,220	2.1	3,287,587	239	248,991	317
Maldives	193	3.1	300	643	89	462
Nepal	17,440	2.6	140,800	124	2,709	155
Pakistan	105,119	2.8	796,100	132	34,953	333
SRI LANKA	**16,709**	**1.7**	**65,610**	**225**	**6,681**	**400**

Source: UNCTAD Handbook of International Trade and Development Statistics (1989), United Nations N.Y. 1990

Nevertheless its capacity to enhance its economic structure through technological and industrial advancement has been restrained not only by inappropriate and somewhat dis-oriented industrial policy measures, but also by the non-predictable and hazardous international trade winds.

On the other hand Sri Lanka has benefitted from highly favourable health, nutrition and education policies since independence, leading to a Physical Quality of Life Index, not matched by many developing countries. Its population growth rate of 1.7 percent per annum during 1980-1987 is the best among SAARC nations (see table 5.1) although its population density is still on the higher side. Its GDP percapita of US $ 400 is however, very low although it is well above the average for SAARC nations, and just surpasses the lower limit of one of the criteria set to qualify for Least Developed Country status.

The data summarized in Table 5.2 shows the general economic performance of Sri Lanka in relation to its neighbours over the past several decades. Thus the average annual growth rate of total and percapita GDP had declined, despite of major policy reforms throughout this period. While SAARC countries in general have been able to maintain a steady growth in GDP during the period 1985 to 1988, Sri Lanka grapling with rebellious and ethnic violence, and Bangladesh battered by repeated natural disasters have shown a downward trend. It is significant that the two smallest members Bhutan and Maldives, classified as LDC's, are amongst those with highest growth rates for total and per capita GDP.

TABLE 5.2

ANNUAL AVERAGE GROWTH RATES OF TOTAL AND PER CAPITA REAL GDP AT MARKET PRICES (IN PERCENT)

Countries	1960 - 1970	1970 - 1980	1985 - 1986	1986 - 1987	1987 - 1988
ASEAN Countries	5.3	7.4	3.2	5.3	7.2
SAARC countries	4.2	4.4	6.1	6.5	6.1
Bangladesh	3.8	3.7	4.7	4.0	2.6
Bhutan	-	6.6	10.2	17.8	3.3
India	3.6	3.6	4.6	4.4	9.0
Maldives	-	-	9.4	8.9	8.7
Nepal	2.3	2.7	3.9	2.4	9.7
Pakistan	6.1	4.9	5.5	**6.4**	**7.0**
SRI LANKA	**5.0**	**4.8**	**4.3**	**1.5**	**2.7**

Source: UNCTAD Handbook of International Trade and Development Statistics (1989), United Nations. N.Y. 1990.

TABLE 5.3

ENERGY PRODUCTION, TRANSFORMATION, CONSUMPTION AND GROWTH IN SOUTH AND SOUTH-EAST ASIA

Countries	Total production (million tonnes coal eq.)	Electricity		Consumption	
		Installed capacity ('ooo kw)	per 1000 population	Total (10^6 tonnes coal eq)	Per capita (Kg of coal eq)
ASEAN Countries					
1970	74.80	6,779	33	43.5	210
1980	183.70	18,407	70	84.6	323
1987	222.20	32,755	109	124.6	413
SAARC Countries					
1970	73.20	18,935	17	89.1	89
1980	126.00	38,317	22	155.7	87
1987	232.40	68,308	38	257.7	138
SRI LANKA					
1970	0.09	281	22	1.5	122
1980	0.18	421	28	1.6	109
1987	0.27	1071	64	2.1	124

Source: UNCTAD Handbook of Trade and Development Statistics (1989), United Nations, N.Y. 1990

Table 5.3 presents comparative information on total and *percapita* energy consumption, another of the common indicators of economic progress. Despite of the fact that *percapita* energy consumption is considerably higher in ASEAN countries in general, the total production of energy exceeds by almost 2 - fold, the total energy consumption. Whereas in the SAARC countries unfortunately energy consumption does not match energy production, which means that member countries of SAARC have in general to import a substantial component of its energy requirements. Although both total and *percapita* energy consumption had increased significantly in both groups of countries, Sri Lanka's growth in energy consumption has been only marginal. However, Sri Lanka's production of electrical energy per 1000 population has increased substantially over the period 1980 - 1987, and compares favourably with both ASEAN and SAARC group averages.

Accordingly, the ratio of overall energy production to consumption in Sri Lanka, has increased from 0.06 in 1970 to 0.13 in 1987.

TABLE 5.4

TRENDS IN BALANCE PAYMENTS AND TRADE BALANCE OF SRI LANKA IN RELATION TO SOUTH AND SOUTH EAST ASIA (In million USD)

Countries	Export (f.o.b.)	Imports (c.i.f)	Trade balance	Debits	Credits	Private trans-fers	Balance of payment
SRI LANKA							
1970	339	353	- 14	96	40	1	- 71
1980	1062	1845	- 783	424	278	136	- 793
1985	1316	1833	- 517	667	328	266	- 589
1988	1472	2018	- 545	787	402	319	- 611
South and South East Asia							
1970	14202	16956	- 2754	5189	3726	245	3971
1980	140666	151856	-11189	41763	32885	5939	14129
1985	173403	166559	6844	57584	42919	6233	1589
1988	306500	287208	19473	75559	64663	5881	14458

Source: UNCTAD Handbook of International Trade and Development Statics (1989) United Nations N.Y.

The data presented in Table 5.4 shows the trends in international trade as they affect the national budgets of countries in the South and South East Asia. Although the picture looks gloomy for Sri Lanka the overall changes in the Region seems to be much more promising than what is generally seen individually in a majority of countries of the Region. Thus the Region appears to have experienced a 20-fold increase in export earnings as against a 17 - fold increase in import expenditure from 1970 to 1988, resulting therefore in net positive trade balance, which increased three fold from 1985 to 1988. On the other hand in Sri Lanka, while export earnings increased only about 4 1/2 times from 1970 to 1988, expenditure on imports increased almost 17 times, resulting in an ever widening trade gap, that increased from about US$ 14.2 million in 1970 to US $ 545 million in 1988. The Balance of Payment position also shows a similar trend with the overall South and South-East Asian position improving to a favourable positive figure, while Sri Lanka, despite

of a 300 - fold increase in private transfers, widening the Balance of Payments gap from US $ 71.4 million in 1970 to US $ 610.8 million in 1988.

TABLE 5.5

TRENDS IN INTERNATIONAL RESERVES FOR SOUTH AND SOUTH -EAST ASIAN COUNTRIES

(In millions of dollars at end of year)

Countries	1970	1975	1980	1985	1988
ASEAN Countries	2992	8250	21159	25900	36254
SAARC Countries	1335*	2087*	8645**	8521**	7315**
L.DC's	770	-	3986	3168	5897
Bangladesh	-	148	302	339	965
India	1007	1374	7327	6782	391
Maldives	-	-	1	5	22
Nepal	94	101	190	62	227
Pakistan	191	405	577	881	486
SRI LANKA	**43**	**59**	**249**	**454**	**225**

* Excludes Maldives and Bhutan
** Excludes Bhutan

Source: UNCTAD Handbook of Trade and Development Statistics (1989), Unaited Nations N.Y. 1990

Table 5.5 shows the growth in International Reserves for the South Asian Region in relation to the respective performances, of SAARC countries. A striking feature of the data is the differences in volume and growth of International Reserves between ASEAN and SAARC countries. In 1970, when the International Reserves for SAARC Countries was US$1335 million, that of ASEAN countries was US $2992 million , but by 1988, this difference had increased, with the later sub-region now enjoying a 5-fold difference. Although all SAARC countries had shown a fluctuating increase in International Reserves, from 1970 to 1988, the growth had been slower than for the ASEAN countries.

TABLE 5.6

LONG TERM DEBT AND ITS RELATION TO GNP AND EXPORTS OF GOODS AND SERVICES

Country	Year	Total debt (million USD)	Total debt as % GNP	Total debt service (million USD)	Total debt as % exports of goods & sevices
SAARC COUNTRIES					
	1975	20125	17.4	1343	15.3
	1980	32641	39.9	2310	9.2
	1988	69989	52.3	6132	16.7
ASEAN COUNTRIES					
	1975	15229	19.6	1779	6.6
	1980	36315	20.1	5130	6.1
	1988	114999	57.2	16666	15.9
SRI LANKA					
	1975	617	21.1	138	21.6
	1980	1431	35.8	93	7.4
	1988	4506	67.7	373	21.9

Source: UNCTAD Handbook of Trade and Development Statistics (1989) United Nations, N.Y 1990.

Table 5.6 shows the trends in the growth of long-term debt in relation to Gross National Product (GNP), and the growth of debt service in relation to export earnings in the Region. Although the growth in total debt of ASEAN countries has been higher than for SAARC countries, when computed in relation to GNP, the relative rates of growth appear parallel for the two sub-regions. This is due to the higher growth of GNP in ASEAN countries. Sri Lanka on the other hand experienced a growth rate of 'total debts' which was in general higher than that for

SAARC countries as a whole. Hence its debt expressed as a percentage of GNP is also higher than the average for SAARC countries. Total debt expressed in relation to export earnings shows the capacity of a country to service its debt and also its negotiating capacity for credit from financial institutions and donor countries. Here again Sri Lanka's position appear less favourable than what is seen for SAARCountries in general, as well as for ASEAN countries on the whole.

5.3 INTERNATIONAL TRADE

A country's capacity to acquire goods and services as well as technologies from international markets depends on the strength of its export earnings. Hence one of key policy measures in international trade is to seek enhancement and diversification of exports. Diversification of exports should not only be in terms of the variety of export, but also in its geographic distribution. Two new indices of diversification of exports providing measures in respect of the export structure are the "Diversification Index" and the "Concentration Index".

"Diversification Index" discriminate more finely between countries which are relatively more diversified in the export structure, while "Concentration Index" discriminates more finely between countries which are relatively more concentrated in their export structure (26).

TABLE 5.7

EXPORT DIVERSIFICATION AND CONCENTRATION INDICES OF SELECTED SOUTH ASIAN COUNTRIES

Country	1970			1980		
	Number of commodities	Diversification Index*	Concentration Index**	Number of commodities	Diversification Index**	Concentration Index **
Bangladesh	-	-	-	42	0.876	0.323
Bhutan	NA	NA	NA	NA	NA	NA
India	141	0.653	0.139	154	0.662	0.153
Maldives	NA	NA	NA	NA	NA	NA
Nepal	6	0.972	0.597	42	0.883	0.367
Myanmar	17	0.918	0.499	49	0.871	0.341
Pakistan	91	0.822	0.264	105	0.822	0.240
Singapore	159	0.605	0.295	171	0.492	0.210
SRI LANKA	33	0.935	0.584	84	0.814	0.371

* "Diversification Index" discriminates more finely between countries which are relatively more diversified in the export structure. Absolute deviation of the country commodity shares from world structure is as follows:

$$S_j = \frac{\Sigma_i [h_{ij} - h_i],}{2}$$

where "h_{ij}" = share of commodity in total exports of country 'j' and "h_i " = share of commodity 'i' in total export.

** "Concentration Index" discriminates more finely between countries which are relatively more concentrated in their export structure. Hirschmann index normalized to make values ranging from O to 1 (Max. Conc), according to the following formule,

$$H_j = \frac{\Sigma_{i=1}^{182} \left(\frac{x_1}{\bar{x}}\right)^2 - \frac{1}{182}}{1 - \frac{1}{182}}$$

where j = country index, x_1 = valve of export of commodity 'i', 'X' = $\Sigma_{i=1}^{182} x_i$, and 182 = No. of products at the 3 - digit SITC level.

Source: *UNCTAD Handbook of Trade and development Statistics (1989) United Nations, N.Y. 1990.*

Table 5.7 summarizes the Export Diversification and Concentration Indices of selected South Asian Countries for 1970 and 1986.

It is significant that in Sri Lanka, Myanmar and Nepal, despite of a substantial increase in the number of commodities exported between 1970 and 1986, the growth of the Diversification Index as well as the Concentration Index has been less impressive than for Singapore, which indicates that Sri Lanka's export structure is still biased towards a fewer number commodities.

Table 5.8 compares the trends in exports of selected resource based products from Sri Lanka with those of SAARC partners and other economic country groups. SAARC countries as a whole account for 49.3 percent of the world trade in tea and mate, of which as much as 41 percent (20.6 percent of world exports) is provided by Sri Lanka. SAARC countries also contributes 15.5 percent of rice, 13.5 percent of leather and 10.9 percent of precious stones to the International market. It is significant that in respect of precious stones, traded by the SAARC nations in the international markets, 96.7 percent is accounted for by India and only a meagre 3.3 percent is seen to be provided by Sri Lanka. These official figures obviously do not reflect the substantial volume of precious stones that are known to be smuggled out of the country, depriving the country of valuable foreign exchange earnings. The ASEAN countries on the other hand account for 70 per cent of fixed vegetable oil, 52.4 per cent of rubber, 29.3 percent of rice 24.7 percent of rough wood and 13.7 percent of prepared and canned fish exports in the world.

Table 5.9 shows the country ranking among developing countries for the export of sixteen major commodity groups of selected countries. Sri Lanka occupies the second position in respect of the exports of tea and mate, fifth position in respect of rubber exports, fourth position in respect of pearls, tenth position in respect of fixed vegetable oil and twenty fifth position in respect of fresh fruits, nuts and dried fruits. On the other hand Malaysia takes first place in respect of rubber, rough wood and fixed vegetable oil, while its ASEAN partner, Thailand leads in canned and prepared fish products , Rice and fresh or simple processed vegetable exports. Amongst SAARC nations, India takes first place in tea and mate, leather, and pearls.

Table 5.10 provides a more detailed breakdown of the export structure of Sri Lanka, and its relative magnitude among developing countries and in the world trade. It is significant that clothing which appears as the second largest export commodity of Sri Lanka (25.6 per cent of total exports) during 1985-86, represents only 1.35 per cent of developing country contribution and only 0.67 per cent of world trade. Where as tea and mate which accounts for 31.4 percent of total exports from Sri Lanka, represents 24.8 percent of developing country contribution to exports and one fifth of world trade in this commodity. On the other hand, vegetable fibers accounts for only 1.38 percent of Sri Lanka's exports, but represents a significant 12.9 percent segment of developing country trade and 4.9 percent of international trade in this commodity.

5.4 TRENDS IN TECHNOLOGY FLOWS:

The capital goods industry, including the in-flow and outflow of capital goods, are indicative of the technological strength of a nation. Since the international flow of technology is an essential ingredient of international economic relations, an assessment of the directional flows and channels become important features of national

TABLE 5.8:

TRENDS IN EXPORTS OF SELECTED RESOURCE–BASED PRODUCTS FROM SRI LANKA AND SAARC PARTNERS (1985-86 AVERAGE VALUES) (as percent of world exports)

Export and 3 digit SITC Group	DMEC	D.C	ASEAN COUNTRIES	SAARC COUNTRIES	BANGLADESH	BHUTAN	INDIA	MALDIVES	NEPAL	PAKISTAN	SRI LANKA
Meat fresh chilled and frozen (011)	86.4	12.2	0.82	0.46	0.07	-	0.39	-	-	-	-
Fresh fish, simple pre-served	57.0	42.4	7.61	4.11	0.91	-	2.56	-	-	0.64	-
Fish tinned prepared etc. (032)	55.2	44.8	13.68	-	-	-	-	-	-	-	-
Rice (042)	44.1	55.9	29.32	15.52	-	-	5.60	-	-	9.92	-
Fresh fruit, nuts,fresh dry(051)	56.5	43.2	3.30	2.46	-	-	2.04	-	-	-	0.44
Fruits preser-ved, prepared etc.(052)	57.9	38.9	8.01	0.96	-	-	0.96	-	-	-	-
Vegetables fresh, simply preserved (054)	64.72	33.8	9.48	0.85	0.18	-	0.67	-	-	-	-
Cofee (071)	10.9	89.1	7.20	1.89	-	-	1.89	-	-	-	-
Tea and Mate(074)	16.86	83.2	8.23	49.26	2.06	-	26.6	-	-	-	20.6
Oil seeds nuts & kernals (221)	78.4	20.7	0.95	0.25	0.25	-	-	-	-	-	-
Rubber(231)	39.8	59.5	52.42	1.56	-	-	-	-	-	-	1.56
Wood rough (042)	47.5	41.4	24.66	- -	-	-	-	-	-	-	-

Table 5.8 contd.

Other fixed vegetable-- oil (422)	17.4	82.6	70.22	1.84	-	-	1.00	-	-	-	0.84
Leather (611)	70.4	29.6	0.88	13.47	1.92	-	7.31	-	0.27	3.97	-
Textile yarn and thread (651)	73.2	26.6	1.50	2.96	1.90	-	0.49	-	-	2.28	-
Pearls (667)	83.5	16.5	2.36	10.86	-	-	10.50	-	-	-	0.36

Source: UNCTAD Handbook of Trade and Development Statistics (1989) United Nations. N.Y. 1990

TABLE 5.9:

COUNTRY RANKING FOR EXPORT OF 16 MAJOR COMMODITY GROUPS OF SELECTED COUNTRIES (RANKING AMONG DEVELOPING COUNTRIES BASED ON AVERAGE 1985-86 VALVES)

Commodities by SITC grouping	BANGLADESH	INDIA	NEPAL	PAKISTAN	SRI LANKA	INDONESIA	MALAYSIA	PHILIPPINES	SINGAPORE	THAILAND
Meat, fresh chilled frozen	18	9	-	-	-	18	-	-	14	6
Fresh fish simple processed	14	5	-	17	-	6	21	16	9	3
Fish tinned, prepared	-	-	-	-	-	-	9	9	14	1
Rice	-	3	-	2	-	6	-	-	-	1
Fresh fruit nuts fresh dry	-	7	-	-	25	-	29	6	23	31
Fruit preserved, prepared	-	9	-	-	-	-	13	3	10	2
Vegetables fresh simple processed	23	11	-	-	-	10	-	-	5	1
Coffee	-	13	-	-	-	5	-	26	18	-
Tea and mate	6	1	-	-	2	4	-	-	8	-
Oil seeds nuts & kernels	-	-	-	-	-	-	-	-	-	-
Rubber	-	-	-	-	5	2	1	-	3	4
Wood, roughs	-	-	-	-	-	-	1	9	-	-
Other fixed vegetables oil	-	9	-	-	10	4	1	2	3	-
Leather	5	1	12	3	-	13	-	-	16	9
Textiles, yarn & Thread	19	11	-	4	-	-	17	-	14	7
Pearls	-	1	-	-	4	-	16	-	14	2

Source: *UNCTAD Handbook of Trade and Development Statistics (1989) United Nations, N.Y. 1990*

TABLE 5.10

EXPORT STRUCTURE OF SRI LANKA AND ITS RANKING FOR INTERNATIONAL TRADE (RANKED BY AVERAGE 1985-86 VALUES)

Commodities by SITC	Total value in 1000's of USD	As percent of country total	As percent of develop-ing country-trade	As percent of world trade	Ranking among developing countries
Fresh fish & simple processed	19,458	1.62	0.34	0.14	-
Fruits-fresh nuts, fresh dry	45,375	3.77	1.03	0.44	25
Coffee	9,274	0.77	0.08	0.07	-
Tea and mate	378,093	31.44	24.77	20.62	2
Spices	23,281	1.94	2.32	1.92	-
Clothing (not offer)	307,915	25.60	1.35	0.67	14
Rubber, crude & synthetic	92,769	7.71	2.63	1.56	5
Vegetable fibres except cotton, jute etc.	16,539	1.38	12.85	4.92	-
Non ferrous base metal ore	7,741	0.64	0.21	0.11	-
Crude vegetable materials	5,781	0.48	0.46	0.10	-
Petroleum Products	89,802	7.47	0.27	0.11	-
Other fixed vegetable oils	29,712	2.47	1.01	0.84	10
Coal Petroleum (crude chemicals)	19,038	1.58	3.78	1.42	-
Pearls (Precious, semi-precious)	46,517	3.87	2.16	0.38	4
Other manufac-tured goods	7,263	0.60	0.47	0.14	-
Articles of plastic	5,532	0.46	0.27	0.05	-
Others	98,461	8.19	-	-	-
All commodities	1,202,693	100.00	0.29	0.06	-

Source: *UNCTAD Handbook of Trade and Development statistics(1989). United Nations, N.Y. 1990*

and global techno-economic investigations. Such studies on a global scale by international agencies such as UNCTAD, have shown rather disturbing trends as may seen by the following observations made by UNCTAD.

