TECHNOLOGY PROMOTION

EXPERIENCES OF SELECTED ASIAN COUNTRIES

PCTT

AND PACIFIC CENTRE FOR TRANSFER OF TECHNOLOGY

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REPORT

ON

TECHNOLOGY PROMOTION

EXPERIENCES OF SELECTED ASIAN COUNTRIES

APCTT
ASIAN AND PACIFIC CENTRE FOR TRANSFER OF TECHNOLOGY
OF THE ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC (ESCAP)

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PREFACE

The Asian and Pacific Centre for Transfer of Technology (APCTT) is actively engaged in strengthening technology transfer capabilities of member countries of the Economic and Social Commission of the Asia and Pacific (ESCAP). Towards this end, it has been evolving new methodologies and refining existing mechanisms in areas relating to technology promotion and management. It is organizing national and regional workshops, expert group meetings in specialised fields and also bringing out reports and publications to promote exchange of information and experiences at various levels. The current emphasis is on promotion of sustainable development and regional cooperation.

With the globalisation of the market, there is now intensive pressure on member countries to review the economic policies and restructure their industrial development programmes. In this context, the choice of relevant technolog(ies) is an important factor in the planning and decision making process.

APCTT initiated this study on Technology Promotion based on selected countries from Asia (Bangladesh, India, Indonesia, Nepal, Pakistan, Sri Lanka and Thailand). The report also brings to focus the specific institutional mechanism and activities initiated to strengthen linkages among enterprises, R&D organisations, financial and promotional agencies. We express our appreciation and thanks to Dr. H.R. Bhojwani, Adviser, Technology Utilization, CSIR, India and his colleagues Mr. V.B. Lal, Dr. A.K. Guha, Mr. S.N. Sharma, Dr. D. Yogeswara Rao and Dr. Sudeep Kumar for preparing the background paper within the tight time-frame work.

I hope that the information given in this report will provide some insights for planning and managing the technological development process.

May 1995
New Delhi

Dr. Jürgen Bischoff
Director, APCTT

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Prolegomenon

Technology driven industrialisation is recognised today to be the means of rapid economic growth almost universally, and hence the means for alleviation of poverty and social development. The countries of the West, till the first half of the twentieth century, successfully applied the strategy to achieve rapid industrial and economic development. In recent times, several countries of Asia and the Far East, led by the legendary Japan, have successfully adopted similar strategies. The industrial performance of the Asian Tigers has made the world to take note of the Asian potential and performance. Some other nations of the Asian continent, though late followers in this strategy, have demonstrated remarkable resilience and dynamism to join the world economic community as equal partners.

The present report takes a broad look at the science, technology and industry scene of seven countries - five from South Asia, viz. Bangladesh, India, Nepal, Pakistan, Sri Lanka and two from South East Asia viz. Indonesia and Thailand.

Commonality

All seven countries have one thing in common - the recognition of technology-driven industrialisation as the guiding policy for rapid economic growth. These countries are also conscious of and have accorded adequate consideration to their endogenous resource base, and the socio-cultural context and national priorities and aspirations, besides the need for environmental preservation.

Another uniform feature that deserves special mention is a very low expenditure on R&D not only in absolute money terms but also as a percentage of the national GDP. In India the expenditure on R&D is around 0.9 per cent of GDP while in most others it is in the neighbourhood of 0.2 per cent. Also most of the R&D expenditure is incurred by the government - private sector spending on R&D has been rather dismal.

Further, there are no institutions/mechanisms in any of the countries for technology assessment serving technology import, which essentially remains a transaction between two individual firms and due to a disparity in the technological levels of the seller and buyer is tilted in favour of the seller.

In fact, low technology generation and poor conversion of research results (lab-scale technologies) into commercially viable production technologies, besides a near total absence of linkages between the national R&D and industry systems, remain common features in all countries. Additionally technology imports have not been interlocked with domestic R&D endeavours with the result that technology imports, massive in some cases, have not led to actual transfers of technology, and the importing countries have failed to create and realise the benefits of the 'Virtuous Circle' of economic growth and technological advancement. It appears that R&D in most countries has been pursued, if at all, for its own sake, rather than for serving as an essential input to the national economic system. Although no effective formal mechanisms for commercialisation of indigenous technology are in place in these countries, in some countries, e.g. India, Pakistan, Sri Lanka and Thailand, incentives and support measures are being provided for the purpose, including risk and venture capital and tax reliefs as well as accelerated depreciation of R&D costs.

Divergences

However, beyond this, divergences are manifest. The countries in our ensemble show wide differences in size, economy and incomes, social indicators, science and technology infrastructure and capabilities and the approach to foreign investments and technology. Table 1 gives some of the indicators; size-wise, we have Sri Lanka at one end with a surface area of less than 65,000 sq. km. and India on the other which is 50 times bigger with an area of 3,287,590 sq. km.; in terms of population, again Sri Lanka and Nepal with populations of 18 million and 20 million respectively are at one end and India with nearly 900 million people is at the other. On the basis of GDP per capita figure, Bangladesh and Nepal figure at the lower end with a GDP of less than US $ 250 per capita, India and Pakistan are next with per capita GDP between US $ 250 and $ 500, Sri Lanka and Indonesia have a higher per capita GDP and Thailand stands out with a per capita GDP of $1850. Life-expectancy at birth is a composite measure of the socio-economic conditions prevailing in a country, and on this basis, Nepal and Bangladesh lie at the lower end with a life expectancy of less than 55 years while India, Indonesia and Pakistan are in the range of 58 to 60 years with Sri Lanka at 68 years and Thailand at 71+ years.

However, broad average figures conceal wide disparities, and despite some reasonably good indicators for some of the countries, poverty and regional disparities within each country are quite marked and remain major developmental concerns of the governments.

Table 1: Some Comparative Indications

Country	Size mill. Sq.Km.	Population million (1992)	Pop. Growth % (1985-92)	Life Expectancy (1992)	GNP/Cap. US $ % (1992)	GDP** Growth % (1980-91)	GDP Growth 1992/93
Bangladesh	0.144	119.3	2.2	53	220	4.1	5
India	3.287	870	2.1	59.9	310	5.4	4
Indonesia	1.919	186	1.8	60	670	5.6	-
Nepal	0.147	19.85	2.6	53	170	4.6	2.9
Pakistan	0.796	119.11	3.1	58.8	410	6.1	3
Srilanka	0.0646	17.40	1.3	71.5	540	4.6	6.9
Thailand	0.513	57.76	1.7	68	1840	7.9	-

* Estimate of World Bank, of GNP per capita in 1992, measured at average 1990-92 prices.

** Annual average increase in GDP in real terms, for 1980-91.

Sources:

1. Statistical Year Book for Asia & The Pacific, 1993, UNO, for Cols. 2, 3 & 5
2. The Europa World Book 1994, Vol.I, Vol.II for Cols. 4,6,7 & 8.

S&T policy

The status of science & technology (S&T) and industry varies widely from one country to the other. While India had a formal Scientific Policy Resolution adopted by its Parliament as early as 1958 followed by a Technology Policy Statement in 1983, in other countries a formal policy announcement has been rather late in coming : Thailand had a S&T Policy in 1983; Pakistan in 1984, and a separate Technology Policy in 1993; Nepal in 1989; Bangladesh, Indonesia and Sri Lanka do not have a formal S&T Policy document. Thus the dawning of the critical role of S&T in national development has been relatively recent in most of these countries.

S&T capability

There is considerable variation in the national S&T capabilities among these nations. India, for example, is quite well endowed in terms of R&D institutions and the numbers and the calibre and skills of its S&T manpower at practically all levels and for all stages of the innovation chain from research, design and development, to production etc. besides management and other professional support functions needed in a complex social organisation, as also a high-level of infrastructural facilities, particularly, specialised libraries, data bases and computational power. The problem of technical manpower, particularly at higher professional levels, is acute in other countries.