(a) firstly there was the rapid increase from the 1960's to the early 1970's of all major types of technology - related flows, including imports of capital goods, Foreign Direct Investments (FDI), licensing, and technical co- operation grants, with the United States as the major technology supplier;

(b) Secondly the occurence of a diversification of technology flows by geographical origin and type of flow throughout the 1970's exemplified by the rising importance of Japan and Western Europe as technology suppliers; and a sharp increase in the relative importance of capital goods flows, compared with FDI by transnational corporations;

(c) Thirdly, a stagnation of technology flows, particularly to developing countries during the 1980's, and the emergence of the United States as a net importer of technology (27).

This reversal in the pattern of technology flows during the past few decades, has been due to the general sluggish performance of the world economy. Although these changes have been more marked in the developing countries of the American and African continents, the factors that appear to have been responsible are, debt-servicing payments, rates of domestic investments, indigenous technological efforts and government policies (27).

In the context of the above observations it may be interesting to reflect on the pattern of technology flows concerning Sri Lanka, before embarking on a review of the regional setting. Table 5.11 illustrates the trends in the outflow and inflow of technology related capital goods in Sri Lanka during the period 1980 to 1990.

It is evident that, at least during the last decade, exports of unprocessed (primary) and semi-processed (intermediate) goods have shown a 14 fold increase in rupees terms, but only about a 5 - fold increase in U.S. dollar equivalents. On the other hand imports of the category of goods had initially increased upto 1985 and declined sharply by 1990. Could this observation mean that Sri Lanka is becomming less inclined to add valve to primary resource materials generated internally, as well as though possible sources from abroad? Obviously there could be no simple answe to this question, since the interplay of many complex legal and fiscal policy measures play a decision role on this issue.

The exports of manufactured capital goods in domestic use, has increased significantly, while imports had increased in 1985 and then declined by 1990. Although it is likely that customs records of imports may not include the large volume of domestic appliances brought into the country by Sri Lankan nationals employed abroad, this trend is reflected more favourably when observed in US dollars terms. It is interesting to note that both exports and imports of machinery, general equipment and transport equipment have increased sub stentially over the period 1980-1990 in terms of rupee valuves, although in terms of dollar valves, the imports of machinery as well as transport equipment have diclined during this period.

However, the most dramatic change in the international trading of capital goods is the sharp rise in both exports and imports of unspecified technology-related goods during 1990.

Evidently the current pattern of technology flows for Sri Lanka are influenced by the recent economic reforms of the country, which tend to mask the global trends for trading in technology-related goods.

TABLE 5.11

TRENDS IN TECHNOLOGY-RELATED OUTFLOW AND INFLOW OF CAPITAL GOODS FOR SRI LANKA (In Rs. million)

Category of goods	1980		1985		1990	
	Exports	Imports	Exports	Imports	Export	Imports
Primary and Intermediate	508.6 (31.9)	10,780.2 (675.7)	2,803.6 (102.3)	15,078.4 (555.1)	7,193.9 (178.8)	3,450.3 (85.7)
Domestic (luxury & semi-luxury	3.2 (0.2)	441.5 (27.7)	2.2 (0.1)	903.7 (33.0)	22.8 (0.6)	486.1 (12.1)
Machinery	38.9 (2.4)	4,407.1 (276.2)	113.8 (4.2)	5002.9 (182.5)	916.3 (22.8)	9301.9 (231.2)
Equipment General	0.7 (0.1)	170.4 (10.7)	55.3 (2.0)	347.8 (12.7)	232.6 (5.8)	1886.5 (46.9)
Office Equipment	2.7 (0.2)	256.0 (16.1)	6.6 (0.2)	479.3 (17.5)	4.2 (0.1)	1004.3 (25.0)
Transport (incl. transport equipment	29.1 (1.8)	3444.8 (215.9)	27.1 (1.0)	3,905.0 (142.5)	587.0 (14.6)	8,165.4 (202.9)
Other	8.3 (0.5)	278.8 (17.5)	14.7 (0.7)	556.0 (20.3)	485.1 (12.1)	11,670.8 (290.0)

Source: Extracted and re-classified data from External Trade Statistics of Sri Lanka Customs, for the year 1980, 1985 and 1990.

Note: Figures in parenthesis are US dollar equivalents determined by the appropirate rate of exchange as given in Annual Reports of the Central Bank of Sri Lanka.

UNCTAD in one of its studies has attempted to examine the relationship between Technology inflows and the behaviour of the 53 selected developing countries, using three economic performance indicators, namely the growth of *per capita* GDP, growth of manufacturing value added and growth of exports of manufactures. The relationship between the growth of manufacturing value added *per capita* and growth rate of technology-related imports is illustrated in Figure 5.1 The dispersion of countries in the diagram suggests that technology inflows are not the only factors affecting productivity growth. Similar observations have been made in respect of the other indicators too, with correlations though statistically significant being not sufficiently strong (27). It may be observed that Sri Lanka is one of the countries in which a positive correlation is observed between capital goods inflows and growth of manufacturing value added *per capita,* during the period 1981 to 1985. While this is indicative of the positiveness of responses to the new economic policies of the government, it shows the strong dependence of the country on imported technologies.

TABLE 5.12

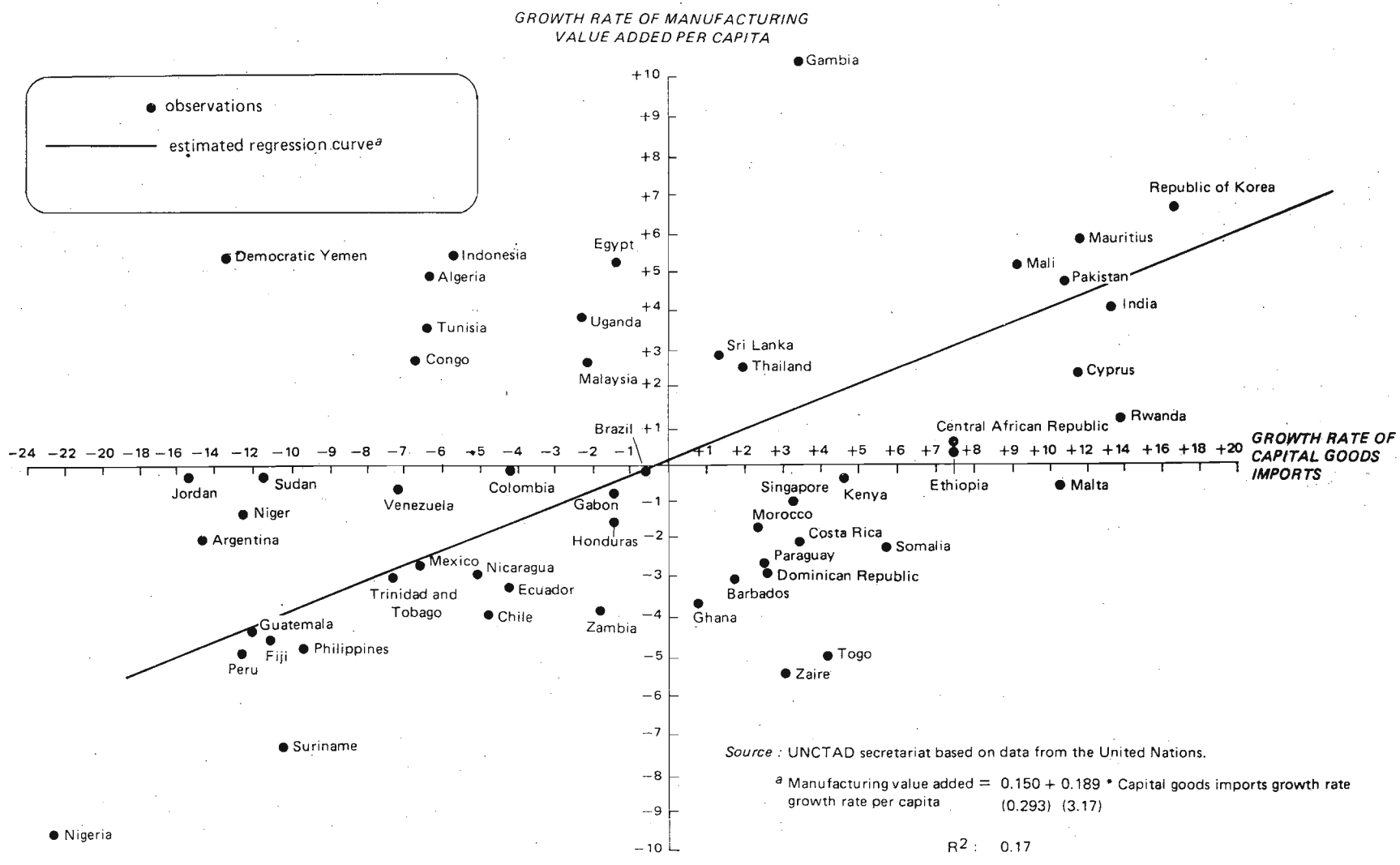
EXPORTS AND IMPORTS OF CAPITAL GOODS FROM DEVELOPED MARKET ECONOMY COUNTRIES TO SELECTED DEVELOPING COUNTRIES (In 1000's of US $ - 1988)

Country	Exports	Imports	Ratio of Exports to Imports
SAARC Countries	7,161,929	244,954	29.2
Bangladesh	322,494	1,954	165.0
Bhutan	4,562	96	47.5
India	4,658,749	195,916	23.8
Maldives	11,918	984	12.1
Nepal	124,624	1,593	78.2
Pakistan	1,767,499	11,079	159.5
SRI LANKA	272,083	33,332	8.2
ASEAN Countries	25,086,962	13,641,966	1.8
Brunai	91,367	5,784	15.8
Indonesia	3,199,239	51,101	62.6
Malaysia	4,012,015	2,817,757	1.4
Philippines	2,153,069	1,147,659	1.9
Singapore	10,756,920	8,268,962	1.3
Thailand	4,874,352	1,350,703	3.6

Source: United Nations Centre for Transnaional Corporation Data from IMF and OECD (compiled by Georg Keel of UNCTAD)

FIGURE 5.1

MANUFACTURING VALUE ADDED PER CAPITA AND CAPITAL GOODS IMPORTS: GROWTH RATES BETWEEN 1981 AND 1986
(in percentages)



Source : UNCTAD secretariat based on data from the United Nations.

[a] Manufacturing value added = 0.150 + 0.189 * Capital goods imports growth rate
growth rate per capita (0.293) (3.17)

R^2 : 0.17

Table 5.12 shows the trends in exports and imports of capital goods by Developed Market Economy Countries to SAARC and ASEAN countries during 1988. This is another aspect of technology flows, and reflects the capacity of developing countries to enhance exports of capital goods to developed countries. The ratio of Exports to Imports by DMEC's is in the range of 2:1 for ASEAN countries as against 29:1 for SAARC countries. Among SAARC countries however, Sri Lanka appears to have performed best with a receiving ratio of about 8:1, which though favourably much below the SAARC average, is substantially higher than the ASEAN average. Another striking feature of the export - import performances of these countries is the apparently 50 fold higher value of capital goods exports to DMEC's by the six nation ASEAN above the seven nation SAARC.

TABLE 5.13

FOREIGN DIRECT INVESTMENT INFLOWS TO SELECTED ASIAN COUNTRIES (in million of Us $)

Countries	1975	1980	1982	1984	1986	1988
SAARC Countries	112.7	186.3	198.6	107.7	256.1	291.9
Bangladesh	0	0	0	0.5	2.5	1.9
Bhutan	N.A	N.A	N.A	N.A	N.A	N.A
India	85.1	79.2	72.1	19.2	118.0	66.0
Maldives	2.0	0	0	0	1.0	0
Nepal	0	0.3	0	1.0	1.0	1.0
Pakistan	25.5	63.8	62.9	55.4	105.6	177.4
SRI LANKA	**0.1**	**43.0**	**63.6**	**32.6**	**30.0**	**45.6**
ASEAN Countries	1239.3	2419.6	3440.8	2739.7	1784.3	4546.5
Brunai	0.9	19.6	6.2	0.8	6.0	0
Indonesia	475.9	179.6	226.3	226.5	259.5	542.9
Malaysia	350.9	934.5	1397.7	797.5	489.2	649.1
Philippines	98.3	100.1	15.5	9.2	126.7	935.4
Singapore	291.4	1235.2	1601.9	1301.8	651.1	1300.9
Thailand	21.9	190.0	193.2	403.9	264.0	1118.1

Source : United Nation Centre for Transnational Corporation data from IMF and OECD (compiled by Georg Keel of UNCTAD)

Several channels are available to facilitate the flows of technology in the international scene. The commonest of these are: Foreign Direct Investments, technical co-operation grants and Official Development Assistance, technical collaboration through joint venture enterprises, licensing agreements, direct acquisition of capital goods, buy-back arrangements, commodity loans etc. The trends in respect of two of these mechanism for technology transfer are discussed in the following paragraphs.

Table 5.13 shows the pattern of Foreign Direct Investment flows to SAARC and ASEAN countries from 1975 to 1988. While during 1975, FDI in ASEAN countries was a little more than ten times that of SAARC countries, by the year 1988, this difference had widened to more than 15 fold. However, the growth of FDI in Sri Lanka from 1975 to 1988 has been substantial, although the general level compared to ASEAN countries (except Brunei), was still much less than one tenth. It is to be noted that although in Foreign Direct Investment, Technology transfer could be substantial, it may only marginally support diffusion and assimilation of technology in the country.

Another of the common channels for transfer of technology is through technical Co-operation grants. These may come under bilateral agreements or through multilateral co-operation programmes.

TABLE 5.14

BILATERAL AND MULTILATERAL TECHNICAL CO-OPERATION GRANTS TO SELECTED SOUTH ASIAN COUNTRIES (in million on US Dollars)

Countries	1980	1985	1986	1987	1988
SAARC Countries	547.1	658.8	770.8	849.7	993.8
ASEAN Countries	426.5	569.4	645.5	744.8	917.4
Bangladesh	158.9	168.8	158.1	165.0	181.4
Bhutan	6.0	10.4	10.6	10.0	17.5
India	151.5	178.1	226.4	270.6	316.1
Maldives	2.8	4.9	4.4	8.0	6.3
Nepal	50.5	70.3	78.8	84.7	100.1
Pakistan	120.0	171.4	220.7	235.5	268.3
SRI LANKA	**57.4**	**54.9**	**71.8**	**75.9**	**104.1**

Sri Lanka as % of SAARC Countries	10.5	8.3	9.3	8.9	10.4
Per capita assistance for ASEAN	1.4	1.9	2.1	2.5	3.0
Per capita assistance for SAARC	0.4	0.6	0.7	0.8	1.0
Per capita assistance for Sri Lanka	3.4	3.3	4.3	4.5	6.2

Source: Derived from United Nations Centre for TransnationalCo-operation compilations based on IMF and OECD data (Courtsay Georg Keel of UNCTAD)

Table 5.14 shows the trends in such technical assistance programs for 1980 to 1988. It is clear that in general, SAARC countries have received more grants than ASEAN countries through this channel.

However, when measured on the basis of *per capita* assistance, ASEAN countries appears to receive a 3 fold higher rate of Technical Co- operation grants than SAARC countries. Although Sri Lanka is seen to account for only about 10 percent of the total Technical Co-operation grants received by the SAARC countries, on a *per capita* basis it has a six fold advantage over the overall SAARC *per capita* assistance. Technical Co-operation assistance is generally tied up, and where technology transfer is also involved, usually there is not much of a choice for the recipient country.

In a final conclusion, a striking feature of the data presented and discussed in this chapter is the observed consistency, dominance and forward position occupied by the ASEAN nations as opposed to the variegated, economically oppressed and backward position occupied by the SAARC nations.

The discussion also highlights the fragility of Sri Lanka's current socio-economic, trade and technological balance vis-a-vis its closest neighbours (SAARC partners), as well as other South Asian nations (especially the more affluent ASEAN countries), demanding a unique and innovative approach towards a technology led transformation.

Chapter 6

A TECHNO METRIC REVIEW OF SELECTED INDUSTRIAL TECHNOLOGIES

6.1 RATIONALE

The basic concept of technology is that it is a physical tool used in a technological transformation. However, over years, the role of technology in the process of economic and social change has led to a highly complex relationship demanding a multidimensional approach to the study of technology and its management. Technology as it is known today, is a marketable commodity protected by proprietary rights and carrying a price tag. Hence it demands an element of acumen both on the part of the vendor and buyer for its transfer and utilization. Secondly, unlike science, which is universal in its outlook and usage, technology is often culture - specific and therefore lends itself to the restrains of societal preferences. Despite these assertions and contradictions, developed countries continue to seek technological domination as the master key and determinant of socio-economic progress.

Whatever may be the understanding and interpretation of technology, it has to be recognized that technology is the means for the transformation of natural resources to economically usable goods. Thus although technology becomes an indespensable tool for economic progress, its choice, acquisition, management, diffusion and absorption are the critical issues that determines its versatility as a key to national development. What then are the means available to determine the technological strengths and needs of the country, and what are the yard-sticks that one could use to select new technologies or to upgrade existing technologies? In order to answer these and many other related questions, it is prudent in the first instance, to assess the current technological capability in the country in terms of resource endowments (natural resources, human resource and financial resources), as well as in terms of the efficacy and efficiency of available technologies.

During the past few years, much attention had been paid to the study of natural resources endowments, and human resource potential as strategic variables in eco-development. However, despite of a concerted effort towards industrialization so far no serious effort has been made to assess the potential and structure of the technological fabric currently in vogue in Sri Lanka. Apparently, as a result of this lacunae no effort has so far been made to evolve a technology policy for the country. In fact even in current economic planning operations, technological considerations are implicit, receiving treatment only as exogenous variables.

Few methods are available for evaluation of technology, based largely on financial performances, such as internal rate of return, profitability and value added. Unfortunately many of these methods are vulnerable to price distortions and market imperfections, generally operative in developing countries, where subsidies, unrealistic parity rates of exchange as well as high protective tariffs are common issues of economic policy. Hence such methods do not serve a useful purpose for decision making in technology related issues, or in choice of technologies. However, a method evolved recently by the Asian and Pacific Centre for Transfer of Technology (APCTT) of UN-ESCAP, which had already been referred to in Chapter Two of this treatise, has the specific advantage of not being subjected to this limitation (17 a). This method which is simple in its conceptual framework, and has wide applicability, was chosen in the current study for the evaluation of a few selected industrial technologies at the level of the firm. The objective of this exercise is, (a) to demonstrate the role played by the different functional components of technology in a given industrial transformation, (b) to assess the current status (strengths and inadequacies) of the functional components of technology in a given industry as observed at the level of the firm, (c) to assess the status or the degree of sophistication of the functional components of technology in relation to State of the Art, in the selected industries, (d) to demonstrate the potential of such an evaluation to introduce technological changes, (e) to evolve a mechanism to facilitate choice of technology and technology transfer, and (f) to illustrate its usefulness in international comparison of technological transformation processes, as indicators of international competitiveness in products and processess.

6.2 METHODOLOGY

In this method of assessment, technology is considered to comprise of four basic functional components or factors, all of which interact dynamically and jointly to accomplish the task of transforming the given basic inputs (primary products) into finished or semi-finished economic products (17 a). The quality and quantity of the transformation is thus determined by the operational efficiency and efficacy of these four factors of technology, as well as by a complex interplay of governmental policy measures, which consitutes the industrial and technology climatic factor.

These four functional components of technology have been described as facilities, abilities, facts and frameworks.

Facilities constitutes the hardware or the object embodied factor of technology and has been referred to as as "Technoware". It includes all mechanical facilities such as machinery, equipment instruments, tools etc., as well as the physical infra-structures like buildings, factories and supplies (fuel, water and electricity).

Abilities constitute the production skills, experiences, expertise, creativity, ingenuity and diligence of the human resource or person embodied factor of technology, referred to in this method as "Humanware".

Facts constitute vital production facts and information, and has been considered as document-embodied factor of technology or "Inforware". These may constitute anything from the simple operating manuals to specifications, models, designs, management information systems(MIS), and sophisticated software packages.

Frameworks constitutes the organizational arrangements for production, and is referred to as institution - embodied technology or "Orgaware". It includes arrangements for management, sub-contracting, systematization, networking, MIS delivery, and marketing.

According to the concept advanced in this evaluation methodology,no transformation could take place in the complete absence of any of these functional components, and the operational chain has been identified as follows:

"(a) Technoware is the core of any transformation, and is developed, installed and operated by Humanware.

(b) Humanware is the key element of any transformation, and this in turn is guided by Inforware

(c) Inforware is generated and utilized by Humanware for decision- making and operation of Technoware.

(d) Orgaware acquires and controls Inforware, Humanware and Technoware to effect the transformation operation" (17 a).

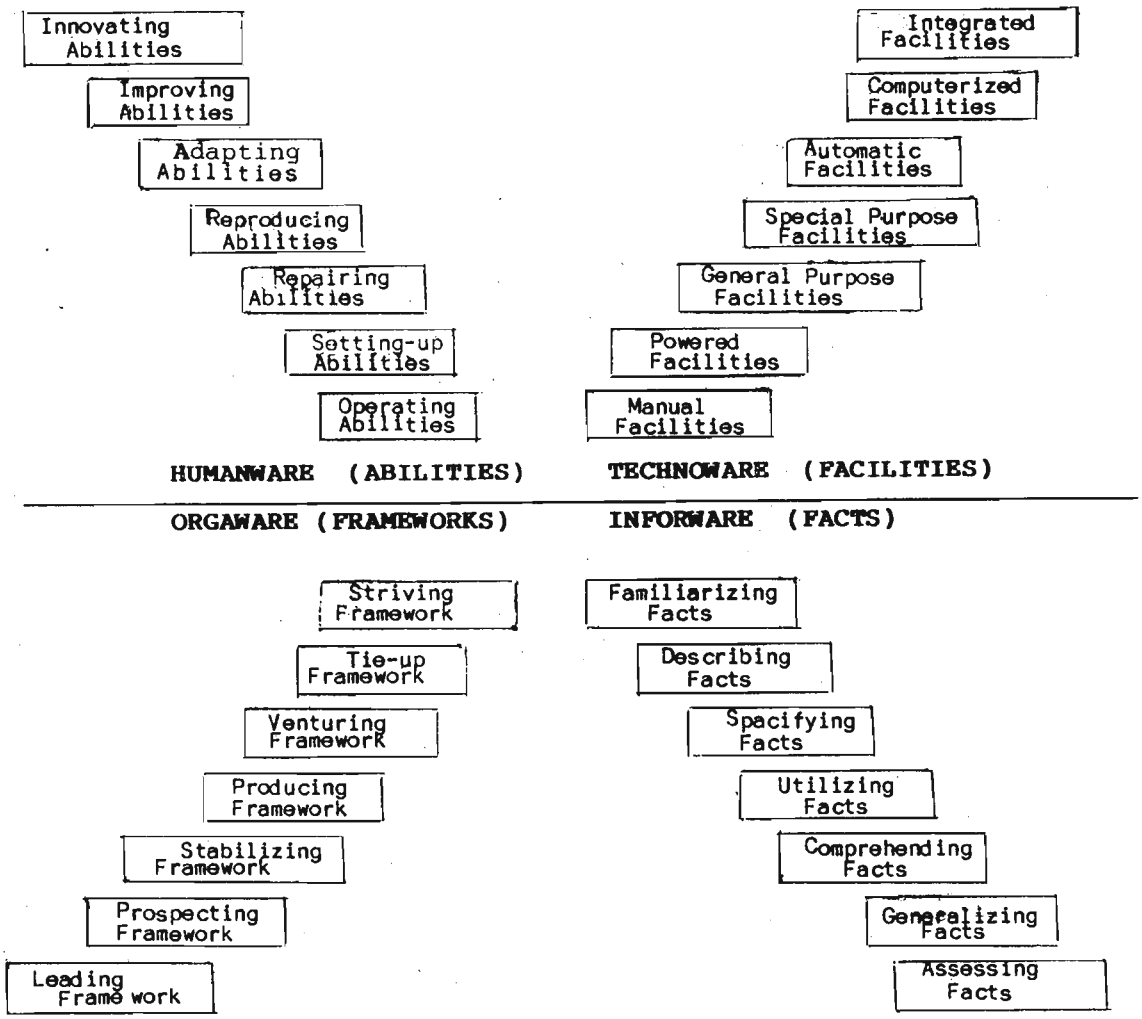
The evaluation model strives to measure the joint contribution of the four functional components of technology towards the overall transformation facility. This joint contribution has been referred to as the "Technology Content Added" which reflects the contribution made by the four components to the transformation facility. Since the four factors of technology which transform inputs into outputs operate in an industrial unit, the initial step in the evaluation process is to study the technological characteristics of the firm in respect of these four factors of technology.

The technometric approach for such a study requires a knowledge of the status of each of the four functional components of technology relative to the most advanced and sophisticated available any where in the world. This would thus mean that the degree of sophistication of each component of technology should be identified and defined in a sequence to enable assigning of a ranking or a rating measure.

Obviously, this would require a substantial technical input and expertise from specialists conversant with not only the mechanics of the technical transformation, but also with the frontier status of technology. A possible classification of increasing degrees of sophistication is illustrated diagramatically in the APCTT model (17 a) by Figure 6.1. Generally, most transformation facilities involve several operational stages or steps, which in turn require different degrees of skills, and occassionally even different organisational frameworks. In the evaluation process therefore, each such step has to be studied carefully against the backdrop of a possible series of generic criteria, and ranked in relation to the State-of-the-Art.

FIGURE 6.1

SUCCESSIVE DEGREES OF SOPHISTICATION OF FOUR COMPONENTS OF TECHNOLOGY



The assessment procedure which has been described in detail in the APCTT Report (17b) consists of the following steps:

I. A scoring procedure is set out for the four functional components of technology in relation to increasing degrees of sophistication. (A suggested procedure is given in Table 6.1). In order to do this firstly, a qualitative study is carried out on each of the four functional components of technology, which includes related hardware in respect of the different steps of the transformation facility. Since each step in the transformation facility could have several levels of sophistication, it is necessary at this stage, to identify the possible minimum and maximum levels of the degrees of sophistication.

II. In the next stage a set of measurable criteria are set out for each step of the transformation facility, and each criterion is ranked from zero to ten, where zero represents the lowest possible level and ten the highest level, (or the best in the world). Using this information, the State-of-the-Art ratings of Technoware, Humanware, Inforware and Orgaware are determined using the following expressions.

(i) State-of-the art rating of Technoware item "i",

$$STi = \frac{1}{10}\left[\frac{\Sigma_k \; tik}{k_t}\right] \qquad k = 1,2 \ldots\ldots k_t$$

where t_{ik} is the k'th criteria score for Technoware item i,

(ii) State-of-the-art rating of Humanware category j

$$SH_j = \frac{1}{10}\left[\frac{\Sigma_l \; hij}{l_h}\right] \qquad l = 1, 2 \ldots\ldots l_h$$

where h_{ij} is the i' th criteria score for Humanware category

(iii) State of the art rating of Inforware,

$$SI = \frac{1}{10}\left[\frac{\Sigma_m \; fm}{m_f}\right] \qquad m = 1, 2 \; m_f$$

where f_m is the m'th criteria for Inforware at the firm level.

(iv) State-of the art rating for Orgaware

$$SO = \frac{1}{10}\left[\frac{\Sigma_n \; On}{n_o}\right] \qquad n = 1, 2 \ldots\ldots n_o$$

where o_n is the n"th criteria score for Orgaware at the firm level.

TABLE 6.1

DEGREES OF SOPHISTICATION AND A SUGGESTED SCORING PROCEDURE FOR THE FOUR COMPONENTS OF TECHNOLOGY

Technoware	Humanware	Inforware	Orgaware	Score
Manual Facilities	Operating Abilities	Familiarizing Facts	Striving Frameworks	1 2 3
Powered Facilities	Setting-up Abilities	Describing Facts	Tie-up Frameworks	2 3 4
General Purpose Facilities	Requiring Abilities	Specifying Facts	Venturing Frameworks	3 4 5
Special Purpose Facilities	Reproducing Abilities	Utilizing Facts	Protecting Frameworks	4 5 6
Automatic Facilities	Adapting Abilities	Comprehending Facts	Stabilizing Frameworks	5 6 7
Computerized Facilities	Improving Abilities	Generalizing Facts	Prospecting Frameworks	6 7 8
Integrated Facilities	Innovating Abilities	Assessing Facts	Leading Frameworks	7 8 9

III. On the basis of knowledge of the degree of sophistication and the State-of-the-Art rating, the contribution of each of the factors of technology (T,H,I,and O) are calculated as follows:-

$$T_i = \frac{1}{9} [LT_i + ST_i (UT_i - LT_i]$$

$$Hj = \frac{1}{9} [LH_j + SH_j (UH_j - LH_j)]$$

$$I = \frac{1}{9} [LI + SI (UI - LI)]$$

$$O = \frac{1}{9} [LO + SO (UO - LO)]$$

In these equations, LT_i and UT_i represent the lower and upper limits of technological sophistication for each item "i" of Technoware, respectively, and LH_j and UH_j represent the lower and upper limits for each category "j" of Humanware respectively.

The degrees of sophistication of Orgaware and Inforware are determined at the firm level, and hences LO, UO and LI and UI represent the lower and upper limits for these two factors of technology respectively. The division by 9 is used to make the contribution by a functional component at the State-of-the Art to be 1. Hence the overall contributions from Technoware and Humanware at the firm level is obtained by aggregating Ti and Hj values.

$$T = \frac{\Sigma_{ui}\ Ti}{\Sigma_{ui}} \quad , \quad H = \frac{\Sigma_{vj}\ Hj}{\Sigma_{vj}}$$

IV. The Technology Contribution Coefficient (TCC) of a firm, which is defined by the expression, $TCC = T^{\beta}t * H^{\beta}n * I^{\beta}i * O^{\beta}o$ could now be obtained by determing the " β " values which are the component contribution intensities. The determination of " β " values is carried out using the " pairwisecomparison matrix approach", as described by APCTT (17 b), after initially determining the increasing order of importance of the four components of technology.

The TCC of a firm provides an index of the technology contribution of the transformation facility to the product output. The TCC can also be considered as the Technology Content Added (TCA) per unit output. Accordingly two industrial firms operating with the same TCC, but with different output could report different TCA's - with the firm enjoying a higher output, also recording a higher Technology Content Added. The TCA may also be considered as the difference between the technology content of the outputs and that of the inputs. In general inputs consisting of natural resources may be considered to have lower technology contents, although most natural resources have in fact some amount of technology content. Inputs which are considered as intermediate products have a higher technology content as these have already had some technology content added during transformation to intermediate products. The component contributions can also be presented diagramatically as shown in Figure 6.2 for four hypothetical situations.

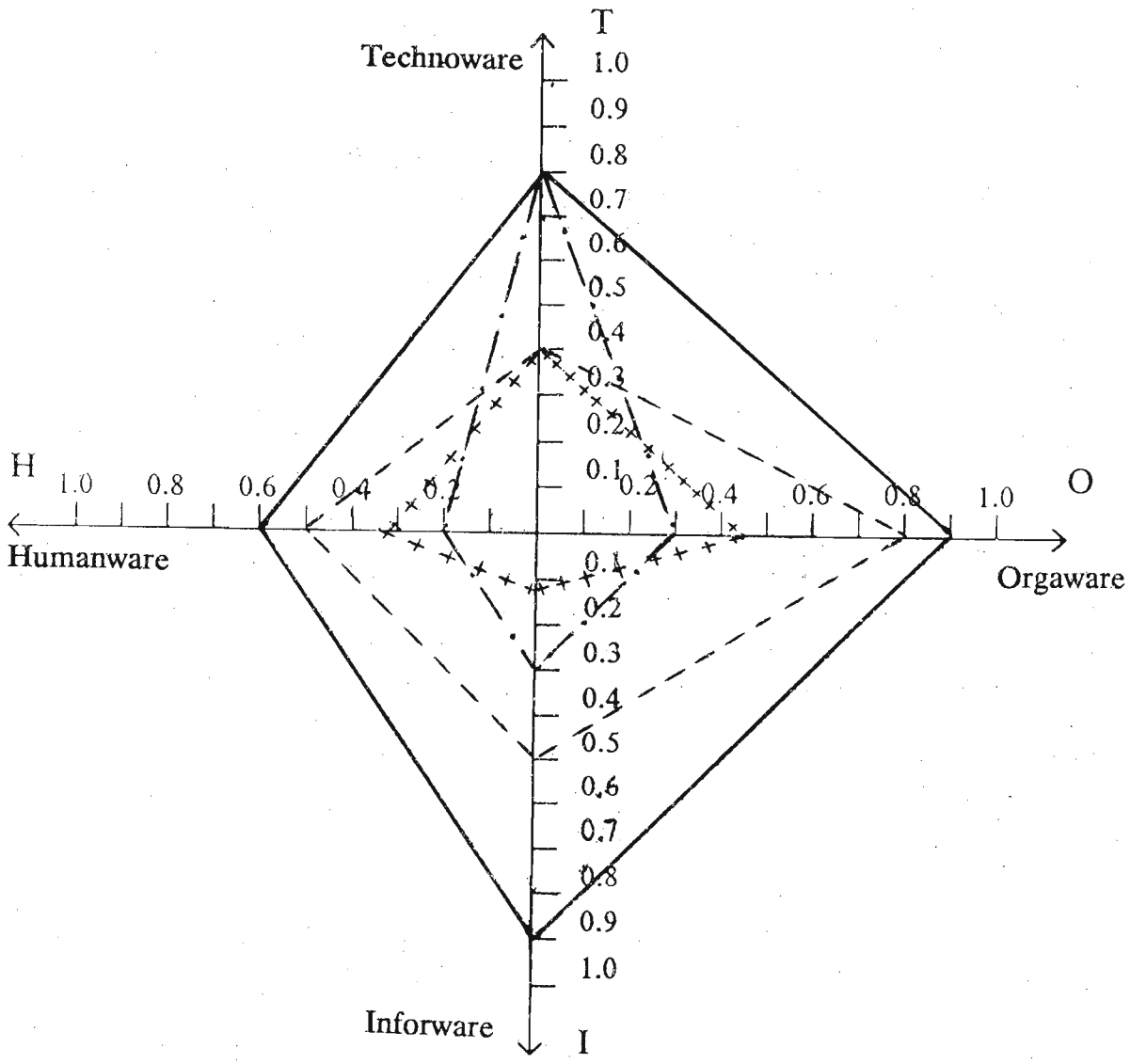
6.3 TCC ASSESSMENT OF SELECTED INDUSTRIES

In the current study , the method described above was tested and used to assess the Technology Content Coefficient of nine selected industries. The industries selected were steel, leather manufacture, shoe manufacture, PVC pipes, electric water pumps, dry cells, biscuit manufacture, mineral water (soft drinks) and computer assembly.

In each industry, excepting the biscuit manufacture industry, all firms contributing to the total national output, or at least to the major component of the country's output, were studied for the respective TCC's. The scheme adopted for the study of each industry was as follows: In the identified industry, all recognized firms contributing to the national output of the industry were selected. Next the chief executive of each firm was approached and a fairly detailed explanation of the proposed activity was given, in order that a technical officer of the appropriate level

FIGURE 6.2

DIAGRAMATIC REPRESENTATION OF TECHNOLOGY COMPONENTS FOR FOUR HYPOTHETICAL SITUATIONS



·————· An Enterprise with Modern Technoware Operating in a Developed Country

·—— · —— · An Enterprise with Identical Technoware Operating in a Developing Country

·— — — — · An Enterprise with Old Technoware Operating in a Developed Country

·+++++· An Enterprise with Old Technoware Operating in a Developing Country

of managerial and technical skill will be identified to function as a counterpart. The officer named in all cases was the best qualified to be associated with the study. In smaller firms often the chief executive himself being the most knowledgeable person, participated in the study. Once the counterpart was identified, a preliminary visit was undertaken to the manufacturing facility, in order to obtain first-hand information on the operational phases and systems. Thus based on the structure of the industry, a questionnaire was formulated to collect information for a computer model. The questionnaire was completed jointly by the research team and the counterpart officer, after which an analysis was performed using the computer model. For the determination of the degree of sophistication, technical reports and the latest available literature were consulted. In some instances specific technical information was obtained from abroad. Where feasible and available the expertise of the Sri Lanka Standards Institution were tapped. The stepwise analytical process was than set out in a report for each individual firm. Some of the firms which requested copies of the report were provided with a copy of the report in respect of their firm. In order to illustrate the evaluation process, a detailed stepwise account of the analytical process is presented in respect of the industry on manufacture of leather.

6.3.1 Leather Manufacturing Industry:

The main raw materials in the manufacture of leather are hides and skins. The difference between the two is that the former originate from bigger animals such as cows, buffaloes and camels while the latter are from smaller animals such as sheep and goats.

Tanning refers to the process of converting raw hides and skins into leather. Technically it is the process of converting the protein in hides and skins which is subject to decay,into a stable non- putrefiable material.

The two tanning agents are vegetable tannage and chrome tannage. In vegetable tanning (also called bark tanning), raw hides and skins are treated in water containing tanning extracts from plant leaves, barks, fruits, roots, etc. In chrome tanning, raw hides and skins go through a process called pickling with sulphuric acid and common salt, after which they are treated with solutions of basic chromium salts.

Raw hides are obtained by leather manufacturers in three main forms: dry salted, sun dried and wet salted. The hides thus obtained needs to be stored in a cool and insect free place so as to protect these against sun light, insects & mould growth. The three stage tanning process may be described as follows:

(a) Wet Blue Stage:

The wet blue stage involves the processing of raw hides to tan them in chrome liquor after which the leather is ready for the first phase of finishing stage i.e. upto crust stage.

Soaking: The main objective at this sub- process is to restore hides to their original stage, i.e to the state these were in after flaying. Soaking not only removes dung, blood and soil from hides, but also improves the penetrating capability of chemicals into the hides.