India, besides a well developed R&D infrastructure, has also a well diversified industrial base including very dynamic small and medium industry sectors. The indigenous capabilities for adaptation and assimilation of sophisticated technologies are highly developed, but capabilities for innovative technology generation have been rather limited. In Sri Lanka the public sector employs over 90 per cent of the economically active scientists and engineers and accounts for 93 per cent of R&D expenditure. Though it has a reasonably developed R&D infrastructure and industrial base, the national capabilities for technology generation remain low, perhaps because of the sub-optimal size of efforts. Industrial/technological capabilities in both Nepal and Bangladesh are relatively poor.

Whilst there are competing demands on scarce national resource, it is needless to say that no country can afford to ignore the building up of endogenous capabilities for the management of technology and locale specific R&D. Indeed, realising this, some of the countries in the report seek to raise the resources for R&D to 2 per cent of GDP by the turn of the century.

Technology choice and acquisition

The question of technology choice in these countries has, by and large, not gone beyond the expression of identification at the government level of areas of priority for national development and for scientific R&D. There have been no institutional mechanisms deliberately directing the choice of technology. However, as the political systems in various countries have been different, there are shades of difference in the technology-choice in different countries.

The approach to technology imports, of course, has differed from country to country.

In Bangladesh, permission for technology import is needed, and such requests are processed through a bureaucratic negotiating mechanism which includes representatives of government and financial institutions along with the technology supplier and importer.

In India, till 1991 when the new-economic policy (NEP) was announced, requests for import of technology were critically examined, besides the legal and financial angles, from the technology point of view to ensure that comparable technology was not available from indigenous technology generators. Under the NEP, the necessity for seeking permission for technology import has been abolished except in a few areas in a small 'negative' list, concerned with national security, environment and social considerations.

In Indonesia, the Investment Coordination Board issues every three years, an Investment Priority List specifying the areas open to domestic, foreign and small enterprises; a negative list is also issued, which does not apply to export oriented projects.

Nepal has depended heavily on technology transfer on turn-key basis under foreign aid programmes which incorporate, in a sense, the technology choice. The country is promoting a more open and market oriented economy where technology choice will be determined increasingly at the firm level.

The Pakistan Industrial Policy of 1989 welcomes import of technology in key identified industries; the National Technology Policy (1993) seeks to 'promote efficient technology transfer through liberalisation of regulations and through the promotion of direct foreign investment. This is in contrast to the earlier situation in which Pakistan, had supported 'heavily protected industry and large public sector'.

Sri Lanka through the Industrial Promotion Act, (December, 1990) opted to simplify rules for foreign investment aiming to attract export oriented industries into industrial promotion zones. Most technologies in the country were quite old and technology and capital inflows were needed to be globally competitive.

Thailand has not sought to regulate inflow of technology though regulation of foreign exchange remittances in technology-related payments existed. The Sixth Plan (1987-91) laid down guidelines/measures for encouraging technology import.

There is, an acute realisation that even transfer of imported technology deserves careful attention so that it is assimilated nationally and leads to augmentation of innovative technology capabilities - import of packaged, turnkey technology does not add to a nation's inherent strengths in S&T or even industry, except in a short time period. For example, Pakistan, Thailand, and Indonesia have welcomed foreign capital and technology, often in packaged, turn-key form which has led to speedier economic growth, yet it has not contributed to the building up of significant indigenous capabilities for technology generation and innovation.

Strategies for industrialisation

The winds of liberalisation and globalisation sweeping the world in spheres of economy, trade and industry make it obligatory to devise new policies and institutional mechanisms to enhance the levels of domestic productivity and acquire skills in newer areas of S&T. By now we have at our disposal sufficient experience of newly developing economies that could suggest certain elements of uniform validity for all developing countries set on the course of technology led industrialisation to make a success of their endeavour, despite the fact that each country has to pay heed to its unique contexts to succeed. This report points to a few of more significant features of wider validity related both to the international level and the national level.

At the international level, it would be advisable to keep in mind the following two realities despite all the lure and promise of globalisation being held out by the new GATT agreement:

(i) Access to foreign technology is both difficult and costly

'Frontier' technology is not easily available for two reasons:(a) As it is a major instrument of competitive advantage, sellers would not like to part with it and create competition; (b) As obsolescence sets in fast, the technology generators seek to maximise returns from it by using it themselves, or through strategic alliances rather than licensing it to other parties. Even when it is available, it is usually from large MNCs, and the small or medium enterprises from developing countries have neither the means nor the negotiating skills to acquire technology on satisfactory terms.

However, it is important to note that both the range and sources of technology have increased giving a wider choice. Also, a slightly outdated technology is more likely to be available.

(ii) Greater market protectionism in developed countries

Recent instances would suggest that there are subtle and not so-subtle ways which developed countries can use to protect their own markets. Developing countries may not be well equipped to cope with these pressures and strategies.

These considerations at the level of global competition point, on the one hand, to the inescapable need and urgency to build up all round national S&T capabilities, particularly with regard to (a) adequate manpower at various levels and for various functions, (b) innovative R&D (c) commercialisation of indigenous R&D output, and (d) assessment and negotiating capabilities for technology import, as well as on the other, to seek strategic sub-regional/regional alliances which will optimise returns from limited resources through synergy of strengths and factor advantages.

The compulsions to look beyond national frontiers for forging strategic alliances arise from several factors: first, for several nations, the financial and human resources for development of adequate R&D infrastructure are often inadequate; second, for relatively smaller developing nations, the cost of independently pursuing R&D programmes, including the risk, may be too high;

third, market-size in individual countries may often be too small to yield adequate returns in R&D investment (in view of high R&D costs and short product life cycles).

Fortunately, the countries of the Asian region, including the ones not studied here, have significant complementary strengths in resources, infrastructural facilities, knowledge and skills in R&D, production, quality control, technology transfer, design engineering and management, markets information sources and above all development experience.

The role of the government

Governments have to play a critical role, even in a liberalised regime, in at least four areas to assist the national S&T and industrial communities to realise the competitive edge in keeping with a country's unique socio-economic factor endowments and characteristics. These are:

(a) Macro-economic policies to provide general economic stability (equitable growth) and political maturity;

(b) Developing of physical infrastructure, human resources and inter-systemic linkages;

(c) Selective intervention (advice, guidance) to maximise returns from a nation's investment and efforts;

(d) Forging, or creating a helping environment to forge, strategic international - possibly regional - alliances at government enterprise levels to capitalise on complementary strengths and emerging opportunities.

It is heartening that the governments of the countries, discussed in this report, are alive to these issues and are in varying degrees attempting to set up mechanisms/instruments to secure these objectives as suited to their national contexts.

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Bangladesh

Status and trends of economic and industrial development

Bangladesh is situated in the southern part of Asia and has a land area of around 1,44,000 sq.km. and has a sub-tropical monsoon climate. The estimated population of the country is around 120 million and the density of population is around 728 persons/sq.km.

Bangladesh has an agriculture based economy with rice, wheat, jute, sugar cane, tobacco, oilseeds, pulses and potatoes as the principal crops. Forest area is about 10 per cent of the total land area. Mineral deposits are practically non-existent but Bangladesh is blessed with some deposits of natural gas; proven gas reserves in 13 gas fields are estimated to be around 400 billion cu.m.

The objectives of the country's Fourth Five Year Plan (July 1990-June 1995) are to accelerate economic growth, alleviate poverty, achieve self-reliance and solve unemployment problem through human resource development. To achieve these targets, the plan envisages bringing women into the mainstream of development and improving management efficiency in both the private and public sectors.

The size of the Fourth Plan has been kept at Tk 689 billion out of which Tk 419 billion would be deployed in the public sector. The plan also envisages that 26 per cent of public sector investment and 83 per cent of private sector investment coming from domestic resources. This means 48 per cent of the overall investment would be funded domestically while the rest 52 per cent is to be raised through foreign assistance. The annual growth rate has been set at 5 per cent compared to the Third Plan's target of 5.4 per cent and actual achievement of 3.8 per cent. The annual average growth target for agriculture has been kept at 3.6 per cent, while it is 9.1 per cent for industry, 8.8 per cent for construction, and 5.4 per cent for transport and communication. The domestic savings as a percentage of GDP have been estimated to grow from 3.8 per cent in 1990 to 7.1per cent in 1995. Similarly, domestic investment and tax receipts have also been projected to grow from 13.15 per cent to 17.64 per cent and 8.27 per cent to 9.97 per cent respectively of GDP.