Cutting into sides: After soaking, hides are generally cut into two parts, called sides. Very small-sized hides are processed whole, and for some special products, eg. upholstery leather.

Liming: The operation is aimed at removing hair from hides and loosening fat, flesh, etc.

Fleshing: This is the process of removing the connective tissues which usually adhere to the hide, carried out manually or with a fleshing machine.

Deliming, bating, pickling and tanning: The degree of deliming depends on the type of tanning carried out. The simplest way is to wash with water. The method which is generally practised is chemical deliming.

Sammying: In this process the moisture content of the semi finished leather is reduced, using either a sammying machine (which squeeses the wet leather as it passes between the two rollers of the machine for this operation), or by drip drying.

Sorting: After sammying , the leathers are graded according to grain quality.

(b) Crust Stage:

The chrome-tanned leather, called wet-blue because of its light blue colour, undergo a number of operations before it is ready for the finishing stage.

Trimming : Rough edges of the leather are trimmed to remove uneven and ragged edges.

Splitting: Thick hides are split by a splitting machine, separating the top layer called the grain part from the bottom fleshy layer. Both grain and flesh splits can be used for manufacture of finished leather.

Shaving: Thickness of spilt is adjusted in a machine fitted with shaving blades which reduce the substance of the leather according to the desired thickness.

Re-tanning, fat-liquoring and dyeing: This is a combined process in which the semifinished leathers get a final tanning and some further treatment.

Drying: At this process the damp leather is dried under temperature controlled condition using one of the following drying techniques: toggle drying, vaccum drying, paste drying.

Conditioning: After drying, leather becomes stiff. For further operations a certain degree of conditioning, i.e. moisturing the leather to 28% to 30% content is essential. Although the use of damp saw dust is a commonly used

technique for conditioning, some manufacturers use a conditioning machine in which the leather is sprayed/sprinkled with water.

Staking: Leather thus conditioned is softened so as to make it flexible, and this operation is known as staking. Two techniques are used for this process: a jaw type machine or a vibratory machine. This process is usually followed by a final drying or "airing off" operation.

Sorting: The leathers are again sorted on the basis of grain quality.

(c) Ready to Finish Stage

This is the final stage of the finishing operation, and comprise of the following steps:-

Buffing - Dusting: Where the grain of the leather appears defective its surface is sand papered to remove such defects, using a buffing machine. Buffing is followed by dusting to clear dust from the surface with an air blast machine which sucks the dust.

Seasoning: During this stage the leather surface is given a pigment solution, called "binders". The treatment puts a coating on the leather.

Plating/ Embossing: In this process a press is used to give a leather surface a smooth appearence, which can be plain, smooth or have some artificial grain pattern called embossing.

Spraying: After plating, leather is given a final colouring . This is done by an auto spray machine or by a hand spray gun.

Sorting and measuring: Before dispatch the product is sorted and measured. Two types of measuring techniques are used (a) pin-wheel type and (b) electronic type

Effluent treatment and other requirements: In leather manufacture substantial effluent is generated which, if not fully treated can cause air and water pollution. Effluent treatment therefore forms an essential built-in phase of leather manufacture.

Determination of the Limits of the Degrees of Sophistication of the Components of Technology

Based on the information collected during the survey, the upper and lower limits of the degrees of sophistication were arrived at using the scoring procedure discussed earlier. The data in respect of one of the firms studied is summarized below.

TABLE 6.2 (a)

LIMITS OF THE DEGREES OF SOPHISTICATION OF THE COMPONENTS OF TECHNOLOGY

Components	Degrees of Sophistication	
	Lower limit	Upper limit
Technoware:		
Wet Blue Stage	2	4
Crust Stage	2	4
Ready-to-Finish Stage	2	4
Humanware :		
Workers	1	4
Supervisors	2	5
Managers & Executives	3	6
R&D Personnel	6	8
Inforware :	3	5
Orgaware :	3	5

State-of the-Art assessment of the Components of Technology

***Technoware :** *Performance Specifications for Evaluating Wet-Blue- Stage Operations*

(a) Method of soaking

- Using pits : 0
- Paddle : 2.5
- Wooden drum : 5.0 **
- Concrete mixture type vessel : 7.5
- Y-Compartmental steel vessel : 10.0

(b) Method of liming

- Using pits : 0
- Paddle : 2.5
- Wooden drum : 5.0 **
- Concrete mixture type vessel : 7.5
- Y-Compartmental steel vessel : 10.0

(c) Method employed for fleshing

- Manual fleshing : 0
- Mechanical fleshing : 5 **
- Hydraulic fleshing : 10

(d) Method of deliming, bating, pickling & tanning.

- Using pits : 0
- Wooden drum : 3.33 **
- Concrete mixture type vessel : 6.67
- Y-Compartmental steel vessel : 10.0

(e) Method of sammying

- Mechanical sammying : 0 **
- Hydraulic sammying : 5
- Hydraulic through feed machine : 10

* **Technoware :** *Performance Specification for Evaluation of Crust Stage Operation*

(a) Method of splitting

- Mechanical splitting : 0 **
- Hydraulic splitting : 10

(b) Method of shaving

- Manual shaving : 0 **
- Mechanical shaving : 5
- Hydraulic shaving : 10

(c) Method of re-tanning, fat-liquoring, & dyeing

- Using pits : 0
- Wooden drum : 3.33 **
- Concrete mixture type vessel : 6.67
- Y-Compartmental steel vessel : 10

(d) Method of setting-out

- Mechanical setting-out : 0
- Hydraulic setting-out : 10 * *

(e) Method of drying

- Hang drying : 0
- Batch toggle drying : 3.33
- Auto toggle drying : 6.67
- Vaccum drying : 10.0 * *

(f) Method of staking

- Jaw-type staking : 0
- Vibratory staking : 10 * *

* **Technoware:** *Performance Specifications for Evaluating Ready to Finish-Stage Operations:*

(a) Method of buffing

- Open ended narrow band : 0 * *
- Lightening buffing : 5
- Endless band buffing : 10

(b) Method of seasoning

- Hand padding : 0 * *
- Semi-auto padding : 3.33
- Curtain coating : 6.67
- Roller coater : 10

(c) Method of pressing

- Hydraulic pressing : 0 **
- Roto pressing : 10

(d) Method of spraying
- Hand spraying : 0
- Semi-auto spraying : 5
- Auto spraying : 10 **

(e) Method of measuring
- Pin-wheel measuring : 0 **
- Electronic measuring : 10

(f) Method of intra-factory transport
- Manual handling : 0 * *
- Mechanical handling : 10

* **Humanware :** *Competence Characteristics for Evaluating Humanware*

(a) Workers
- Percentage of target attained per year with respect to output (100% : 10 , 50 % : 0) = 74 %

(b) Supervisors
- Effective capacity utilization of the plant (100% : 10, < 50 % : 0) = 70 %

(c) Managers and executives
- Effective capacity utilization of the plant (100% : 10. < 50 % : 0) = 70%

(d) R & D Personnel
- Level of innovative activity as evaluated by type of contribution made (very high : 10, None : 0) - Medium

* **Inforware :** *Adequacy Requirements for Evaluating Inforware*

(a) Extent of management information
- Total industry information : 10
- Partial industry information : 5 * *
- Only corporate information : 0

(b) Extent of networking

- On-line corporate networking : 10
- No on-line corporate networking : 0 * *

(c) Leather database availability

- (available : 10, not available : 0) - Available

(d) Monitoring schemes

- Completely distributed process control : 10
- No distributed process control : 0 * *

(e) Availability of computer based policy models for studying (3.33 points per item) - None

- Wet blue stage operations
- Crust stage operations
- Ready-to-finish stage operations

* **Orgaware :** *Effectiveness Measures for Evaluating*

(a) Profitability : Industry avg. = 25%, ROI = 25%

- Return on Investment (ROI) above industry average : 10 * *
- ROI below industry average : 5
- Loss making : 0

(b) Overall capacity utilization (100% : 10, < 50% : 0) = 70 %

(c) Sales (in sq.dm) per employee per year (< 222000 : 10, < 168000 : 0) 13515 sq.dm

(d) Direction : Medium
High futuristic orientation: 10, no futuristic orientation : 0)

(e) Autonomy (completly deregulated : 10, completely controlled: 0) : Intermediate

(f) Organization for improvement engineering : No scope
(high level : 10, no scope : 0)

(g) Modernization : No efforts
(consistent program : 10, no efforts : 0)

(h) R & D expenditure as a percentage of sales
(0% : 0 ---% : 10) : %

In respect of the leather manufacturing industry, the following firms were evaluated.

* Ceylon Leather Corporation
* M.A.M. Abdul Cader Leather Co, Colombo
* S.A. Perera, Kelaniya
* Tanlanka, Hendala
* Indo-Ceylon Leather Co, Colombo
* Silva & Co, Kelaniya
* Mubarak Tannery, Colombo

TABLE 6.2 (b)

STATE-OF-THE-ART ASSESSMENT OF WET-BLUE STAGE OPERATIONS

Criteria	Criteria Value	Score
Method of soaking	Wooden drum	5
Method of liming	Wooden drum	5
Method of fleshing	Mechanical fleshing	5
Method of deliming, bating Pickling & tanning	Wooden drum	3.33
Method of sammying	Mechanical sammying	0
Total		18.33
ST_i		0.37

TABLE 6.2 (c)

STATE-OF-THE-ART ASSESSMENT OF CRUST STAGE OPERATION

Criteria	Criteria Value	Score
Method of splitting	Mechanical splitting	0
Method of shaving	Mechanical shaving	0
Method of setting-out	Hydraulic setting-out	10
Method of re-tanning, Fat liquoring & dyeing	Wooden drum	3.33
Method of drying	Vaccum drying	10
Method of staking	Vibratory staking	10
Total		33.33
ST_i		0.56

TABLE 6.2 (d)

STATE-OF-THE-ART ASSESSMENT OF READY TO FINISH-STAGE OPERATIONS

Criteria	Criteria Value	Score
Method of buffing	Open ended narrow band	0
Method of seasoning	Hand padding	0
Method of pressing	Hydraulic pressing	0
Method of spraying	Auto spraying	10
Method of measuring	Pin-wheel measuring	0
Method of intra-factory transport	Manual handling	0
Total		10
ST_i		0.17

TABLE 6.2 (e)

STATE OF THE ART ASSESSMENT OF HUMANWARE

Criteria	Criteria Value	Score	SH_j
Workers			
Percentage of target attained per year w.r.t. output (100% : 10, < 50% : 0)	74%	4.8	0.48
Supervisors:			
Effective capacity utilization of the plant (100% : 10, < 50% : 0)	70	4	0.4
Managers & Executives			
Effective capacity utilization of the plant (100% : 10, < 50% : 0)	70%	4	0.4
R & D Personnel			
Level of innovative capacity as evaluated by type of contribution made (very high : 10, non : 0)	Medium	5	0.5

TABLE 6.2 (f)

STATE OF THE ART ASSESSMENT OF INFORWARE

Criteria	Criteria Value	Score
Extent of management information (Total industry information: 10, Partial industry information: 5, Only corporate information : 0)	Partial industry information	5
Extent of networking (on line corporate net working: 10, No on line corporate networking : 0)	No on-line corporate net working	0
Leather database availability (Available : 10, not available : 0)	Available	10
Monitoring schemes (Completely distributed Process control : 10, No distributed process control : 0)	No distributed process control	0
Availability of computer based policy models (Available : 10, not available : 0)	Not available	0
SI		0.3

TABLE 6.2 (g)

STATE OF THE ART ASSESSMENT OF ORGAWARE

Criteria	Criteria Value	Score
Profitability (ROI above industry avg. : 10 ROI below industry avg.: 5, loss making : 0)	25%	10
Overall capacity utilization (100 % 10, <50% : 0)	70%	4
Sales per employee per year (222000 : 10, 16800 : 0)	13315 (Sq.dm)	0
Direction (High futuristic orientation: 10, no futuristic orientation : 0)	Medium	5
Autonomy (completely deregulated : 10, completely controlled: 0)	Intermediate	5
Organization for improvement engineering (High level : 10, no scope: 0)	No Scope	0
Modernization (Consistent program: 10, no efforts : 0)	No efforts	0
R & D Expenditure as a % of Sales (0 % : 0, - % : 10)	0.9	1
SO		O.31

TABLE 6.2 (h)

SUMMARY OF COMPONENT CONTRIBUTIONS

Component of techno-logy	Upper Limit	Lower Limit	State of the Art Value	Normalized Contribu-tion	Weightage	Overall Contribu-tion
TECHNO-WARE	UTi	LTi	STi	Ti		
Wet blue stage	4	2	0.37	0.30	0.333	
Crust stage	4	2	0.56	0.29	0.333	0.26
Ready to finish stage	4	2	0.17	0.19	0.333	
HUMAN-	UHj	LHj	SHj	Hj		
Workers	4	1	0.48	0.27	0.25	
Supervisors	5	2	0.4	0.36	0.25	
Managers & Executives	6	3	0.4	0.47	0.25	0.47
R&D Personnel	8	6	0.5	0.78	0.25	
INFORWARE			SI	I		
Firm Level	5	3	0.3	0.4	1	0.4
ORGAWARE			S0	0		
Firm Level	5	3	0.31	0.40	1	0.40

TABLE 6.2 (i)

SUMMARY OF TCC COMPUTATION

Technology Component	Component Contribution	Component Contribution Intensities	TCC
Technoware-T	0.26	0.2	
Humanware -H	0.47	0.4	0.39
Infoware -I	0.40	0.2	
Orgaware - 0	0.40	0.2	

TABLE 6.3

SUMMARY OF COMPONENT CONTRIBUTIONS AND TECHNOLOGY CONTENT COEFFICIENTS OF FIRMS IN THE LEATHER MANUFACTURING INDUSTRY

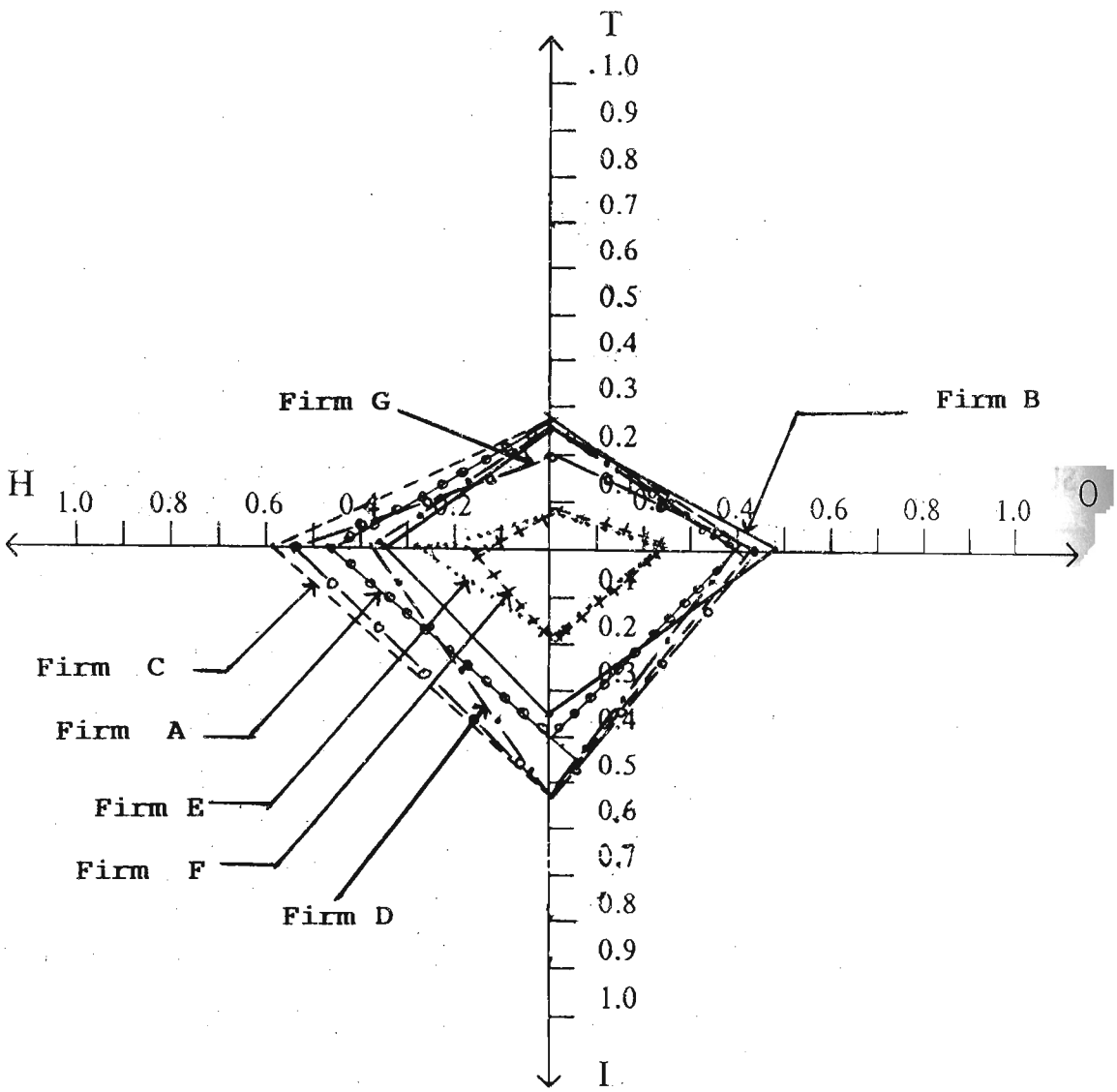
	Technology Component Contributions & TCC						
Technology Component	Firm A	Firm B	Firm C	Firm D	Firm E	Firm F	Firm G
Technoware	0.26	0.24	0.26	0.25	0.07	0.07	0.20
Humanware	0.47	0.35	0.59	0.38	0.28	0.17	0.56
Inforware	0.40	0.30	0.53	0.53	0.18	0.18	0.53
Orgaware	0.40	0.48	0.42	0.42	0.22	0.22	0.42
TCC	0.39	0.35	0.46	0.38	0.19	0.15	0.43

The data summarized in Table 6.3 compares technology component contributions as well as the TCC of the seven industrial concerns evaluated. In order to maintain confidentiality in the technological operations of firms in the industries selected for this study, where relevant the respective firms are identified only with symbols. The technological contributions are also presented diagramatically in Figure 6.3. This figure shows that while in general the component contributions of the industry are

FIGURE 6.3

LEATHER MANUFACTURING INDUSTRY -

TECHNOLOGY COMPONENT CONTRIBUTIONS



T - Technoware

H - Humanware

I - Inforware

O - Orgaware

substantially low, the firms within the industry also operate at different technological levels, with the technological contributon of two firms (E and F being substantially low.

Taking, Firm A for example, the technology contribution analysis shows that the techhnological capability of this firm is only around 40 percent of the best in the world. Hence its products are unlikely to be internationally competitive. Thus from a technology planning perspective, it should not only be possible to identify deficiencies, but also to propose appropriate remedial measures for techhnological changes. It is also suggestive that a firm with a higher TCC value has a higher bargaining power than a firm with a lower TCC, when acquiring technologies from the international market. Such consideration could therefore affect even the evaluation processes of foreign investment offers.

Thus while national planners and policy makers may use these measures for technology planning strategies, decision makers and managers could go beyond the realm of indicators and use such information as decision support tools.

The technometric evaluation could proceed further, by estimating what is referred to as the Technology Content Added (TCA), using the relationship.

$$TCA = \lambda . TCC.VA,$$

where VA is the value added and " λ " is the factor which figures out the status of the environment for technology development. Such estimates provide further information on the technological transformations. Thus for instance, even if a firm produces a large value added with a low TCC, the overall TCA will be low, and in fact, the TCA value of a firm with high value added but a low TCC, may be exceeded by a firm with a medium value added but a high TCC (17b).

6.3.2 Shoe-making Industry

In the shoe making industry, four well known companies, Bata, D. Samson Industries (DSI), Arcadia and Ceylon Leather Corporation were selected for the study.

This industry, like the leather manufacturing industry comprises of at least five stages and several different process, each of which has different degrees of sophistication. In the analysis all differentiations were considered and state-of-the-art assessments were done through consultations. The final technology component contributions determined are summarized in Table 6.4 and illustrated diagramatically in Figure 6.4.

Firms B and C which had the highest TCC values had also export orders for their finished products. Thus it was found that at the industry level, the exports accounted for 27 percent of total sales in 1988. On the other hand, the import content of finished products was 31 per cent. It was also observed that out of a total of 1803 persons employed in the four firms, only three were foreign experts. Accordingly after weighting for appropriate levels of skills, it was found that the import content of Humanware was only 0.76 percent for the industry.

FIGURE 6.4

SHOE MANUFACTURING INDUSTRY -

TECHNOLOGY COMPONENT CONTRIBUTIONS

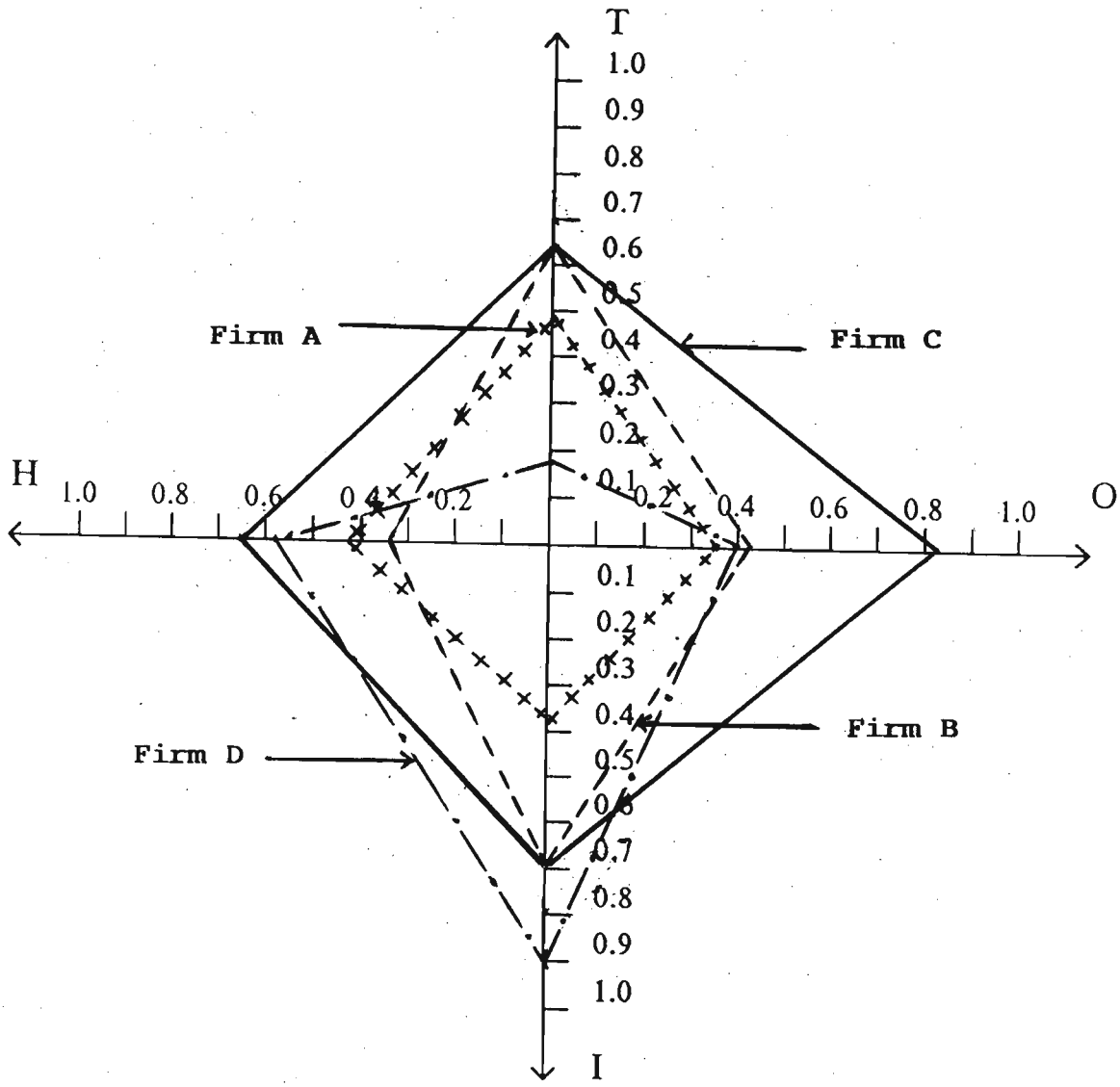


TABLE 6.4

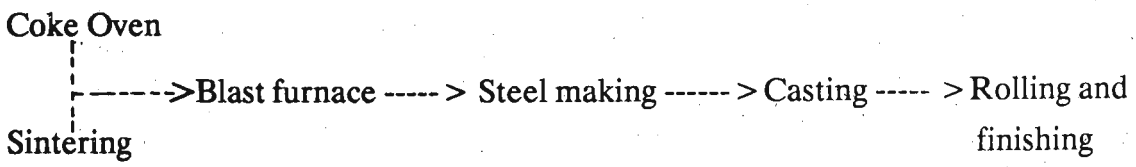
SUMMARY OF COMPONENT CONTRIBUTIONS AND TCC OF FIRMS IN THE SHOE-MAKING INDUSTRY

	Firm A	Firm B	Firm C	Firm D
Technoware	0.49	0.65	0.64	0.17
Humanware	0.41	0.35	0.65	0.58
Inforware	0.38	0.71	0.71	0.93
Orgaware	0.35	0.43	0.84	0.35
TCC	0.41	0.48	0.69	0.45

One of the significant observations in the leather and shoe making industries was the superiority of some of the private sector firms in all four functional components of technology, over the long standing public sector institutions in this field.

6.3.3 Steel Industry

Until recently the Ceylon Steel Corporation was the only producer of iron and steel in Sri Lanka. During the past few years two other small firms have entered the field with facilities only for rolling of steel billets. The schematic flow chart for an integrated Iron and steel plant is as follows.



The Ceylon Steel Corporation which is the main steel producing organization in Sri Lanka does not run through the coke oven, sintering and blast furnace stages, since its main raw material is scap iron. The steel making stage constitutes an electric arc furnace, to melt the scrap iron, and the resulting 'melt' is passed through a continuous casting process to produce solid steel which are in billet form. These steel billets are then hot rolled to produce Tor Steel, Veb Steel etc.

The Asian and Pacific Centre for Transfer of Technology which evolved the model for a technometric assessment of technology, illustrated the evaluation process using data on the Japanese and Indian Integrated Iron and steel industries (17b). This evaluation process was recapitulated in respect of the Sri Lankan steel industry drawing all necessary technical information from the Ceylon Steel Corporation. Summary of the component contributions of the steel industry in the three countries is given in table 6.5 and illustrated diagramatically in Figure 6.5.

TABLE 6.5

SUMMARY OF COMPONENT CONTRIBUTIONS AND TCC OF THE STEEL PLANTS FROM INDIA, JAPAN AND SRI LANKA

	Technology Component Contributions & TCC		
	Indian Plant *	**Japanese Plant ***	**Sri Lankan Plant**
Technoware	0.48	0.84	0.55
Humanware	0.22	0.58	0.33
Inforware	0.51	0.89	0.57
Orgaware	0.70	0.96	0.29
TCC	0.44	0.84	0.44

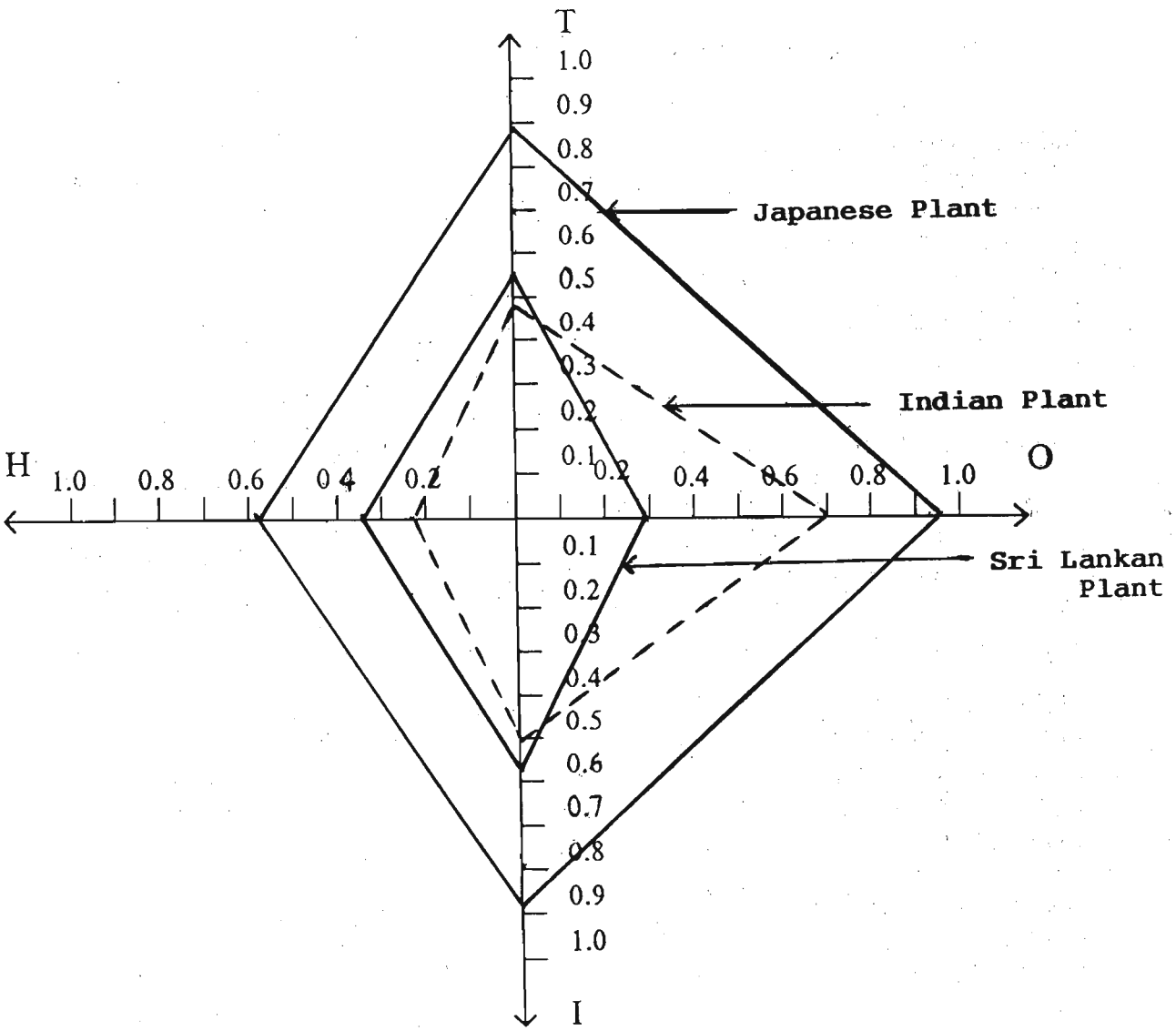
**Source : A framework for Technology - based Development, vol.2, Technology Content Assessment, UN-ESCAP/-Asian and Pacific Centre for Transfer of Technology, Bangalore, India (1989).*

The figures and the diagrams show the technological structure of the iron and steel industries in the three countries. While in the Japanese industry, the technological contributions from the four functional components far exceed any of those from the Indian and Sri Lankan industries, the organizational framework of the Indian industry seems to be far superior to that of the Sri Lankan Industry. However, in respect of the Technology Content Coefficient (TCC), the Indian and Sri Lankan steel plants are at par, though still substantially below the level of the Japanese plant. The APCTT study (17 b) discusses the evidence for the technological superiority of the Japanese integrated iron and steel industry, and the steps taken by Japanese industrialists for cost effective production norms and quality standards,in the face of high labour costs, low capacity utilization and reduced production.

FIGURE 6.5

IRON AND STEEL INDUSTRY

TECHNOLOGY COMPONENT CONTRIBUTIONS



These were in contrast to the situation in the Indian (and Sri Lankan) scene, which continued to depend on high energy consumming older generation technologies. Thus despite of very high labour wages and costlier raw materials, Japan is far ahead of India and Sri Lanka in this industry. This comparision shows how and why a manufacturing industry (in this case the iron and steel industry), can become internationally competitive, through the systematic upgradation of the four components of technology.

6.3.4 Dry - Cell Battery Industry

There are at present only two firms in Sri Lanka in the dry-cell manufacturing industry, with a third firm which existed sometime ago being forced to close down due to damages caused by civil disturbances. Of the two firms, the Eveready Battery Company Lanka Ltd, is the subsidiary, or branch office of the multinational group Union Carbide, while the second firm Elephantlite Corporation was until August 1991, a joint venture between the government and the private sector - a pioneering local enterprise in dry cell manufacture.

The latter firm produces a locally formulated and registered product bearing the Sri Lanka Standards Institute Certificates, as well as an internationally traded product. Both firms import more than 95 percent of the inputs. While the multinational company depends on its principals for transfer of technology, the joint venture corporation has aquired its technology from accredited foreign sources, apparently through licensing agreements and royalty payments. But neither firm has yet embarked, or received a mandate for exports, although the potential exists. There were also some protective measures for the joint venture company, through a government pricing policy.

The manufacturing process comprises of a multi-stage semi-automated process, with some minor difference between the two firms in the cell lining and finishing stages. The flow chart for the manufacturing process is shown in Figure 6.6 and the summary of component contributions of the two firms in the dry-cell industry are given in Table 6.6 and illustrated diagramatically in Figure 6.7.

A significant feature of this industry in the fairly high Technology Content Coefficient of the competing firms which indicates in away the potential of the industry to enter the international market if any restrictive measures in licensing agreements are relaxed. One of the firms also has achieved the State-of-the-Art stage in Inforware. Firm B which has the higher TCC, was also found to have a greater value added. Hence its technological capability was much higher than that of Firm A.