At present major industries comprise jute goods, paper and newsprint, textile yarn, fabrics, steel, cement, fertiliser, sugar, T.V., diesel engines and bicycles. The country's major imports are consumer goods, food, petroleum and capital goods while major exports are agricultural products. In 1991, the balance of trade was a deficit of US $ 1733. Its major trading partners are the countries in ESCAP and ASEAN regions.

S&T policy framework

A National Council of Science & Technology (NCST) was set up in August 1975 and this body could be considered the focal point for technology related decision making in the country. The Council discharges its responsibilities through an Executive Committee and the Division of Science and Technology under the Ministry of Education acts as the secretariat of NCST.

NCST is the highest decision making body with respect to S&T matters. The Chairman and Vice-Chairman of NCST are the President and Vice-President of the Republic and other members comprise Ministers, Members of Parliament, Secretaries to Ministries, VCs of Universities and Chief Executives of R&D organisations. The main terms of reference of NCST are to : (a) recommend national policies on Science and Technology; (b) recommend priorities for specific research programmes, evaluate the quality and effectiveness of research programmes undertaken by the various agencies and the extent to which results are put to actual use; (c) suggest measures for coordination of scientific research and development activities; and (d) recommend approval of research plans and programmes.

An Executive Committee of NCST (ECNCST) headed by the Vice-President of the Republic is charged with the implementation of the policies and programmes of NCST. As a part of the implementation of the National Science and Technology Policy, the ECNCST constituted a committee named "Consultative Committee on Transfer of Technology" with the Minister for Education, Science and Technology as its Chairman. The Consultative Committee recommends the action programmes and the institutional arrangements for implementation of the action programmes which are approved by the ECNCST.

Though the role of technology in the development efforts was formally recognised after 1971 implicitly, yet explicit role of technology was not given its recognition in the laws of the country. In the year 1980, a first attempt was made to formulate a state policy for Science & Technology which dealt with broad objectives and declarations of intentions. However, the draft S&T policy could not be adopted due to undue emphasis on organisational matters and other inherent difficulties. In January 1985, the Science and Technology Division of the Ministry of Education circulated another draft National Science & Technology Policy Document which was subsequently approved by the NCST in early 1986.The S&T policy recognised the need to integrate scientific and technological considerations with the overall development strategy of the country. The primary aims of the S&T policy are (a) to attain scientific and technological competence and self-reliance to help increase production and employment in various sectors and sub-sectors of the economy; (b) to be in consonance with socio-economic, cultural, educational, agricultural and industrial policies of the nation; (c) to contribute to the worldwide pool of scientific and technological knowledge; (d) to strengthen cooperation in science and technology between developed and developing countries, and particularly among developing countries themselves; (e) to provide guidelines for institutional arrangements in the R&D structure (including education and training) so as to attain the above objectives.

Although the country has got its S&T policy, it is yet to get the seal of approval from legislative,statutory or legal aspects specifically for dealing with S&T developments.

Three points in the Action Programme of NCST are worth noting; they are: (i) utilisation of appropriate technology at all levels involved in the development activities of the country, (ii) devising legal, fiscal and financial instruments to ensure diffusion and application of technologies, and (iii) taking up programmes for need-oriented training and research to facilitate development of local technologies and adaptation of imported technologies.

A few institutional mechanisms to implement the Action Programme of NCST were envisaged, namely: (a) committees for assessment of technological needs and capabilities of different sectors of national economy under the leadership of Secretaries to relevant ministries; (b) a "Technology Assessment Committee" in each relevant ministry under the leadership of its Secretary for standardisation of technologies, both indigenous and imported, and accordingly, for their evaluation and selection; (c) a 'Technology Support Policy Review Committee' under the leadership of the Secretary, Science and

Technology Division for reviewing different policies (e.g. Industrial Policy, Import Policy, Tariff Policy etc.) concerned with diffusion and application of technology; (d) a permanent "Technology Coordination Cell" in the Science and Technology Division for assisting various ministries in the formulation and implementation of technology plans; (e) a "Technology Evaluation Unit" in the Planning Commission for evaluation of technological aspects of different projects according to the guidelines of technology plans.

National S&T capability and the status of industrial R&D

At the time of partition of India, present Bangladesh inherited only one research institute i.e. the Agriculture Research Institute specialising in rice research, and one university at Dhaka which had well established science departments. After 1947, the erstwhile Pakistan government set up a Regional Laboratory in Dhaka under the Pakistan Council of Scientific & Industrial Research (PCSIR). Later on, a local centre of the Pakistan Atomic Energy Centre was also established in Dhaka which concentrated mainly on research in Theoretical Physics. During this period two other institutions were established, namely: Central Jute Research Institute for genetic improvement of jute plants and to find better commercial use of jute and the Hydraulic Research Institute for utilisation of water resources. However, it may be mentioned that the then government of Pakistan did not have any explicit Science & Technology policy.

Realising that the S&T and R&D activities could play a vital role in improving the socio-economic conditions of the country, the government of Bangladesh took effective steps to establish a number of research laboratories and allied institutions in the post-1971 era. Today, there are 62 research institutions including six universities which undertake R&D in natural sciences, agricultural sciences, medical sciences, social sciences, engineering & technology and information sciences.

The Bangladesh Council of Scientific & Industrial Research (BCSIR) has functional autonomy and has six laboratories working in the areas of food processing, nutrition, energy, biotechnology, herbal medicine, pharmacology, chemicals, ceramics, leather, polymers etc.

A survey conducted by the Bangladesh National Scientific and Technical Documentation Centre (BANSDOC) in 1990 reveals that the total R&D expenditure in 1988-89 was Tk 296 million (revenue and developmental) which was 0.26 per cent of the national revenue and developmental expenditure. The President of Bangladesh had then announced that this percentage would be increased to 1.1 per cent by 1993-94. The total stock of scientific, technical and non-technical manpower engaged in R&D, reported in the survey was of the order of 18,000 out of which around 10,000 were technically qualified. BANSDOC felt that the overall ratio of 5:4 between the technical and the non-technical manpower was reasonable considering the population, unemployment and literacy in the country.

Among the technically qualified personnel, scientists: engineers: technicians were in the proportion 6:1:5 which indicated that more engineers were needed to be engaged in R&D to steer the R&D towards technology innovation and research utilisation. There was also a glaring disparity in the ratio of male to female workers in R&D. The women employees in R&D including universities constituted only 10 per cent of the total workforce and within that the number of women engineers was insignificant.

Technology transfer mechanism

There is no centralised agency in Bangladesh for technology transfer or any suitable mechanism for this purpose. These activities are initiated and implemented in a fragmentary manner by different departments and agencies. The Division of Science & Technology or NCST does not have any operational responsibility for such activities. The advisory nature of these bodies has not been reinforced by any legal instruments or administrative regulations for technology transfer.

Financial incentives and innovative mechanisms for commercialisation of R&D results

As mentioned earlier, there is no fiscal incentive or legal framework of support for indigenous development of technologies or to use them commercially, except perhaps in the agriculture sector. There is no effective demand on indigenously developed technologies, neither is there any organised effort to create such a demand. However, a few private sector industrial units have taken some initiatives in this regard through reverse engineering.

Expertise in carrying out techno-economic studies exist among private consultants and in public corporations, presumably limited to investigations of foreign sponsored or foreign aided projects. The appraisal reports prepared by expatriate consultants are also being evaluated locally. The research projects undertaken in R&D units of the country are not subjected to any formal techno-economic evaluation.

Expertise for marketing of research results and its formal mechanism have not yet been developed, in areas other than agriculture. Efforts in commercialisation and diffusion of indigenously developed agricultural technologies have by far been most successful. Nearly 40 per cent of the total rice production is obtained from cultivation of varieties of rice released by the Bangladesh Rice Research Institute. Moreover, the diffusion activities of the Bangladesh Agriculture Research Institute and the Department of Extension and Management have been instrumental in making successful the introduction of wheat cultivation in the country.

Though there is no formal mechanism for technology transfer in the industrial technology sector, the statistics published in one of the studies carried out by BANSDOC in 1990 show impressive performance of the R&D units in terms of their utilisation of R&D results. Out of 300 patents and processes developed by R&D organisations including the universities, 149 were licensed to industry and 38 were in production, an impressive achievement by any standard.

Technology choice - National priorities and concerns

As far as technology acquisition from abroad is concerned, Bangladesh welcomes inflow of foreign capital and technology to accelerate the rate of industrial growth. No government approval is required for any foreign investment except in five sectors of industry. Certain fiscal incentives for domestic investment in industries were provided, like concessional import duty, special fuel subsidy depending on the location of the project, tax holiday, accelerated depreciation and investment allowance.

But in a study conducted in the mid 80s, it was found that inspite of concessions and incentives, the response from the foreign investors weakened instead of getting strengthened. The study also showed that investment from developing countries like Thailand, India, Singapore etc. concentrated relatively on labour intensive industries like food processing and textiles. Investors from developed countries concentrated on capital intensive industries like chemicals, metals, electrical goods etc. There seem to be no specific regulations or restrictions to encourage and ensure meaningful technology imports and continuity for technology development initiatives so as to enhance domestic capabilities for reduction of dependency on foreign source of technologies. Bangladesh does not have either the tax-structure or differential tariff rate as instruments for encouraging and promoting technology development and its use from indigenous sources. There is also no fiscal incentive even for R&D investment which is considered to be crucial for technology development and transfer. However the S&T policy indicates ten thrust areas where special efforts are to be made for research and development viz. (a) development of high yielding varieties of pulses, edible oil, sugar cane, jute, cotton, etc. (b) averting recurring floods, and soil-water management, (c) new methods in the provision of health facilities and family planning programme, (d) attain self-reliance in the execution of conventional commercial projects (e.g., power generation, transmission and distribution, development of gas fields etc.); development of renewable sources of energy and of small plants to meet rural energy needs, (e) enhancing design and development capabilities, (f) improving the technologies for small scale and traditional cottage industries, to support agricultural development as well as for processing agricultural products, (g) improvement in quality, economy in construction of roads and railways, (h) development of information transmission media like telephone, telegraph, radio, TV, etc., (i) improvements for realising low cost housing by maximising use of local materials, (j) promoting interaction and coordination among educational institutions, R&D organisations and industries in order to encourage industrial exploitation of research results.

Among the thrust areas identified, specific objectives have been outlined as: (i) increase in electricity generation including the use of nuclear power, (ii) production and processing of raw jute, tea, leather and rubber, (iii) manufacture of engines for automobiles, power pumps and power tillers, (iv) production of different grades of steel and alloys, (v) development of electronic industries, (vi) establishment of petrochemical complex based on natural gas, (vii) emphasis on oceanography, meteorology, hydrography and marine-oriented other physical sciences, (viii) exploration and preservation of indigenous plant wealth through germplasm collections, herbaria and establishing nature reserves (biosphere reserves), and (ix) application of biotechnology (including genetic engineering) in health science and agriculture.

Institutional mechanisms for technology assessment and acquisition

Imported technology has mostly been in a packaged form under turn-key contracts. Permission for technology import is processed through a bureaucratic negotiating mechanism involving government departments such as Planning Commission, External Resources Division of the Planning Ministry, donor agencies, the recipient or local agents of TNCs, foreign experts stationed locally, local investment banks and public sector corporations (95 per cent of capital assets were nationalised by the government after independence in 1971). The public sector enterprises have local experts of long standing for assisting in evaluation of technology proposals. But on the whole, institutional mechanisms to assess, adapt and absorb technology are practically non-existent or are still in a rudimentary stage. Thus, in practical terms, in most cases transfer of technology has constituted merely transfer of hardware and services for installation and commissioning of the plant. Moreover, factors external to the formal government decision making mechanisms play a significant role in technology acquisition since Bangladesh depends heavily on foreign assistance in all the sectors of economic activity.

Status of technology assimilation and adaptation

As pointed out in the previous section, due to the absence of a well defined mechanism for technology acquisition from abroad, there is no systematic approach for technology assimilation and adaptation in the country. The indentor or importer of technology, who makes the choice of technology, is in a position to influence both the funding agency and the concerned government agency, with the result that the in-house technology assessment is not carried out on a broader perception of cross-sectoral implications.On the other hand, the funding agencies have their own objectives, formalities and procedures to fund the developmental project. Often they impose technologies which are not exactly suitable to meet technological goals and expectations of the recipient. Moreover, the inclination or the compulsion of the importer to bring in from abroad even the raw materials, intermediates etc. along with the technology package do not leave much scope for adaptation and assimilation of technologies imported. It may be noted that the Industrial Policy (1991), indicated setting up of an Advisory Committee with representatives from different regulatory bodies and industrial technology users to recommend the type of technology to be imported till a National Centre for Technology Development and Transfer was established. Till the end of 1992, this Centre was yet to come up.

The adaptation of technologies imported from abroad have not been impressive as yet. Even the garment and food sectors which are primarily labour intensive and are based on low-level technology, have to depend nearly 80 per cent on imported technology and capital goods. However, the situation seems to be a little better in chemical industries, which have made some technological adaptations.

Technology upgradation in SSI sector

Bangladesh has placed emphasis on the development of small and cottage industries since the Third Five Year Plan. It was duly recognised that technological improvement of small and cottage industries was essential for rapid diffusion of new technology, improving productivity and enhancing the level of industrial development. But concerted efforts to upgrade technology in the SSI sector barring in the agricultural sector, have yet to be mounted.

Strategies to promote industrial growth

It is evident that Bangladesh plans to take recourse to a technology based development strategy, however, except in the case of agriculture, there has not yet been any explicit reliance on technology development, and investment plans do not have a built-in mechanism for progressive development of technological capability.

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India

Status and trends of economic and industrial development

Economy : India is a country of sub-continental size with a land mass of 3.29 million sq.km. and a population set to reach the 900 million mark by 1995. India is the fifth largest economy in the world on a purchasing power parity basis. It has made substantial and steady economic, industrial and technological progress but on a per capita basis the economic progress has been modest due to the large population and the high rate of population growth of 2.2 per cent which along with inflation has devoured much of the real progress. It had a GDP of Rs. 6.3 trillion in 1992-93 of which around 75 per cent was contributed by the private sector. The compound growth rate of GDP was 3.4 per cent in the 1970s and 5.4 per cent in the 1980s; but it slowed down in the first four years of the 1990s. However, the GDP is poised to grow at 5 - 6 per cent in 1994-95.

Over the years the structure of India's GDP has changed noticeably. The share of agriculture and allied activities declined - from 55 per cent in 1950 to 45 per cent in 1970-71 and further to around 33 per cent in 1990; the share of services has grown from 32 per cent in 1970-71 to 38 per cent, and the share of industry and mining has risen from 10 per cent in 1950-51 to 27 per cent; the small and medium industries have contributed significantly to the change in the industrial sector. The gross value added in the industry, electricity and mining sector is in excess of Rs. 1.4 trillion.

Investment as proportion of GDP was 17 to 19 per cent during 1960-73, and since then it has been over 20 per cent with a peak of 26 per cent in 1985 and presently it is about 24 per cent. There has been decisive progress in overcoming inflation with the rate of inflation declining from 17 per cent in 1991 to under 9 per cent in 1993 and is being maintained at a level thereabout.