FIGURE 6.6

BLOCK DIAGRAM SHOWING STAGES IN THE MANUFACTURE OF STEEL JACKETED PAPER LINED CELLS

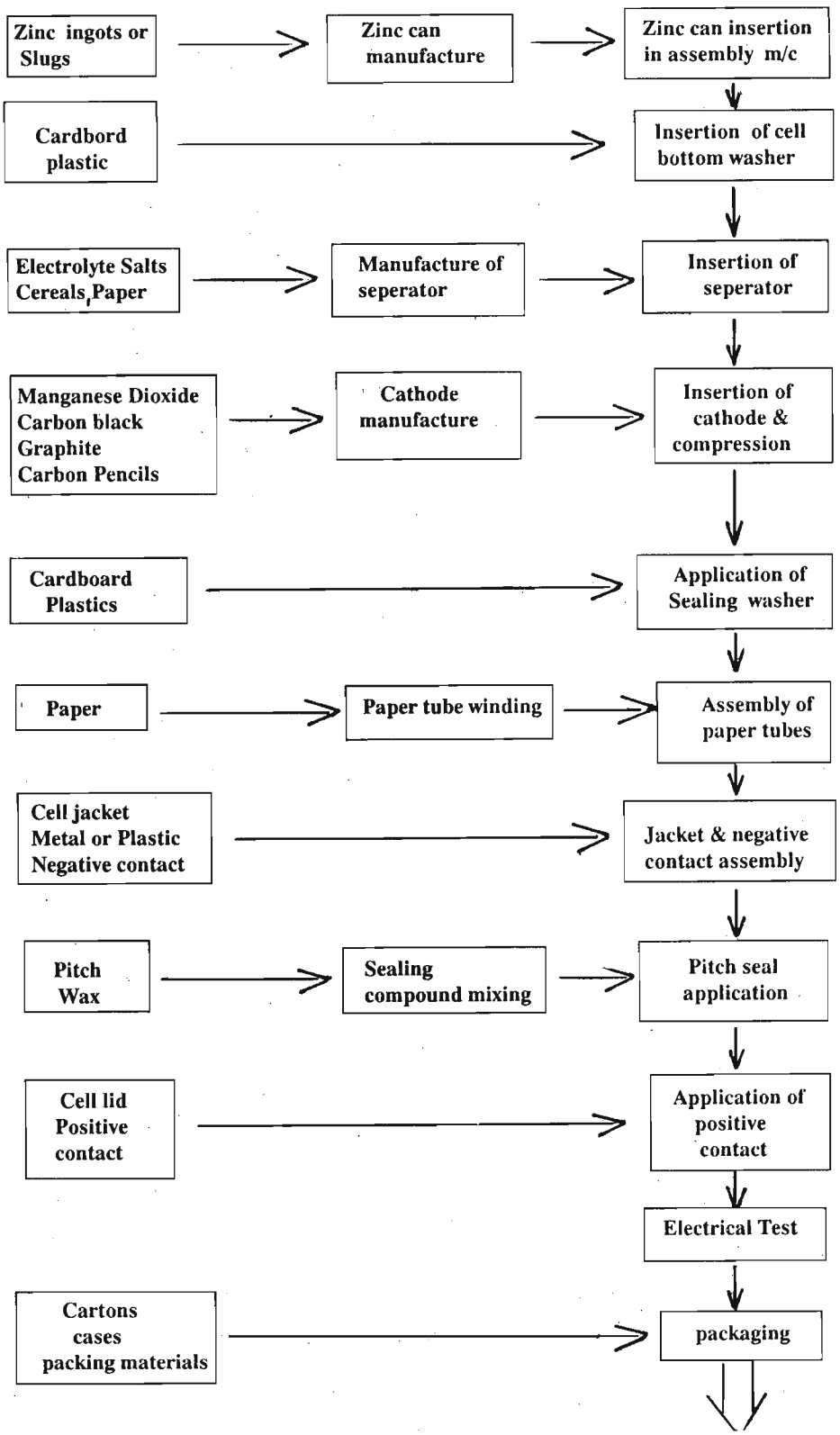


FIGURE 6.7

DRY CELL MANUFACTURING INDUSTRY -

TECHNOLOGY COMPONENT CONTRIBUTIONS

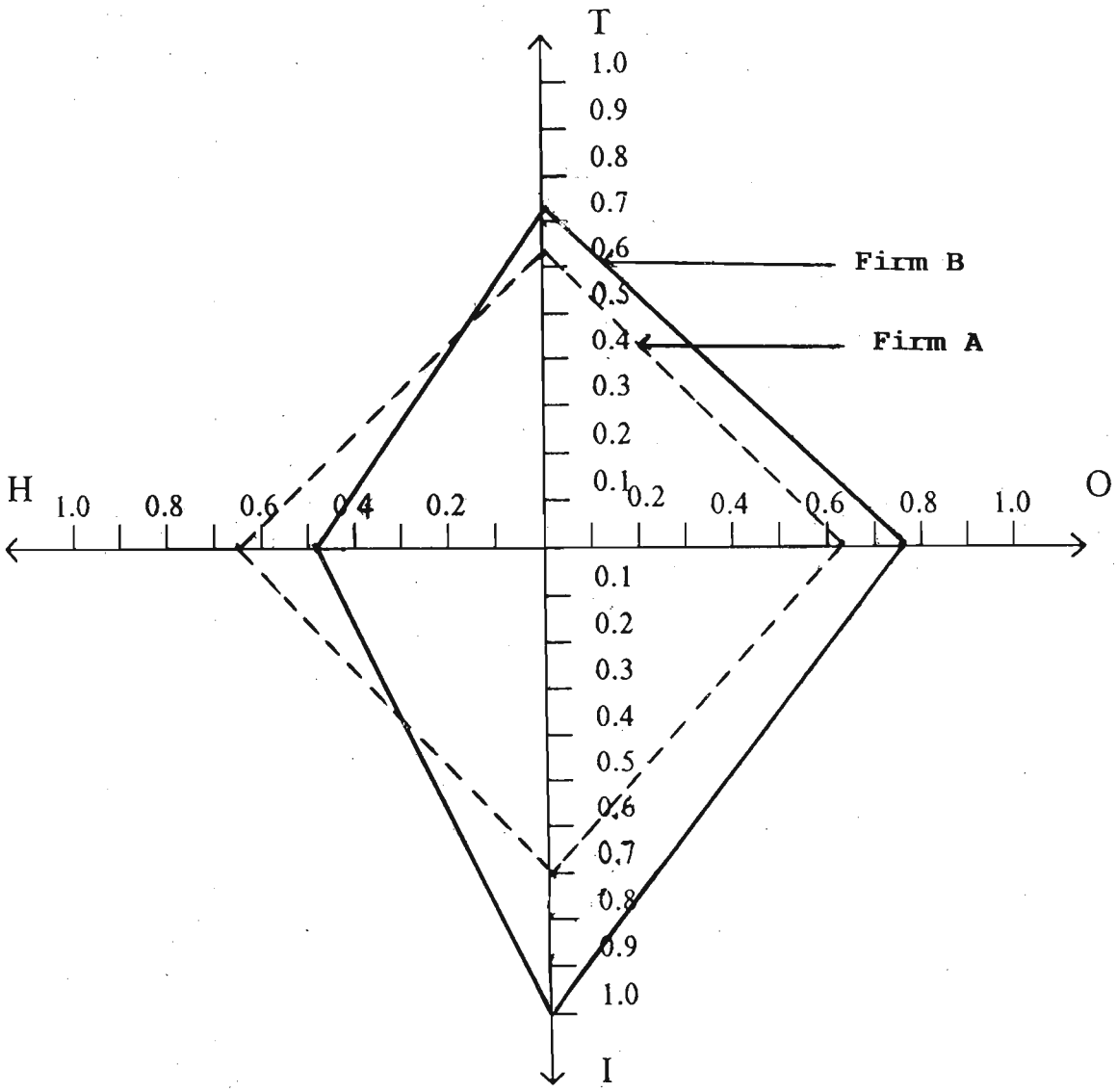


TABLE 6.6

SUMMARY OF COMPONENT CONTRIBUTIONS AND TCC OF THE DRY-CELL INDUSTRY

	Component Contribution Intensities	Technology Component contributions & TCC	
		Firm A	Firm B
Technoware	0.25	0.64	0.73
Humanware	0.25	0.64	0.48
Infoware	0.25	0.71	1.00
Orgaware	0.25	0.64	0.76
TCC	-	0.66	0.77

6.3.5 Biscuit Manufacturing Industry

In the study on the biscuit manufacturing industry only one firm - Williams Confectionaries Ltd, was agreeable to participate. The manufacturing process comprises of the following stages :

(a) Ingredient handling, (b) Mixing, (c) Rotary mouldding, (d) Wire-cut and depositing, (e) Laminating and (f) Ovens and baking. The technology component contributions and TCC are summarized in Table 6.7 and Figure 6.8.

It is apparent that as in most cases in Sri Lanka, the production facilities of firms are fairly advanced although flow of technical information has not kept pace to meet the needs of the industry. The major firms in the industry faces stiff competition internally from a range of quality imports from abroad (catering to the upper strata of society) on the one hand, and sub-standard products of small-scale confectionary makers, catering to the lower-middle and rural classes.

FIGURE 6.8

BISCUIT MANUFACTURING INDUSTRY

TECHNOLOGY COMPONENT CONTRIBUTIONS

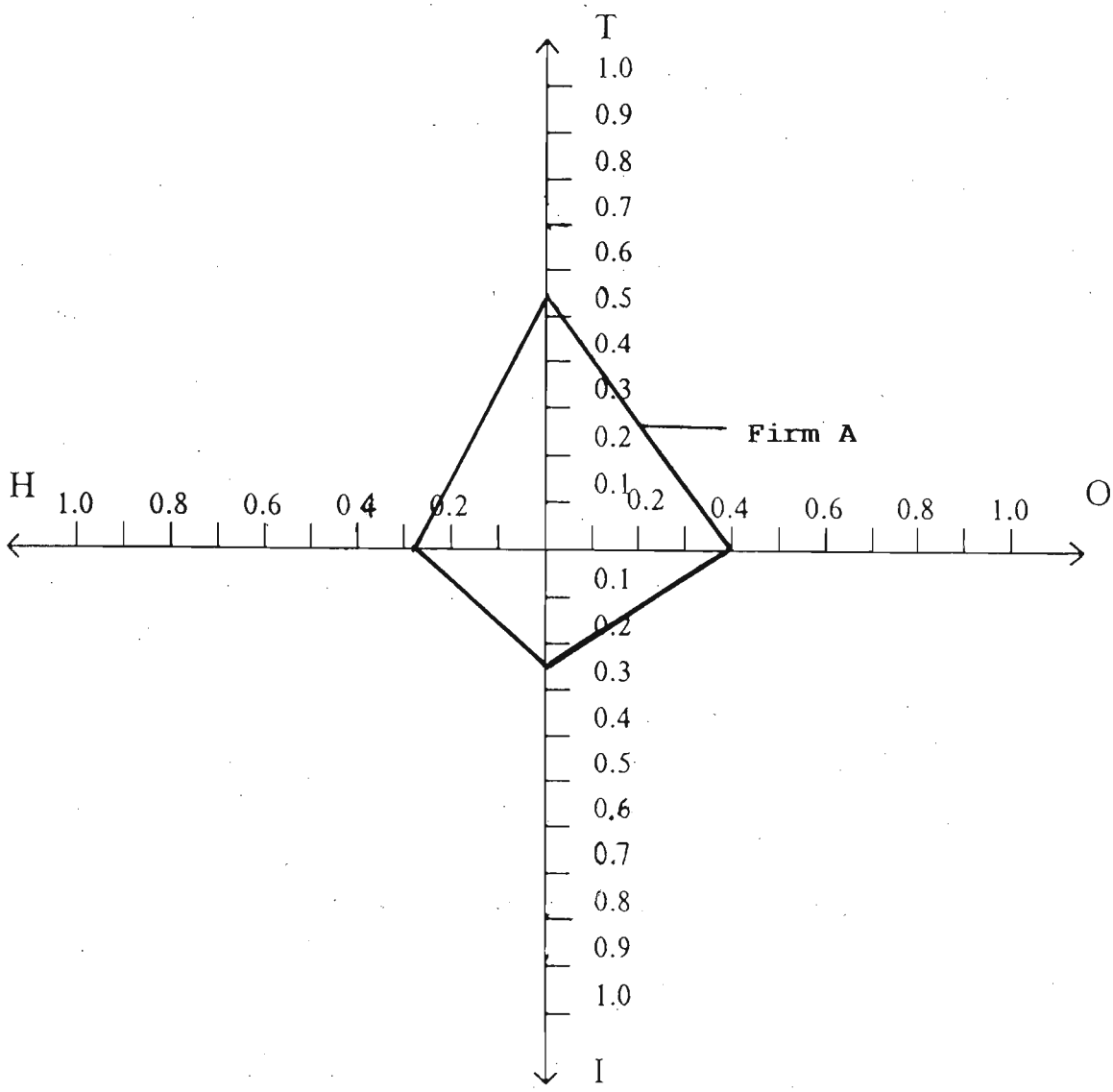


TABLE 6.7

SUMMARY OF COMPONENT CONTRIBUTIONS AND TCC FOR THE BISCUIT MANUFACTURING INDUSTRY

	Component Contribution Intensities	Technology Component Contributions and TCC of Firm A
Technoware	0.25	0.55
Humanware	0.25	0.28
Inforware	0.25	0.26
Orgaware	0.25	0.40
TCC	-	0.36

6.3.6 Manufacture of water pumps

Pumps are machines which increase the static pressure of fluids (liquids). In a more general sense, pumping is the addition of energy to a fluid which is used mainly for the purpose of moving the fluid from one point to another, that is, by the transfer of mechanical energy to the fluid by means of an impeller. In this case, the energy is transferred to the pumped media partly by an increase of pressure due to the centrifugal forces, and partly by an increase in the kinetic energy, which in due course is converted to pressure energy. These are the "rotodynamic" or the commonly known "centrifugal pumps".

The key local manufacturing firm is Jinasena Ltd., producing a range of domestic and industrial pumps under the name "Jinasena Pumps". It is a pioneering industry which has strived to maintain standards, and hence qualified for protection from successive governments. It faces stiff competition from low priced low quality imports.

The technology component contributions and TCC are summarized in Table 6.8 and Figure 6.9.

TABLE 6.8

SUMMARY OF TECHNOLOGY COMPONENT CONTRIBUTIONS AND TCC FOR THE WATER PUMP MANUFACTURING INDUSTRY

	Cmponent Contribution Intensities	Techhnology Component Contribution and TCC of Firm A
Technoware	0.25	0.50
Humanware	0.25	0.49
Inforware	0.25	0.39
Orgaware	0.25	0.58
TCC	-	0.49

The designing and pattern-making stages are facilitated by computer- aided designing using the required technical data. The proto-type drawing is first constructed in wood to specifications, and these are produced in metal as the mould. Although the overall component contributions of these stages are high, the net technology contribution for technoware is reduced because two stages (machining and prime mover winding)operate at a low level of sophistication. Thus even though this firm produces a quality product with high local recognition, its ability to enter the international market is severely restrained by the backsetting effect of some steps of the manufacturing process and the inadequate contributions from the human resource factor and the organizational framework.

6.3.7 Mineral Water Beverages Industry:

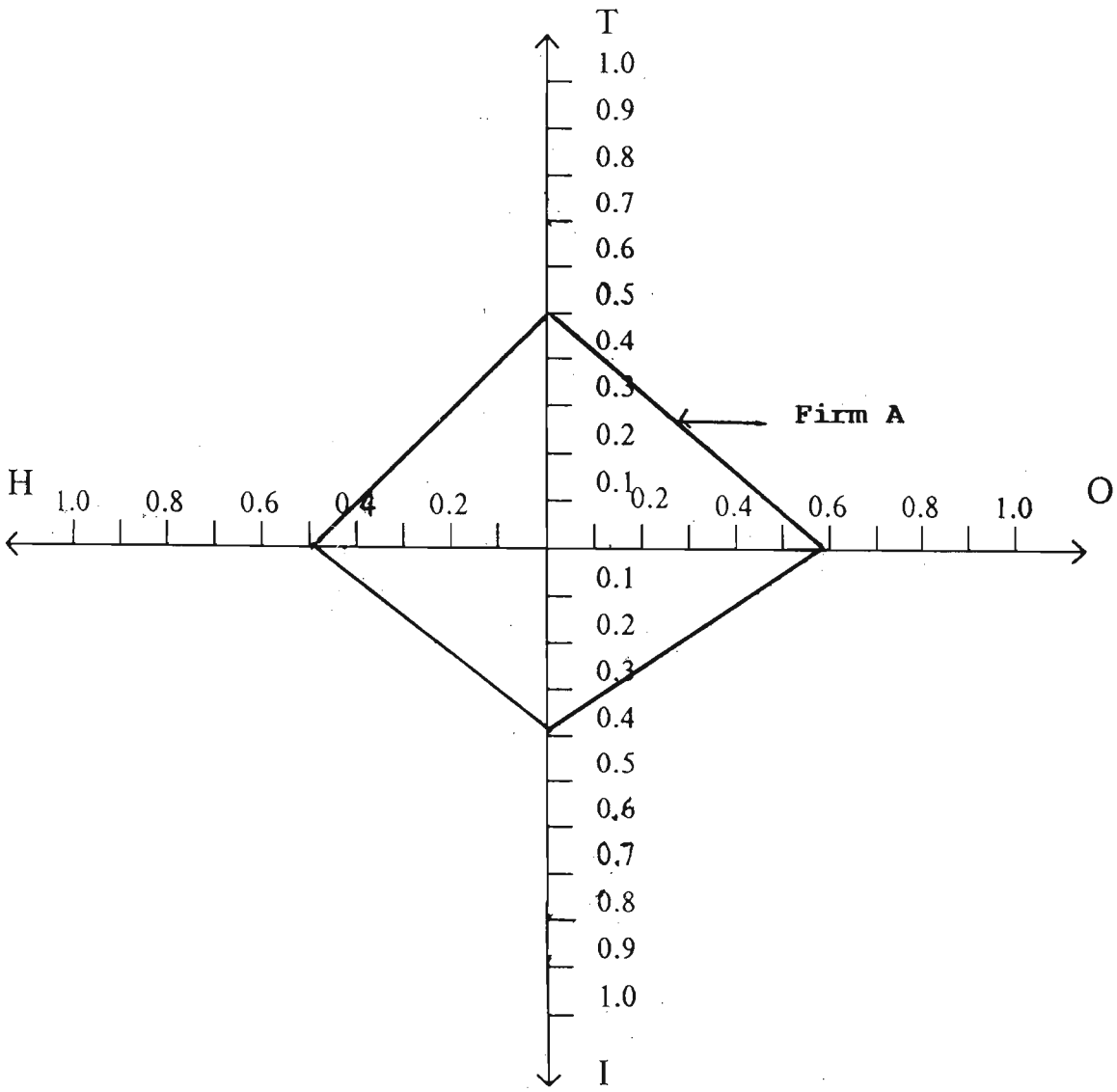
Three well known manufacturers of flavoured mineral water beverages were selected for this study. However, one of these firms had by this time discontinued the production of mineral water drinks and was manufacturing fruit drinks, cordials and nutritive drinks. The firms selected were Ceylon Cold Stores (Elephant Brand), Pure Beverages Ltd. (Lion Brand) and Maliban Mineral Waters Ltd. (Maliban Brand). One of the firms produces a range of popular local brands as well as brands with international proprietary rights.

The soft drink beverage manufacture, involves two distinct technologies giving rise to carbonated and non-carbonated drinks. Both types of drinks are in constant demand in Sri Lanka. Carbonation techniques also necessarily change with other factors such as sweatness, flavours or other ingredient formulations. Hence for

FIGURE 6.9

CONTRIFUGAL PUMP MANUFACTURING INDUSTRY -

TECHNOLOGY COMPONENT CONTRIBUTIONS



the present technometric evaluation process, 11 types and stages in the manufacturing process were identified and assessed which cover both the carbonated and non carbonated processes. These included liquid carbonated beverages, citrus drinks, orange beverage base preparation, process for clouding agents, process for slush beverage preparation, processess for non-carbonated slush process of acidulants, flavouring, packaging, specification, and final product requirements. The technology component contributions and TCC are summarized in Table 6.9 and illustrated in figure 6.10.

TABLE 6.9

SUMMARY OF TECHNOLOGY COMPONENT CONTRIBUTIONS AND TCC FOR THE MINERAL WATER BEVERAGE MANUFACTURING INDUSTRY

	Component contribution-intensities	Technology Component Contributions & TCC		
		Firm A	Firm B	Firm C
Technoware	0.25	0.67	0.59	0.67
Humanware	0.25	0.52	0.47	0.52
Inforware	0.25	0.42	0.32	0.56
Orgaware	0.25	0.65	0.62	0.64
T.C.C.	--	0.57	0.50	0.60

The data generally indicate that all three firms have reasonably good production facilities, and hence the overall Technology Contribution Coefficient has been satisfactory. However the flow of technical information and specification data are satisfactory only with one firm possibly the result of licensing arrangements with its multinational collaborator for proprietory manufacturing rights for international brand products.

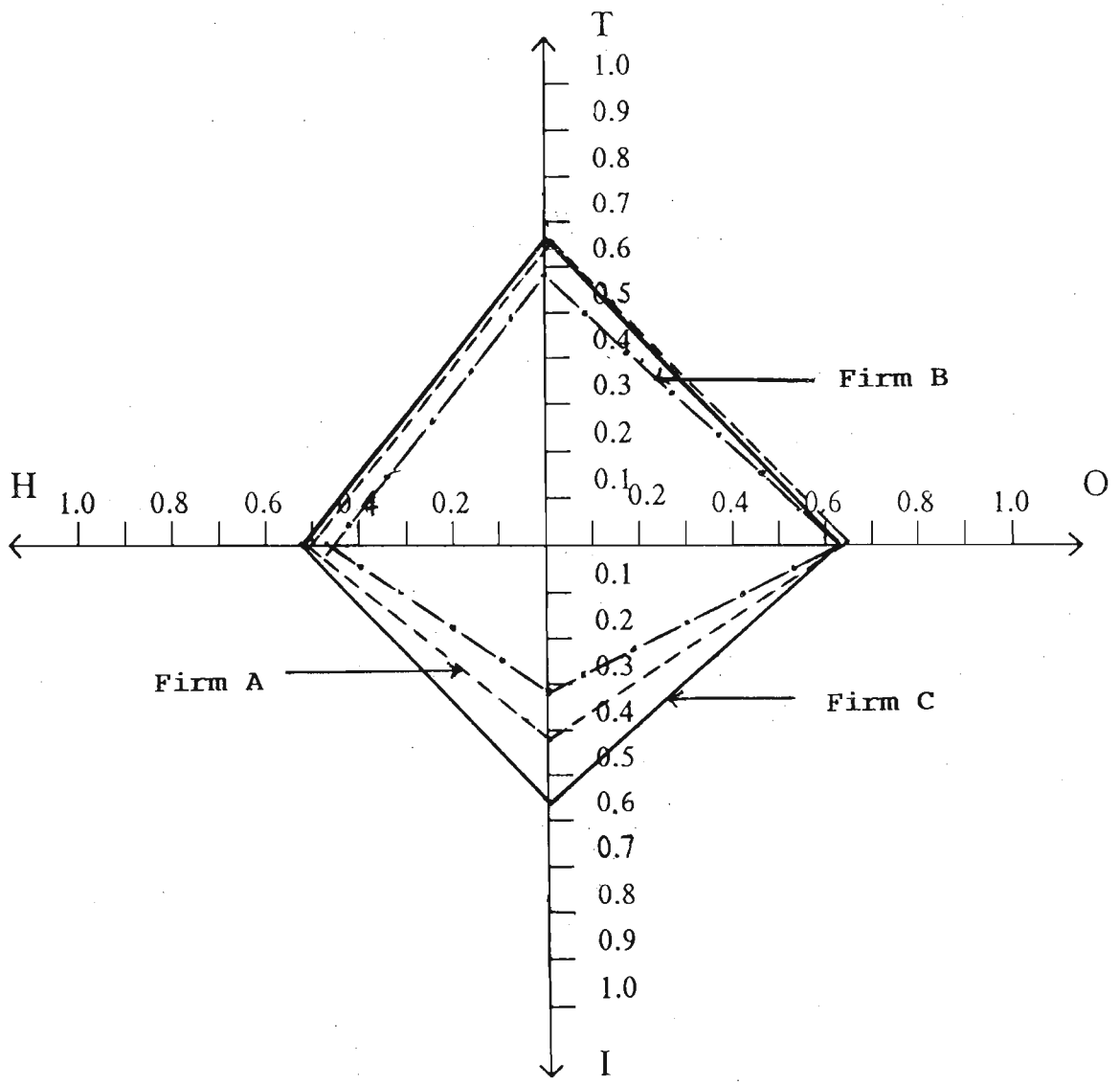
6.3.8 Computer Manufacturing Industry

Although the computer became a common and widely used piece of equipment in Sri Lanka during the past decade, commercial manufacture became a reality only during the last 3-4 years. The industry is still in its infancy, with a couple of entreprenurial electronic technologists making the initial entry into the local market with assembly of imported components. In the meanwhile, a Sri Lanka-

FIGURE 6.10

MINERAL WATER INDUSTRY

TECHNOLOGY COMPONENT CONTRIBUTIONS



Singapore joint venture firm also entered the fray with an assembly plant to manufacture an international brand.