India has consistently had a negative balance of trade which was around Rs.55 billion in the early eighties increasing to around Rs.75 billion in the later half of the decade. The situation has improved as in 1993-94 exports were US $ 22.2 billion and imports US $ 23.2 billion; exports grew by 20 per cent while imports grew at only 6 per cent. Manufactured products now form 75 per cent of exports up from 55 per cent in 1980-81; the major Indian exports have been gems and jewellery, engineering goods, leather, textiles and readymade garments, tea etc. The imports have basically been petroleum oil and products, machinery and equipment, raw materials for jewellery, fertilisers etc. An interesting feature of the exports in 1993-94 was an increase of 38 per cent in agricultural exports (13.4 per cent share) as compared to an increase of only 9 per cent in manufactured exports.

One of the most significant achievements of India on the economic front during the post-independence era has been the attainment of self-reliance in food production. By the mid 1960s, India became grossly deficient in food, which necessitated fairly large imports. India, in fact, stopped imports of food grains in 1978. The transformation of agriculture in India, though as yet confined to selected parts of the country and a few crops, indisputably has been brought about through various policy initiatives and the emphasis placed on the application of science and technology to all facets of this activity. The yield/hectare has increased over the years, doubling over the four decades since independence. The production of food grains increased from 51 million tonnes in 1950-51 to 176.4 million tonnes in 1990-91.

Industrial Development : Indian industry, while practically non-existent at the time of independence in 1947, has grown substantially over the years. Industrial activity now embraces not only sophisticated consumer goods but also heavy, key, basic and all infrastructure industries. The country's dependence on imported equipment and machinery has gone down appreciably. Imports now are primarily of industrial intermediates, equipment and machinery for the technological upgradation of the economy and certain raw materials like basic metals and crude oil and petroleum products in which the indigenous production is not sufficient to meet demand either because of inadequate domestic resources or due to limited domestic requirements. Several machine-building industries are currently catering even to the demands of a number of developing countries, reflecting the high quality standards they have attained. India has been assisting other developing nations in such areas as development of infrastructure - transportation, including railways and civil aviation, and power - and in setting up industries such as paper and paperboard, cement, textiles, engineering products, consumer durables as well as non-durables, and so on. The investment in the manufacturing industry alone is estimated to be over Rs.1000 billion and industrial production is of the order of Rs.5000 billion of which the small scale industries contribute around 40 per cent (a small scale unit is defined as one which has less than Rs 6.0 million investment in capital goods; this limit is presently being revised).

Over the 30-year period up to 1980-81 an industrial growth rate of approximately 5.7 per cent per annum was achieved; during the period 1980-85 the average growth was about 5.5 per cent and over the period 1986 to 1990 it was 8 per cent. The growth rate achieved by Indian industry in the 80s was higher than that of industry in the OECD countries as well as several comparable industrialising countries like Argentina, Brazil and Indonesia.

Industrial Policy : The evolution of the Industrial Policy of India can be traced to the following major policy pronouncements: The Industrial (Development & Regulation) Act 1951; The Companies Act, 1956; The Monopolies and Restrictive Trade Practices Act, 1969; The Foreign Exchange Regulation Act, 1973; The Sick Industrial Companies (Special Provisions) Act, 1985; and, The Environment (Protection) Act, 1986.

The Industrial Policy Resolution of 1948 and later reaffirmed in the Industrial Policy Resolution of 1956, enjoined on the State an active role in setting up industrial enterprises on its own in several areas of crucial importance to the national economy and also for supplementing the endeavours of the private sector in certain areas, should gaps in development in these areas arise. The adoption of the goal of ushering in a socialistic pattern of society in the mid-1950s prompted the building up of the public sector to the commanding heights of the economy. The Industrial Development and Regulation Act of 1951 was the instrument to achieve these objectives and over a period of time it gave rise to an elaborate and involved system of industrial licensing - procedures and controls for the establishment of industry, its location and expansion. Also sickness in private industry further expanded the public sector's role in industry, with the nationalisation of several engineering units and a large number of units in the textiles sector, including jute manufacture, to keep up production and protect employment of workers. The slow growth in exports and the need to contain the foreign exchange outflow on account of imports as well as to improve the bargaining power of the country necessitated the entry of the State in the field of trade in the form of the State Trading Corporation of India Ltd., and the Minerals and Metals Trading Corporation of India Ltd. The State also entered the insurance area in the mid-1950s to accelerate its growth and the banking sector later in 1960 with a view to catering to the requirements of the weaker sections of society, rationalising the use of bank advances and spreading the banking habit in the semi-urban and rural areas. As a consequence of developments, the public sector in India hitherto operated exclusively, or to a dominant extent, not only in the basic, key, heavy and core industries, railways, civil aviation and communications, insurance and banking, but also had a very significant presence in several consumer goods industries, service-oriented areas, external trade, and even to some extent in agriculture. In the latter, both the public and the private sectors co-exist.

The 90s witnessed the government initiate a process of liberalisation, privatisation and deregulation, in a series of far-reaching and radical changes heralding a new industrial policy, a new trade policy, and reforms in the financial sector etc. The new industrial policy is reflective of greater reliance on the market, a bold attempt at deregulation, a desire to integrate with the world economy and to modernise Indian industry. It has abolished industrial licensing for all projects except for 15 specific groups, and allowed private investment in several areas so far reserved for the public sector. The permissible foreign equity limit was raised from the then ceiling of 40 per cent to 51 per cent in high priority industries and automatic approval is available to foreign technology agreements as well as foreign equity participation up to 51 per cent. However, foreign equity above 51 per cent is also permitted in special cases which are considered by a special Board (Foreign Investment Promotion Board set up in 1992). The government also scrapped the assets limit in respect of MRTP companies and the 'convertibility' clause which enabled government financial institutions to convert loans into equity. Import of capital goods was made automatic provided the foreign exchange requirement for such import was ensured through foreign equity. The policy also envisaged disinvestment of government equity in public sector units in favour of mutual funds, financial institutions, general public and workers and this has been selectively done in a few units to a very limited extent. Government is also encouraging private sector involvement and participation in the infrastructure sector, e.g., roads, power, telecommunication, to supplement the efforts being made by the public sector.

Science and technology policy framework

India was amongst the first few countries to have a formal scientific policy. The Scientific Policy Resolution of the Government of India was announced in 1958. It recognised and affirmed the cardinal importance of promoting science on a large scale as it had a major role in the country's development. It stressed that the key to national prosperity was in the effective combination of three factors namely technology, raw materials and capital. The science policy has remained unchanged since then as the expectations from and the role of science enunciated by it are as relevant today as they were then.

The government's technology policy was announced through the Technology Policy Statement (TPS) of 1983. The basic objectives of the technology policy are the development of indigenous technology and efficient absorption and adaptation of imported technology appropriate to the national priorities and resources. The TPS aimed at achieving major technological breakthroughs in the shortest possible time for the development of appropriate indigenous technologies. This could come only by strengthening the technology base for which emphasis was given to consolidation of the existing scientific base and selective strengthening of thrust areas and newly emerging and frontier areas such as information and materials sciences, electronics and biotechnology. Importance of basic research and trained and skilled manpower at various levels covering a wide range of disciplines was duly stressed. Besides R&D and education, the importance of appropriate institutional, legal and fiscal infrastructure was recognised. Following the new economic, industrial and trade policies announced by the government in 1991 it was felt that some parts of the TPS needed to be modified. Thus in 1993 a draft of a New Technology Policy was prepared and widely circulated for comments and inputs from various agencies and the public. The draft paper aimed at giving a renewed sense of purpose for accelerated development and use of indigenous technology in the context of the Industrial Policy Statement of 1991 keeping in view the need to adhere to international quality systems as well as preserve the environment. However a new Technology Policy is yet to be announced.

Integration of S&T planning with national socio-economic planning is done by the Planning Commission. To assist the various socio-economic ministries to formulate long term S&T programmes and to identify and promote the adoption of appropriate technologies by the concerned sector, Scientific Advisory Committees (SACs) have been set up in various ministries.

Intellectual property rights : India has a well developed system for the protection of intellectual property. There are seven areas of intellectual property, namely, Copyrights, Trademarks, Trade Secrets, Industrial Designs, Integrated Circuits, Geographical Appellations, Patents. India is at par with the international standards with regard to the first six categories. In respect of patents protection, India in view of its commitment to join GATT is poised to change its Patent Act in the following important respects :

(a) To honour product patent for medicines, food products and other products of chemistry;

(b) To include biotechnological products and processes by either modifying the law or by a *sui generis* system;

(c) To extend the term of patent to 20 years; and

(d) To consider importation of the patented product as "working of patent".

National S&T capabilities and status of industrial R&D

Institutional infrastructure : India has a vast S&T infrastructure for human resource development as well as R&D activities aimed towards achieving technological self reliance and enhancing domestic technological capabilities. This includes a chain of around 400 national laboratories and R&D institutions which are under three major scientific agencies : the Council of Scientific & Industrial Research (CSIR), Indian Council of Medical Research (ICMR) and the Indian Council of Agricultural Research (ICAR); additionally there are scientific departments of the government viz. Departments of Atomic Energy, Biotechnology, Ocean Development, Space, Science and Technology, Non-conventional Energy Sources, socio-economic Ministries like Railways, Communication, Power etc. and the Defence Research and Development Organisation etc. Industry has set up over 1200 in-house R&D units and 13 cooperative research institutes; besides there are 500 non-commercial Scientific & Industrial Research Organisations. There are around 200 universities/deemed universities with 7500 affiliated colleges including 300 engineering and technology colleges and five Indian Institutes of Technology (IITs), over 1000 polytechnic institutions, and 3000 technical/industrial arts and crafts schools. Several government organisations and departments have created S&T information systems and networks such as National Information System for Science and Technology (NISSAT), National Informatics Centre (NIC), TIFACLINE set up by Technology Information, Forecasting and Assessment Council (TIFAC), BISNET of Federation of India Chambers of Commerce and Industry, Information Centre on Patents under the Department of Industrial Development and an on-line patents service of the NRDC etc. The Bureau of Indian Standards has been set up to evolve national standards and specifications for a host of items being manufactured in the country for domestic markets and exports.

Established in 1942, CSIR is the apex body for the promotion, guidance and coordination of scientific and industrial R&D. Its R&D activities through 40 laboratories, having excellent S&T infrastructure and facilities, cover most fields of civilian S&T, and a total staff of 25,000 of which 6000 are highly qualified scientists/technologists. CSIR has developed 3000 technologies/processes since its inception and has more than 6000 licensees; 80 per cent of the licensees are SMEs. Some of the best known companies in the world have R&D contracts with or have obtained technology license from CSIR. CSIR, in 1993-94 earned US $ 1 million from technology and R&D contracts. CSIR generates about 30 per cent of its R&D expenses from sources other than the government's budget grant. Besides being a source of technology, CSIR offers the whole range of technological support and services to industry from surveys to testing, certification and quality assurance as well as specialised training including formal degree/post-graduate programmes in certain specialised disciplines e.g. Electro-chemical Engineering, Leather Technology and Food Technology. CSIR also provides comprehensive information services to industry including information/assistance on patents. An illustrative case study of technology development and diffusion for pesticides by CSIR is given as an Annexure.

ICAR, established in 1929, is the apex body to undertake, aid, promote and coordinate education and research in agriculture and animal husbandry. ICAR has 42 Institutes, four National Bureaus, 22 National Research Centres, nine Project Directorates and 71 All India Coordinated Research Projects. ICAR is credited with ushering in the green revolution and achieving self sufficiency in the area of food production.

ICMR, established in 1911, is the apex body to formulate, promote and coordinate biomedical and health research. Intra-mural research is carried out through 21 permanent research institutes/centres and six regional medical centres. Besides ICMR, there are four Central Research Councils dealing with different Indian Systems of medicine and homeopathy.

Of the other R&D establishments, those of Atomic Energy, Defence and Space are primarily oriented to satisfying captive technological needs. They have been very successful in building up an industry-partnership based on skill transfer through a buyer-seller relationship. In recent times the volume and value of high-tech spin-off technologies licensed by them for civilian industry has also increased.

Among the government's economic departments, the Department of Electronics (DOE) has been successful in promoting the development of technologies for civilian and defence requirements in the area of electronics. It has set up the Technology Development Council (TDC), the National Radar Council (NRC), the National Micro-electronics Council (NMC) and the Electronic Materials Development Council (EMDC) to foster technology development programmes. Independent societies like Centre for Development of Advanced Computing (C-DAC) and Society for Applied Microwave Electronics Engineering and Research (SAMEER) undertake R&D in their specific areas. Development of a parallel processor based supercomputer, PARAM, by C-DAC is a major achievement. It has also set up a Centre for Microwave Research (CMR) at Bombay, a Centre for Electromagnetics (EMC) at Madras, five Electronics Research and Development Centres (ERDCs) and a Rural Electronic Technology Centre which develops appropriate electronic products for rural applications.

From a mere 20 at the time of independence, the number of universities has risen to 149 at the end of 1991-92. In addition, there are 34 institutions deemed to be universities. However not all universities and colleges impart science education and still fewer of these are engaged in research in science and technology. The enrollment of students has risen from around 100,000 in 1947-48 to nearly 3 million in 1981-82 and to over 4.6 million in 1991-92. The number of teaching staff in the university system has risen from 13,700 in 1947-48 to 2,70,000 in 1991-92. Out of the 8400 Ph.D. degrees awarded during 1990-91 only around 3000 were in pure sciences.

S&T manpower : The annual out-turn of S&T personnel is placed at 200,000 but all of these do not find gainful employment in S&T and related activities. In 1992, around 300,000 S&T personnel were employed in Research and Development establishments, of which 50 per cent were engineers. The estimated total stock of S&T manpower was around 4 million in 1990. This included :

Engineering graduates - 450,000
Engineering diploma holders - 750,000
Medical graduates - 325,000
Agricultural graduates -175,000
Science post-graduates - 425,000
Science graduates - 1,700,000

Industrial R&D : A scheme for granting recognition to in-house R&D units in industry was initiated in 1973. The number of in-house R&D units recognised has increased steadily from about 100 in 1973 to around 1230 in 1994. Of these, around 135 are in the public sector, 35 in the joint sector, and around 1060 in the private sector. There are 300 in-house R&D units set up by small scale industrial units and 315 by companies having foreign equity participation. Their aggregate expenditure is around Rs.13.6 billion/year.

The government has helped industry to set up cooperative research associations in selected sectors such as textiles, cement, automotives, electricals, plywood, jute, tea and rubber. These cooperative research associations are financed jointly by the government and the concerned industry. The R&D expenditure incurred by these associations is of the order of Rs.200 million. There has been a steady increase in R&D manpower employed by in-house R&D units over the years. It is estimated that of the 50,000 R&D personnel employed in the in-house R&D units, 2,600 are Ph.Ds., 8,400 post graduates, 17,000 graduates and 22,000 other qualified personnel.

R&D expenditure : The national expenditure on R&D and related science and technology activities increased from Rs.43.5 billion in 1990-91 to Rs.56.1 billion in 1992-93 and is estimated to be of the order of Rs.62.4 billion in 1993-94. The R&D expenditure was Rs.39.7 billion in 1990-91 and Rs.51.4 billion in 1992-93. R&D expenditure as a percentage of GNP has marginally declined to 0.83 per cent in 1992-93 from a level of 0.85 per cent in 1990-91. Although the compound annual rate of growth of R&D expenditures at current prices for the period 1990-91 to 1992-93 was over 13 per cent but at constant prices for the same period it was a mere 1.5 per cent. It may be of interest to highlight the point that for the period 1988-89 to 1992-93 the annual compound rate of growth of GNP at current prices was 15.3 per cent whereas for the same period the rate of growth of R&D expenditure at current prices was only 11.3 per cent, thus showing that GNP was growing faster than R&D expenditure. Out of the total R&D expenditure for the year 1992-93, the share of the central government including the public sector industry was 76 per cent and the share of the private sector was 15 per cent; the rest, 9 per cent, was incurred by the state governments. Major government scientific agencies accounted for a 72 per cent share of the total central government R&D expenditure and 54 per cent of the national R&D expenditure. The share of the industrial sector considered as a whole, comprising both public and private sectors, in the total national R&D expenditure was 24 per cent in 1990-91 and 26 per cent in 1992-93.