Although computer components manufacture and assembly are done by automated CAD-CAM processes world wide, the local manufacturing firms are contended with manual assembly process for the following reasons:

- The small internal market limiting large scale production
- Intense internal competition from popular makes from foreign and transnational companies
- availability of a cheap but a highly skillful local work force
- The high cost of automated assembly plants.

In the current study two fairly well established computer manufacturing firms were assessed for their technology contribution coefficients. The firms concerned were Jagath Robotics (Pvt) Ltd. a totally Sri Lankan owned company producing "JRL Computers" to the local market as well as for export, and the World Computer Lanka (Pvt) Ltd., a joint venture with a Singaporean firm, producing "Prof" Computers, largely to the local market.

The Technology component contributions and TCC are summarized in Table 6.10 and illustrated in Figure 6.11.

TABLE 6.10

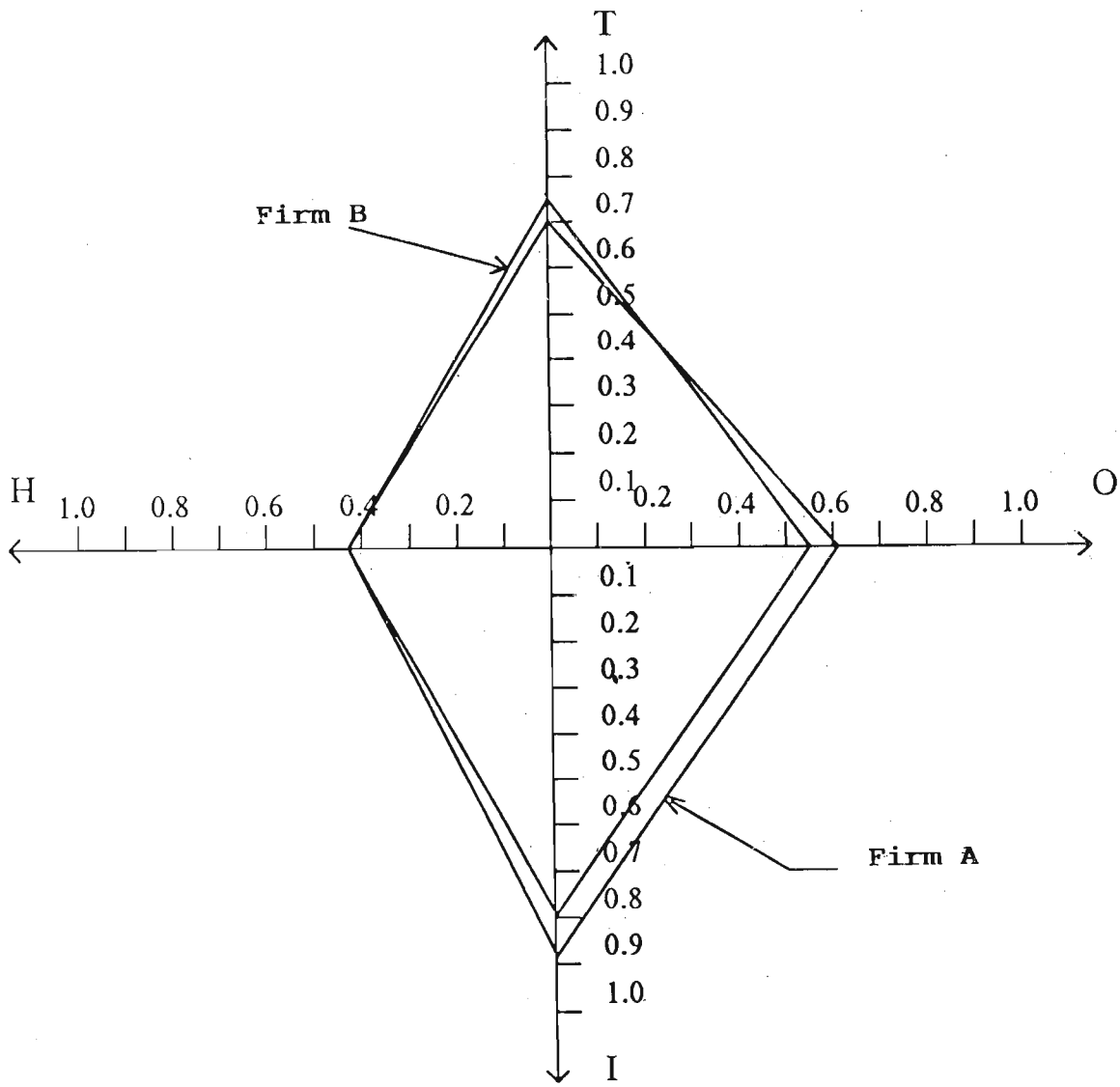
SUMMARY OF TECHNOLOGY COMPONENT CONTRIBUTIONS AND TCC FOR THE COMPUTER MANUFACTURING INDUSTRY

	Component Contribution Intensities	Techhnology Component Contribution & TCC	
		Firm A	Firm B
Technoware	0.25	0.70	0.75
Humanware	0.25	0.43	0.42
Inforware	0.25	0.89	8.78
Orgaware	0.25	0.62	0.65
TCC	--	0.64	0.61

FIGURE 6.11

COMPUTER ASSEMBLY MANUFACTURING INDUSTRY -

TECHNOLOGY COMPONENT CONTRIBUTIONS



The data presented indicate that the two computer assembly firms operate at comparable levels of technological sophistication, with practically no competitive advantage over one another. The fact that one has been able to break into the international market shows the innovative capacity of this firm in producing machines of high quality. This point is also further substantiated by the relatively high TCC of the two firms.

However, the assembly industry is beset with several constraints. The computer manufacturing firms have made representations on these matters to relevant government officials from time to time. Although some of these problems may have been resolved by now, the comments made by one firm is reproduced below in full with the consent of its Directorate:-

"Fiscal Problems Associated with Local Assembly/Manufacture

1. Certain banks presently allow opening of Letters of Credit (LCs) only at nil margin for Computer accessories/parts. This requirement varies from bank to bank.

2. Nil margin is required even for short term LCs. Banks advise firms to open on 100%, since 3% stamp duty is more than the interest that has to be paid at the black market rate (24%-30%). (If stamp duty is paid, it is 36% for one months credit)

3. Even for nil margin except for companies with assets to mortgage to the bank (eg. multinational companies), Banks are reluctant to give on credit, since most officials are ignorant of the value of stock. In otherwords, stock is not taken as security.

4. For the past one year, we have been opened LCs for our company granting 100% LC margin but, no interest has been granted for the cash held.

5. CKD (Complete Knock Down) manufacturing is not possible, as the present duty structure and the government policy on Industry does not give any advantage to the electronics industrialist.

6. BTT is taken at 15% on the price of manufactured products at the time of sale, and if the value is high, the BTT paid is higher than what is paid for an imported item.

7. We had certain orders for duty free imports of computers, and since we import components and assemble, the Customs officers were not willing to grant this concession, with the result, duty had to be paid and goods supplied below cost.

8. As government institutions are unable to pay any advance, the total cost has to be met by the company 1-2 months ahead of opening the LC, and until the assembly/manufacturing, and delivery are complete. Certain Goverment organizations request bid bonds of 10% which amounts to Rs. 30,000-100,000. In such cases we were unable to quote, due to the 100% cash margin which we had to hold for 3-6 months before delivery of goods.

A tender at University Grants Commission required a Bid bond for Rs. 50,000, which I presume only the large companies are capable of quoting due to the current credit squeeze.

9. Organizations like, DFCC and NDB are very reluctant to finance projects of local manufacture, where mostly working capital is required. As such, the re-finance organizations tend to refuse projects when they do not find capital equipments imported from developed countries.

10. Since our Industrial policy does not favour import substitution nor tariff protection, we find very few local Electronic industries here.

11. In most developed countries, an important requirement for a Goverment tender is that at least 40% of the equipment should be of local components, and large firms from developed countries are compelled to sub-contract to the local firms. This does not happen in Sri Lanka".

6.3.9 P.V.C. Pipe Manufacturing Industry

The P.V.C. Pipe manufacturing industry made a firm foothold in Sri Lanka more than 25 years ago when a well known firm entered the field with a manufacturing facility. With the ever increasing demand and the proliferation of the industry, the first standards for rigid unplasticized polyvinyl chloride pipes for potable cold water were established by the Bureau of Ceylon Standards (the present Sri Lanka Standards Institution) in 1972, and then revised in 1983. The P.V.C pipe manufacturing process comprises mainly of three stages namely, raw material hardling, extruding, and pipe product processing. The third stage however, includes several activities for sizing, hauling and cutting. Some firms produce both rigid unplasticized pipes as well as flexible plasticized pipes, while others produce only the rigid pipes.

In the current study following P.V.C. pipe manufacturing firms were evaluated.

- S-Lon Lanka (Pvt.) Ltd., (S-Lon pipes)
- St Anthonys Industries Group Ltd., (Anton PVC)
- Central Industries Ltd., (National)
- Aztex Industries Ltd. (Aztec)
- Kumarage Industries (Kumkelon)
- Duro Pipe Industries Ltd. (Duro)

The technology component contributions and TCC are summarized in Table 6.11 and illustrated in Figure 6.12.

FIGURE 6.12

PVC PIPE MANUFACTURING INDUSTRY -

TECHNOLOGY COMPONENT CONTRIBUTIONS

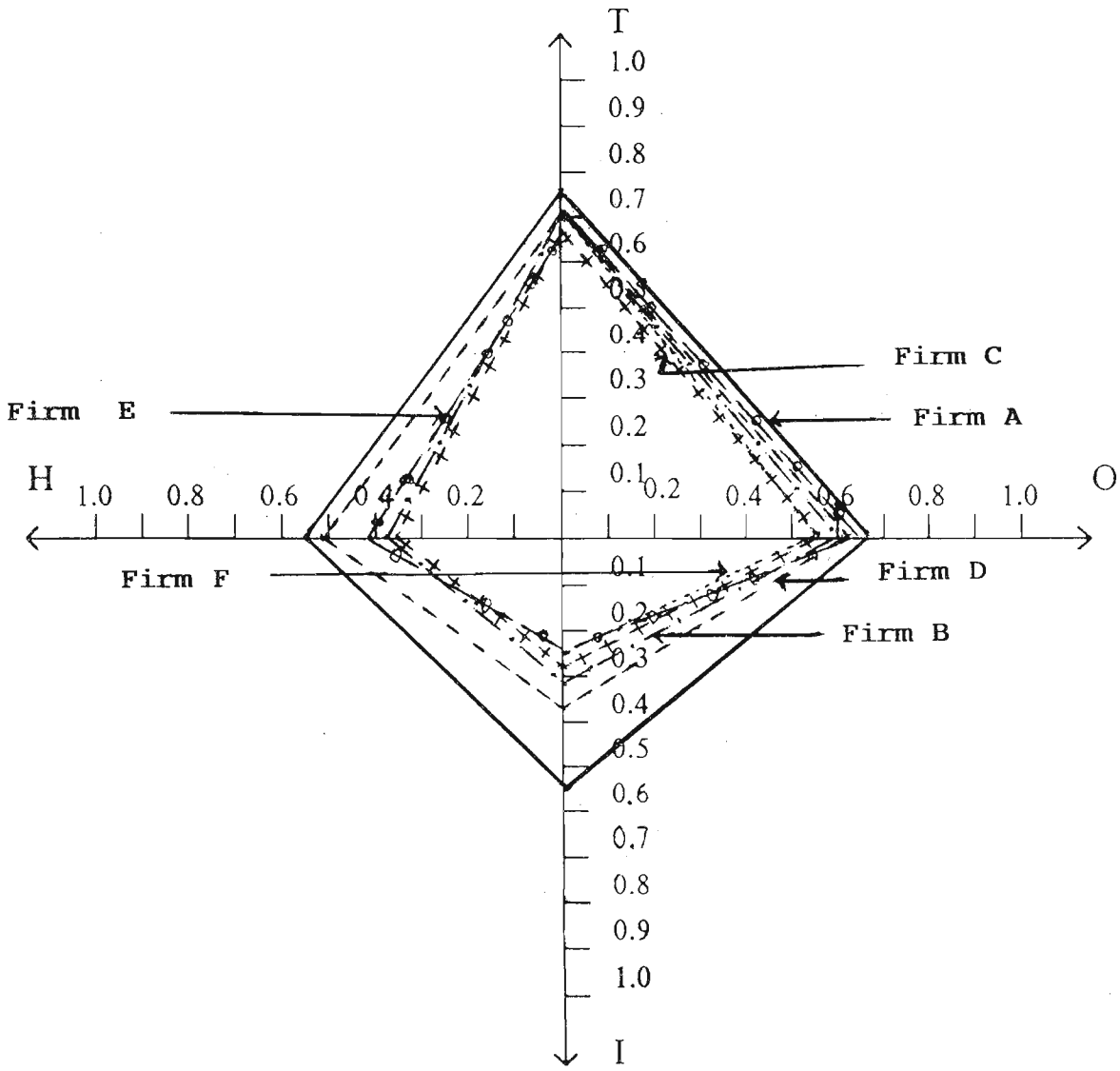


TABLE 6.11

SUMMARY OF TECHNOLOGY COMPONENT CONTRIBUTIONS AND TCC FOR THE PVC PIPE MANUFACTURING INDUSTRY

	Component Contribution Intensities	Technology Component Contribution & TCC					
		Firm A	Firm B	Firm C	Firm D	Firm E	Firm F
Technoware	0.25	0.75	0.72	0.71	0.69	0.69	0.68
Humanware	0.25	0.53	0.39	0.52	0.40	0.41	0.37
Inforware	0.25	0.56	0.32	0.36	0.26	0.26	0.29
Orgaware	0.25	0.66	0.60	0.60	0.57	0.64	0.58
TCC	-	0.62	0.48	0.55	0.45	0.47	0.45

It significant that one firm stands clearly above the others in all four components of technology. Although the technical facilities are high for all firms, this particular firm's superiority in human resource abilities, technical information and organizational structures, makes it the producer with the highest Technology Content Coefficient. Most of the firms have qualified for Sri Lanka Standards Certification and could produce goods acceptable to international markets.

The information presented in this Chapter, through a technometric evaluation of nine selected industries provides insights to the current status of industrial technologies in Sri Lanka. Investigation of this kind, makes it possible for the industry as well as industrial planners to introduce precise developmental and policy measures to guide entreprenuers and industrialists towards higher standards of production. It will also show industrialists how close or how far they are from the best in the world, and what measures should be taken to ensure that products and processes will be internationally competitive. This evaluation will in addition provide guidance on the type of technological changes that could be expected and how the country or industry could respond to a change in terms of human resource development, networking of information, and in organisation and re-structuring of management systems.

Finally, it will also facilitate evolving mechanisms for choice of new technologies and transfer of technology.

Chapter 7

SUMMARY AND CONCLUSIONS

7.1 IN RETROSPECT

Science and technology are key ingredients for promotion and sustenance of development, although it is conceded that there are no short cuts to progress. The concept of development has different connotations to different communities. Thus in traditional societies, the inflexion of development process is towards satisfying the basic needs and aspirations of the people and less towards sophistication in their life styles. The implication here is that a country must in the first instance, ascertain a national consensus on the needs and aspirations of the people in their own perception, of the goals of development. It is indeed futile to be obsessed by the thoughts of a development paradigm in which automation and sophistication in life styles are assumed to be the satisfying goals. In fact the universal display of despondency, disorder and confrontation of the kind seen today amongst members of both "developed" and "less - developed" societies, are convincing evidence of discontentment and rejection of the professed and pre-conceived social orders implanted. These are the basic issues that must be resolved and placed in the correct perspective, before formulating strategies for development.

Much has been said about the role of industrialization and international competitiveness in trade, as concomitant features of progress. On the other hand technology has often been cited as the master key for development. This is evidently based on the notion that a direct thrust towards medium and high technology could leap frog some of the traditional barriers and thus pave the way for an escape route to development.

Alternately, it may be speculated that through the conventional process of foreign capital participation, accompanied by a massive transfer of technology and knowhow towards exports - driven industrialization, a by-pass pathway could be found for an economic revival. These are some of the issues that confront planners and policy makers in their quest for a recipe for socio-economic progress. However, in the final analysis, it is clear from all available evidence, that development as seen from the present day context can never be sustained without an appropriate and adequate scientific base, evolved and fostered within the country.

The present study is an attempt to review cross-sectorally some of these concerns, with the aim of drawing appropriate indices, markers and path-finders to assist in techno-economic planning.

While a part of the information presented in this treatise represents re-classified data from studies undertaken by the United Nations Conference and Trade and Development, and the Central Bank of Sri Lanka, a substantial effort was made for a quantitative and qualitative assessment of a few selected industrial technologies. This evaluation was undertaken both at the company level as well as at the industry level with the objective of, (a) testing and demonstrating a procedure for a technometric analysis of industrial technologies (b) assessing the strengths and weakness of industries in their ability to produce goods that could reach internationally acceptable standards, (c) evolving criteria to determine the needs and directions for technological changes, and (d) evolving mechanisms and guidelines for choice of technology.

The study also includes a historical review of the progress of industrial research and development in Sri Lanka, as well as a survey on technical, vocational and craft level training in Sri Lanka.