Expenditure on industrial R&D increased from Rs.9.6 billion in 1990-91 to Rs.13.6 billion in 1993-94 which works out to around 0.7 per cent of industry's turnover. There are around 150 in-house R&D units incurring an annual R&D expenditure of over Rs.10 million per year; of these around 40 are in the public and joint sectors and 110 in the private sector. The R&D expenditure of the 300 small scale units is estimated to be around Rs.400 million only.

Technology transfer mechanisms

International S&T collaboration : India has always believed in sharing technical knowledge and expertise with other countries in the process of technological advancement. Accordingly, international S&T agreements have been made with over 40 developed and developing countries besides an S&T programme of regional and multilateral nature. These include S&T programmes with USA, CIS countries, France, Germany, Japan, Israel and the European Economic Community from the industrialised countries and with China, Mauritius, Mongolia, Sri Lanka and Vietnam amongst developing countries. An Indo-French Centre for the Promotion of Advanced Research is functioning as a mechanism for S&T cooperation with France. An integrated long-term programme of cooperation in S&T with Russia continues to be an important instrument of cooperation. Newer arrangements have been worked out with some of the East European and CIS countries.

India has received sizeable support and cooperation for domestic technological advancements from the United Nations and other international bodies. Assistance received by India under the United Nations Development Programme (UNDP) was intended to bridge the gap in technology "know-how" and build-up modern talent in essential sectors. India's Country Programme is the second largest in the world, closely behind that of China. It is not only a beneficiary of UNDP assistance but also makes substantial contribution to its resources; India's contribution for the year 1993 was Rs.130 million. Programmes with other international agencies and specific countries include the Commonwealth Fund for Technical Cooperation, Colombo Plan, PL 480 Title - III Programme.

Assistance comes from the Ford Foundation, British Development Assistance and the European Economic Community. The UN-ESCAP has set up the Asian and Pacific Centre for Transfer of Technology in India for enhancing technology transfer in the Asian and Pacific region, for which host facilities are provided by India.

Foreign technology sourcing : With regard to firm level access to foreign technology, there is, however, no specific institutional mechanism for it. The units themselves have been responsible to choose the technology they needed and negotiate the terms of the deal to import technology subject to the government regulations prevailing in this regard at the concerned time. It is to be noted that even within a watchful regulatory framework, there has been considerable import of technology into India.

Domestic technology transfer : At a rough estimate, 50 per cent of annual industrial production is contributed by domestic effort. Formal import of technology has by and large been by the so-called 'organised sector' of industry, while the small scale sector, which contributes around 40 per cent of industrial production has hardly availed of direct import of technology. No doubt, some technology embodied inputs such as imported capital goods (e.g. for plastic processing, electronic components manufacture etc.), horizontal diffusion of imported technology through manpower movement (e.g. pesticide formulations, machine tools etc.) may have contributed to the technology acquired and used by this sector, yet over 90 per cent of its output is due to direct domestic effort. It is estimated that formal indigenous technology transfer has at best contributed around 10 per cent of industrial production, the rest of it is due to technology acquired through non-formal means or that developed in-house by industry. Thus, there are very few indigenous sources of independent technology for industry, these are national R&D establishments, technological institutions like IITs, IISc etc. and consultancy and engineering organisations.

For commercialising indigenous technologies mostly from publicly funded R&D organisations, a National Research Development Corporation (NRDC) was set up as early as in 1953. Its other major objectives are export of technologies and promotion of venture capital for development of indigenous technologies. It is also responsible for creating suitable infrastructure for training young entrepreneurs in utilisation of indigenous technologies. It is of interest that the International Development Research Centre (IDRC),the Crown Corporation of the Canadian Government, has sought NRDC's help for commercialising the technologies developed by IDRC's funding in R&D laboratories and universities worldwide.

Besides NRDC, many state governments have established specific agencies for development, including commercialisation and marketing, of indigenous technologies, like Industrial & Technical Consultancy Organisation of Tamil Nadu, ITCOT and APITCO of Andhra Pradesh and recently, IIT, Delhi has floated a foundation for commercialising technologies developed by IITs. There are other engineering consultants, in the private sector, that offer on a turn-key or disaggregated basis, technology in specific sectors or niche products.

Technology export : There has been significant export of technology from India, through the following mechanisms :

(a) *Project exports :* have been particularly for civil construction and infrastructure development e.g. power generation and supply, water supply and sewage disposal, rail transportation and telecommunications. Also based on the strength of competitive technologies several projects for the production of intermediate products (chemicals, rayon, machine tools) have been established in the Middle East and Africa.

(b) *Consultancy exports :* have been in agro-based industries, electronics, engineering and process industry and as back up to prime consultants.

(c) *Joint ventures :* Indian industrialists have set up around 300 venture companies in Asia and Africa of which three-fourths are in the manufacturing sector specially in light engineering, drugs, chemicals, sugar, cement and textiles.

(d) *Licensing of technology :* several technologies from CSIR, NRDC, ANTRIX and some private sector companies have been licensed to foreign clients. These technologies were developed up to commercial scale involving industry and engineering partners according to need.

It may be interesting to note that in 1990 India's payments on account of patents, trademarks, technology, technicians and professionals were around Rs. 22 billion as against which receipts to India on similar account were only Rs.12 billion thus indicating that India was a net importer of science and technology.

Consultancy and marketing assistance to SMEs

The consultancy movement is now well established in the country. There are close to one thousand consultancy firms and a large number of individual consultants offering a wide range of consultancy services in various areas of engineering and management. A Consultancy Development Centre (CDC), registered as a non-profit society, functions under the aegis of the Department of Scientific and Industrial Research. CDC receives active cooperation from the professional associations of Consulting Engineers and the Federation of Indian Export Organisations. Many states have set up State Technical Consultancy Organisations to promote consultancy in industrial and technological development as a valuable aid to entrepreneurs. Besides these, the extensive network of R&D laboratories and academic institutions of higher learning provides consultancy services. In general, the consultants are very competent and experienced.

To provide marketing assistance to products of the SME sector, market promotion is being done through cooperatives and professional marketing agencies and consortia, backed up by support measures and incentives as considered necessary. The National Small Industries Corporation (NSIC) is concentrating on marketing items of mass consumption under a common brand name and is establishing organic links with SSI Development Corporations. Government also encourages exploitation of complementarity among production programmes of small, medium and large industry sectors so that large units support small scale ancillary units for sourcing parts, components and sub-systems from them. Additionally, Small Industries Development Organisations in various States have been recognised as nodal agencies for promotion of exports from small scale units.

Financial incentives and innovative mechanisms for supporting R&D and commercialisation of R&D results

Though there is a considerable way to go in commercialisation of the results of indigenous R&D, the number of technologies generated in Indian R&D laboratories which have been successfully commercialised has steeply increased in the last ten years. For example, in the professional electronics sector of about Rs.60 billion worth of production, an output of about Rs.25 billion in equipment and systems is based on domestic designs, knowhow and engineering. Telecom switching equipment worth Rs. 3 billion was produced in 1992-93 based on technologies developed by C-DOT (Centre for Development of Telematics). In the agro-chemical sector, 80 per cent of the Rs. 6 billion worth of production is based on locally developed technologies and in the pharmaceuticals industry, 70 per cent of the production valued at Rs.75 billion in 1993 was based on domestic technologies.