The main findings of the study are summarized below:-

7.2 DEPLOYMENT OF RESOURCES AND INCENTIVES FOR R & D

**The financial resources allocated for the education sector had increased from Rs.1344 million in 1979 to Rs.5202 million in 1987, at an annual growth rate of 36 percent. However, the budgeted expenditure for education as percentage of GDP during 1978 to 1984 was only 2.7 percent (as compared to 3.4 percent during the period 1970-1977), although it had been proposed to increase this contribution to 3.3 percent of G.D.P by 1992. It is significant to note that the appropriation of resources for technical education during 1978 to 1984 had been less than 2.5 percent of the total amount allocated to this sector. (ξ 2.5)

**Although the document on "A Strategy for Industrialization of Sri Lanka" has been precise and eloquent in its presentation of administrative, fiscal and financial policies for investments, industrialization and exports, its outlook on science, technology and the academic scene are considered grossly inadequate to buttress and sustain a technology based industrial super-structure. In fact the rate at which efforts in science and technology have been declining over the past two decades (measured in terms of the fall in gross expenditure on R & D as percentage of GDP), has been a matter of grave concern to all concerned. Hence it seems a Herculean task for Sri Lanka to achieve and sustain a favourable outward equilibrium in terms of international competitiveness of exports, Balance of Trade and in Technological Balance of Payments. (ξ 3.1)

**A United Nation Study on the "Role of R & D Institution in Sri Lanka, in Technological Innovation", has concluded that the failure of the industrial research institutions to commercialize many of the research projects undertaken, were due

to (a) the apparent lack of orientation of R & D towards real or actual needs of the production sector, and (b) the absence of functional linkages with the industrial sector. Studies have shown that industrial research had been largely directed towards products and processes developed through in-house research programmes. The contacts with industry had been mainly to provide services and standards rather than for innovative research . (ξ 3.4)

** At present some 19 ministries are said to be associated with technical, vocational and craftsmen training programmes. However, strangely there is practically no accurate data on the current or future needs of trained manpower for the country although over 44,000 persons are trained annually under various training programmes, excluding those of the National Apprenticeship and Industrial Training Authority. This is indeed a serious shortcoming in the consultative processes of national planning. (ξ 2.5)

**A recent study on worker attitudes towards technological changes has led to the observation that the reactions and responses of workers for technological changes are a direct expression of man's critique towards a so-called machine dominated slavery. Hence management of technological changes, demands not only increasingly sophisticated organizational and management instruments, but also highly innovative skills in labour management. (ξ 1.2).

**Experiences from other countries have shown that financial incentives through tax concessions alone have little or no impact an innovation based industrial export development. There is thus a need to draw a distinction between investments in R and D and innovation in R and D, because concessions and guarantees for R and D investment does not necessarily result in innovation, instead may only provide alternative opportunities for tax benefits. Further, investments in research need not necessarily imply in-house research, but could also mean direct contracts to R and D institutions, or even take the form of contributions for a central research foundation. Obviously these proposals need appropriate policy initiatives, supported by adequate financial and legal instruments to create the necessary environment for innovation and mastery of technology. Policy initiatives should not only be supportive of innovation but also of creativity. Accordingly the following proposals may be considered as alternative policy options:

(i) Grant of substantial tax credit for exports generated through innovative formulations, products and processes (as opposed to ordinary exports).

(ii)Grant of substantial tax credit for innovatively evolved diversification strategies

(iii)Grant of export duty rebates for industries for demonstrating significant reductions in the import content of products.

(iv)Provision of merit promotion schemes for researchers for creative contributions to industry, institution and the country (as alternatives to credit marks for scientific publications only).

The failure of the policy document on A Strategy for Industrialization, to provide guidelines on not only the expected thrust of scientific and technological research for industrial and technological development, but also on measures for evaluation and granting of rewards for elements of innovation, invention and adaptation of technology, is thus considered unfortunate.

7.3 SRI LANKA WITHIN THE SOUTH ASIAN CONTEXT.

Chapter 5 of this treatise presents comparative data on several techno-economic issues, and also a comparison of the performance of the SAARC community of nations against its rival South Asian Group ASEAN. The Chapter also discusses the status of Sri Lanka both in relation to its friendly neighbours as well as against the ASEAN partners. The key trading and techno-economic aspects of Sri Lanka in relation to these sub-regional groups are as follows:

**Although Sri Lanka, (like Myanmar and Nepal), had been able to increase substantially the number of commodities exported between 1970 and 1988, the relative growth in "Diversification Index" as well as the "Concentration Index" has been less impressive than for example, Singpore, which indicates that Sri Lanka's export structure is still biased towards a fewer number of commodities. (ξ 5.3)

**It is significant that in respect of precious stones exported by SAARC nations in 1985-86, 96.7 percent was accounted for by India and only a meagre 3.3 percent appeared to have been contributed by Sri Lanka. These official figures apparently do not reflect a substantial volume of precious stones that are said to enter the international markets undetected and unaccounted for in export figures. (ξ 5.3)

**International market figures for 1985-86 shows that among developing countries, Sri Lanka occupies second position in respect of the exports of tea and mate, fifth position in respect of rubber products, fourth position in respect of pearls, and tenth position in respect of fixed vegetable oils. It is interesting to note that while tea and mate accounted for 31.4 percent of total exports from Sri Lanka , it represented 24.8 percent of developing country contribution, and one-fifth of the world trade in this commodity. On the other hand ready-made garments was the second largest export commodity of Sri Lanka during 1985/86, but represented only 1.35 percent of developing country contribution and only 0. 67 percent of the world trade in this commodity. (ξ 5.3)

**An insight into the inflow and outflow of technology related capital goods to Sri Lanka during (1980-1990 have shown that exports of primary (unprocessed) and intermediate (semi-processed) goods had increased 14-fold in rupee terms, but represented only about a 5 - fold increase in US dollar equivalents. On the other hand imports of these types of goods had initially increased upto 1985, and declined sharply by 1990. Does this observation indicate that Sri Lanka is becoming increasingly less inclined to add valve to primary resource materials generated internally as well as from sources outside the country? (ξ 5.3)

**It is noted that both exports and imports of machinery, general equipment and transport equipment of Sri Lanka had increased substantially over the period 1980 - 1990 in terms of rupee values, although in terms of dollar values, the imports of machinery as well as transport equipment had declined during this period. However, the most significant change in international trading of capital goods, is the sharp rise in both export and import of unspecified technology-related goods during 1990. This is evidently a response to the recent economic reforms of the country. (§ 5.3)

**It was noted that Sri Lanka was one of the few developing countries in which a possitive correlation was seen between capital goods inflows and growth of manufacturing value-added *per capita,* during 1981-1985. While this is indicative of a favourable positive response of the country to the new economic reforms, it also shows the degree of dependence of the country on imported technologies. (§ 5.3)

**The growth of Foreign Direct Investments (FDI) in Sri Lanka from 1975 to 1988 has been substantial, although the general level compared to ASEAN countries (except Brunei) was still much less than one - tenth. It may be noted that although in FDI, technology transfer could be substantial, it may only marginally influence diffusion and assimilation of technology, in the absence of an appropriate and adequate S and T base in the country. (§ 5.3)

**Sri Lanka is seen to account for only about 10 percent of the total Technical Co-operation grants received by SAARC nations, yet on a *per-capita* basis, it has a 6 fold advantage over the overall SAARC *per capita* assistance. Technical co-operation assistance is generally tied-up, and when technology transfer is also involved, usually there is not much of a choice for the recipient country.

7.4 STATUS OF INDUSTRIAL TECHNOLOGIES

It is recognized that technology is the physical tool for a technological transformation. Over the years, the intervention of technology in the process of socio-economic change has assumed complex relationships, because of its interactive phases with social, cultural and environmental concerns. Hence its choice, acquisition and management are critical issues in techno-economic planning. Unfortunately no effort has yet been made to evaluate the currently available industrial technologies in Sri Lanka, or to evolve a technology policy framework for the country.

In this study, a method developed by a United Nations agency was tested and used. According to this evaluation procedure, technology comprises of four basic functional components, all of which interact dynamically to accomplish a transformation task. The four functional components are described as facilities (Technoware), abilities (Humanware), facts (Inforware) and organizational frameworks (Orgaware).

The objective of this evaluation exercise, was to (a) demonstrate the role played by the different functional components of technology in an industrial transformation, (b) assess the current status of the functional components of technology at the operational level, (c) assess the degree of sophistication of the functional components in relation to the State of the Art, in selected industries, (d) demonstrate the potential of such an evaluation to introduce technological changes, (e) evolve a mechanism to facilitate choice of technology and technology transfer, and (f) illustrate its usefulness in international comparison of technological transformation processes, as indicators of international competitiveness in products and processes. The evaluation was carried out at the firm level in the industries listed below.

(1) Leather manufacture
(2) Shoe manufacture
(3) Iron and steel
(4) Dry-cell batteries
(5) Biscuit manufacture
(6) Centrifugal water pumps
(7) Mineral water beverages
(8) Computer assembly
(9) P.V.C. pipes

**The seven firms studied in the leather manufacturing industry displayed typical characteristics of an old generation technology operating in a less developed country. Two out of the seven companies studied had Technology Content Coefficient (TCC) of 0.22, which in a way meant that they were operating at less than 25 percent of the technological capability of the best in the world. State of the art assessments of Technoware in these two firms show that at most of the main manufacturing stages, the physical facilities available were inferior, leading to a low technological capability. Hence by identifying these defective stages, it may be possible to selectively upgrade the facilities. This type of assessment also helps the industrialists in choice and acquisition of technology. Two firms enjoyed relatively high contributions of technology information, while one firm reported a superior organization framework. However, physical facilities of all firms were far from satisfactory. (ξ 6.3.1)

**Among the four well known companies producing leather shoes, one firm dominated with a TCC value of 0.69. Its technological capability was high enough to compete in the international market, with some of the best manufacturers of leather footwear. One of the significant observations in both the leather and shoe manufacturing industries, was the superiority of some of the private sector firms in all four components of technology, over the long standing public sector institutions in this field. (ξ 6.3.2)

**In the iron and steel industry, one public sector institution had been the sole manufacturer until a few years ago, when two other private sector firms established smaller production facilities. Comparison of the technological capability of Sri Lanka's pioneer steel manufacturing concern with similar firms in India and Japan shows that the technological capability of the Japanese industry far exceeds any of those from India and Sri Lanka. The TCC values of the Sri Lankan and Indian steel manufacturing facilities are about the same, with the Indian firms organizational

frameworks being superior to those of the Sri Lankan firm, However, for the other three components Sri Lankas steel industry stands ahead of the Indian counterpart. The superiority of the Japanese industry has been due to the concerted efforts taken by Japanese industrialists for cost effective production norms and quality standards, in the face of high labour costs, low capacity utilization and reduced production. Thus despite of very high labour wages, and costlier raw materials, Japan is far ahead of India and Sri Lanka, in quality standards and competitiveness in international market. (ξ 6.3.3)

**A significant feature of the dry-cell battery manufacturing industry, was the fairly high TCC values of the two competing firms, one of which is a subsidiary of a multinational group, and the other a Sri Lankan joint venture. Both firms have a high potential to break into the international market, if any restrictive measures in their respective licensing agreements are relaxed. One of the firms also has achieved the State of the Art in Inforware. (ξ 6.3.4)

**In the water pump manufacturing industry, a pioneering firm with State protection uses computer aided designing and pattern-making. The proto type drawings are initially constructed in wood to specifications and then moulded in metal. Although the overall component contributions are high, the net technology contribution for technoware is reduced due to a sizeable drop in the quality of physical facilities at two of the stages in the manufacture. Thus even though this firm produces a quality product with high local recognition, grave doubts have been expressed of its ability to be competitive even in the local market if state protection is withdrawn. This is because of the back-setting effect of some of the manufacturing stages which makes the overall production process less cost effective.

**Two fairly well established computer manutacturing firms were assessed for their TCC values. The study showed that these two firms operate at a fairly high as well as at comparable levels of technological sophistication, with practically no competitive advantage over one another. One firm has been able to break into the international market, because of its innovative capacity in producing machines of high quality. Being a very competitive industry the local entrepreneurs require a highly favourable technology supportive environment, to maintain a competitive edge which according to one firm, has not been forthcoming. This firm has listed several bottlenecks affecting the manufacturing industry, which include among others, the 100 percent down-payment for Letters of Credit, high cost of credit facilities, inappropriate duty structure for imports of components, and Business Turnover Tax payments.

In conclusion it is important to be reminded that technology assessments are carried out regularly in industrialized countries, as planning initiatives to assist in technology forecasting, as well as in providing assistance to selected industrial sub-sectors. By this means developed nations continually upgrade weaker segments of technology to enhance technological capability, and there-by steering market forces to their own advantage. As a consequence, sustaining international competitiveness of products of less developed countries, amidst cyclonic trade winds in international markets becomes increasingly difficult.

Unfortunately developing countries have rarely or never been able to embark on such technology assessment activities for national planning purposes. Most of these countries therefore are left with the unenviable situation of either facing progressing strangulation of their international marketing potential, or opting to be subjected to technological dependence on industrialized countries. In here lies the need for a strong R and D thrust, in which innovative experimental development work, expedient basic research and strategic design engineering should constitute the vision for technological progress. In fact from a resource allocation perspective, the shifts in emphasis from experimental development activities to basic research and *vice versa* have shown to be determinants of technological leadership.

REFERENCES

1. UN-ESCAP (1989). *Technology for Development - Can You Afford to be a* By-*Stander?* , Asian and Pacific Centre for Transfer of Technology, Banglore, India.

2. Goonetilake, S (1980). Industrial Development and Employment: The Experiences of Sri Lankan Programmes. *Report of the ILO Tripartite Symposium on Choice of Technology and Employment Generation in Asia,* 18-27 June, 1979 ILO, Bangkok.

3. De Silva, M.A.T. (1984). Historical Landmarks in the Orientation of Science Planning in Sri Lanka. *Sri Lanka J.S.S.* 7, 77-96.

4. Ceylon Institute of Scientific and Industrial Research (1956). *Annual Report for 1956.* Colombo ,Sri Lanka.

5. Ceylon Institute of Scientific and Industrial Research (1958). *Annual Report for 1958.* Colombo, Sri Lanka.

6. Laurentius, S.F. (1976). Twenty One Years of CISIR. In "Contribution to Science and Industry". *Proceedings of the 21st Anniversary Seminar of the Ceylon Institute of Scientific and Industrial Research,* May 1976, pp 9-14, Colombo, Sri Lanka.

7. Ceylon Institute of Scientific and Industrial Research (1964). *Annual Report for 1964.* Colombo, Sri Lanka.

8. Ceylon Institute of Scientific and Industrial Research (1965). *Annual Report for 1965.* Colombo, Sri Lanka.

9. Sivapalan, P. (1981). Achievements in Tea Research . *Trop. Agric,* 137, 69-76.

10. Ceylon Institute of Scientific and Industrial Research (1973). *Annual Report for 1973.* Colombo, Sri Lanka.

11. Ceylon Institute of Scientific and Industrial Research (1976). *Annual Report for 1976.* Colombo, Sri Lanka.

12. Ceylon Institute of Scientific and Industrial Research (1977). *Annual Report for 1977.* Colombo, Sri Lanka.

13. Fernando, H.E. (1972). The Coconut Leaf Beatle, *Promecothica Cummingii.,* and its Control. *Ceylon Coconut Planters Rev.,* 6, 152-156.

14. Ministry of Finance and Planning (1980). *Public Investment 1980-1984.* Colombo, Sri Lanka.

15. Ministry of Finance and Planning (1987). *Industrial Policy Statement - Government of Sri Lanka.* Colombo, Sri Lanka.

16. Ministry of Industries (1989). *A Strategy for Industrialization in Sri Lanka.* Colombo, Sri Lanka.

17a UN-ESCAP (1988). *Technology Atlas Project. Volume I. An Overview of the Framework for Technology for Development.* Asian and Pacific Centre for Transfer of Technology, Bangalore, India.

17b UN-ESCAP (1988). *Technology Atlas Project. Volume 2 - A Framework for Technology-Based Development: Technology Content Assessment.* Asian and Pacific Centre for Transfer of Technology, Bangalore, India.

18. Amaratunga, C.J. (1991). Worker Response to Technological Changes - A Paper presented at the Seminar arranged by the Computer Studies Division of the Open University of Sri Lanka. August, 1991, Sri Lanka.

19. Ministry of Finance and Planning (1988). *Public Investment 1988-1992.* Colombo, Sri Lanka.

20. Liyanage, S. and De Silva, M.A.T. (1987). *Sri Lanka Science and Technology Indicators Part I. Organizational Structures and State of National Efforts in Science and Technology.* Natural Resources, Energy and Science Authority of Sri Lanka, Colombo , Sri Lanka.

21. De Silva, M.A.T. (1984). *International Co-operation in Science and Techno logy - A Study of a R and D Programme on Rural Technology in the Asia-Pacific Region.* Commonwealth Science Council, London pp 107-114.

22. UNCTAD (1988). *Role of Research and Development Institutes in Tech*nological *Innovation: A Case Study of Sri Lanka.* United Nations, Geneva.

23. Central Bank of Sri Lanka (1988). *Report on the Survey of Business Activities and Planned Investments in Sri Lanka - 1984/85 to 1986/87.* Colombo, Sri Lanka.

24. De Silva, M.A.T. (1990). *Transfer and Utilization of Technology: A Country Study of the Republic of Maldives, Within the Framework of Project RAS/86/168.* UNCTAD, Geneva.

25. De Silva, M.A.T. (1991) *Transfer and Utilization of Technology: A Country Study of the Kingdom of Bhutan, Within the Framework of Project RAS/86/168.* UNCTAD ,Geneva.

26. UNCTAD (1990). *Handbook of Trade and Development Statistics - 1989.* United Nations, N.Y.

27. UNCTAD (1988) *Report on Recent Trends in International Technology Flows and Their Implications for Development.* Report No: TD/B/C.6/145, UN-CTAD, Geneva.

THE RESEARCH TEAM

1 **M.A.T. de Silva**, B.Sc(Lond), M.Sc(Lond),
Deputy Director General, NARESA and Project Leader. Initiated the programme on Science Statistics and Indicators at NARESA

Formerly research officer (Soil Chemistry) at the Coconut Research Institute of Sri Lanka.

Consultancies undertaken include,

(a)*Ministry of Foreign Affairs, Sri Lanka* : Co-member of an Advisory Mission to the Republic of Maldives, on Improving Coconut Plantations (October 1976)

(b)FAO : Field Evaluation of Fertilizer Demonstrations on Coconut (in Sri Lanka), September - November 1987

(c)*Commonwealth Science Council, London* : Preparation of a Country Report for The Gambia (West Africa) on the Science and Technology Profile (April 1988)

(d)*UN-ESCAP, Bangkok :* Co-member of the Evaluation Mission to seven South Asian Countries under UN Project RAS/86/143, on "Promotion of Technology Utilization. "

(e)*UNESCO - STEPAN, Wollongong, Australia* : Guest Lecturer on S & T Statistics and Science Indicators at the Training Workshop on Science and Technology for Development. New Delhi (October 1991)

(f)*UNCTAD, Geneva :* Under UN Project RAS/86/1 on "Transfer and Utilization of Technology in Small and Least Developed Countries," prepared Country Reports for Maldives (December 1989), Western Samoa (May 1990), Myanmar (August 1990) and Bhutan (April 1991)

Author/co-author of more than 45 Scientific Publications

2. **K.K.G.V. Wijetilleka,** B.Sc Eng. (Hon.),
Research Assistant on the Science Statistics and Indicators Project of NARESA from April 1989 to May 1990
Currently attached to the Kotmale Power Station, Ceylon Electricity Board, Mewatura , as Operations Engineer

3. **N.S. Wethasinghe,** B.Sc Eng., Associate Member, IESL (Provisional)
Research Assistant on the Science Statistics and Indicators Project of NARESA from April 1989 to August 1990
Currently attached to the Victoria Power Station, of the Ceylon Electricity Board, Kandy as Electrical Engineer.

4. **M.Z.M.F. Ameen,** B.Sc. Eng., (Hon.), AMIE (SL), MIEEE (USA) Dip. in Comp. Progg.
Research Assistant on the Science Statistics and Indicators Project of NARESA from May 1990 to December 1991
Currently attached to the Ceylon Electricity Board as Electrical Engineer

5. **O.A. Fouz,** B.Sc. Eng. (Chem. Eng.),
Research Assistant on the Science Statistics and Indicators Project of NARESA from August 1990 to December 1991
Currently attached to the Sri Lanka Standards Institution as the Standards Chemical Engineer