Government has evolved a number of incentives and support measures to encourage R&D in industry. They have been changing from time to time. The incentives and support measures presently available to the recognised in-house R&D units in industry are:

(a) income tax relief by way of 100 per cent deduction of R&D expenditure from the profits of the company;

(b) accelerated depreciation allowance at a higher rate of 40 per cent instead of the normal 25 per cent for plant and machinery installed for manufacture of goods based on indigenous technology;

(c) exemption from price control for bulk drugs produced based on indigenous technology; international R&D collaborations at the enterprise/institutional level; and

(d) weighted tax deduction at 125 per cent for sponsored research in approved national laboratories.

The government has been levying a 5 per cent cess on payments of royalty on imported technologies under the Research & Development Act, 1986, a small part of which has been used as venture capital for commercialising indigenous technologies. However, to give a boost to indigenously developed technologies to reach the stage of commercial application, the Union Budget for 1994 has provided that this cess would be credited into a new Fund for Technology Development and Applications which has been placed at the disposal of the Dept. of Science & Technology.

Issues concerning technology choice - National priorities and concerns

The National Five Year Developmental Plans spell out national concerns and priorities in detail which are reflected in budget allocation to different socio-economic sectors.

Technology imports and foreign investments : Government policies in regard to building up of domestic technological capabilities conceived a mix of both knowhow and foreign technological assistance. Thus the government's basic policy towards import of technology was earlier aimed at reducing unnecessary dependence on external resources and achieving self reliance through optimum utilisation of indigenous resources. It was however, recognised that it was equally necessary to update production technology continuously to keep pace with the rapid technological advances taking place in the developed countries. The import of technology was therefore selective and was permitted in high technology areas, in export-oriented or import substitution manufacture or for enabling indigenous industry to upgrade its existing technology to attain efficiency and competitive strength. The government had then also laid emphasis on the need to ensure efficient absorption and adaptation of the imported technology through adequate investment in research, engineering and development. Towards this end, the government had carefully regulated the inflow of technologies and financial participation in industrial development for about four decades. Thus in 1969 the government set up the Foreign Investment Board (FIB) to regulate the import of technology with the basic aim of ensuring the involvement of local expertise in the import of technology and channelising the scarce foreign exchange resources into priority sectors. The FIB was assisted technically by a Technical Committee (its successor was the Technical Evaluation Committee, TEC) in DGTD which examined in detail the import of technology with a view to unpackaging it and permitting import of only those components of technology for which local capabilities had not been adequately developed. This has since been abolished.

The government in 1991 has liberalised the Industrial Policy and inter-alia import of technology to give greater freedom to industry to select technologies of their choice and give encouragement to foreign investments and as mentioned elsewhere the import of technology is now automatic without any technical evaluation and assessment. As a consequence, technology imports in a number of areas have increased in the past three years, more so the foreign equity participation.

An analysis of the technology imports and foreign equity participation for the pre-and post-liberalisation periods shows that the foreign collaborations approved were in the range 130 - 520 per year during the period 1961 to 1980. However, from 1981 onwards, there was a steady increase to about 1050 collaborations during 1985; the next three years showed a downward trend with a steep fall during the years 1989 and 1990, which was due to problems of balance of payments. However, following economic liberalisation in 1991, there has been a substantial increase in the number of foreign collaborations, the highest being 1520 during the year 1992 followed by 1476 in 1993. The number of collaborations associated with foreign equity, which had remained within 300 per year up to 1990 increased steeply from 1991 onwards with the highest number attained during 1993 being 760. A country-wise distribution of foreign collaboration approvals shows that during the period 1981-90, USA topped the list with 21 per cent of total FC approvals followed by Germany with 18 per cent, U.K. with 15.3 per cent and Japan with 9.7 per cent. The pattern during the post-liberalisation period has remained practically the same. However, a very important point to be noted is that while collaborations with "other" countries was less than 20 per cent in the pre-liberalisation period, this has increased to nearly 37 per cent during 1993. This increase is mainly accounted for by technology imports from countries such as Netherlands (55), Australia (35), Austria (32), and from newly industrialising countries such as Singapore (45), South Korea (36), Taiwan (19) and also a newly introduced category of non-resident Indian's (83).

The foreign investments approved as a part of the collaborations have risen from a bare Rs.110 million in 1981 to about Rs.5300 million during 1991 and further to nearly Rs.90 billion during 1993. Another interesting feature in the post-liberalisation period is that more and more foreign technicians and consultants are involved in the process of technology transfer. Some of the multinational companies have shown interest in setting up 100 per cent owned R&D companies in the country in selected areas. The number of export oriented companies have also shown an increasing trend. It is further observed that some of the existing companies with foreign equity participation have increased the level of their foreign equity participation.

The Department of Scientific and Industrial Research maintains a National Register of Foreign Collaborations (NRFC) which presents a compilation and analysis of data on foreign collaborations approved. Under the scheme, financial, economic and legal analysis of sets of data on foreign collaborations is taken up and studies on the status of technologies in use in the country as well as international trends and other related issues are carried out.

Institutional mechanisms for technology monitoring and acquisition

The Technology Information, Forecasting & Assessment Council (TIFAC) has been set up as a registered society under the Department of Science and Technology. TIFAC's principal objectives include evaluating the existing state of art of technology and direction of future technological developments in various cross-sectoral areas as well as in other sectors of the economy both in India and abroad and to prepare technology forecasting reports, covering 10 years or longer period, specifically in production areas involving (a) substantial investments of financial resources and (b) a large volume of production as also to prepare Technology Impact Assessments and based on these studies to ensure timely availability of requisite technologies relevant to the needs of the country on futuristic basis and minimising the time gap between the developing of new technologies and their utilisation and establish a purposeful linkage between technology development and technology import policies. TIFAC has brought out over 100, TF, TA studies and Techno-Market Surveys (TMS) in various sectors : Steel, Energy, Biotechnology, Advanced Materials, Chemicals, Human habitats, Agro-based Industries, Water-treatment, Manufacturing, Bio-medical Equipment. These reports have been very well received both nationally and internationally.

TIFAC has established special mechanisms to implement actions foreseen in TF/TA/TMS reports e.g., a Homegrown Technologies Scheme that supports promising indigenous technology development efforts.

Status of technology assimilation and adaptation in different sectors (private, public, MNC)

The level of assimilation and adaptation of technology in Indian industry is high. Large public sector organisations have generally both production and R&D functions which reinforce each other e.g., Bharat Heavy Electricals Ltd. (BHEL), and Bharat Electronics Ltd. (BEL). These organisations have not only assimilated and mastered imported technology but possess innovative capabilities of their own. Similarly some of the large firms in the private sector, like TISCO (Tata Iron & Steel Company), have also given emphasis to R&D and have not only fully assimilated technologies but are significant generators of technology. Large MNC units, e.g. Hindustan Lever Ltd., also fall under this category.

However, generally speaking the R&D intensity (ratio of R&D expenditure and sales' of public sector firms has been significantly higher than in the private sector firms, which is reflected in their innovative capabilities. R&D intensity varies also according to the industry sector, for example, in a survey of 195 firms of which 168 were in the private sector, 20 in the public sector and seven in the joint sector, the R&D intensity of the firms in the electronics sector during 1985-91 was the highest (3.76 per cent) - one third of them spent 5 per cent or more of their sales on R&D, while the electrical sector had an R&D intensity of 1.36 per cent and the others of 0.47 per cent only. An interesting feature highlighted by the same study is that during the period 1985-91, the ratio of R&D and technology import by the studied firms was, contrary to general impression, 3.40, that is, they spent 3.4 times more on R&D than on technology imports. This trend was true for each year, though the ratio increased from 2.9:1 in 1980-81 to 4:1 during 1985-86 and 1987-88.

It is also of interest to note another finding of the same study : absorption of imported technologies and indigenisation of production figured among the major R&D objectives along with development of products and quality improvement. Also a majority of the firms preferred foreign collaboration because they lacked the technological resources to set up manufacturing facilities on their own.

With a view to promoting absorption and adaptation of technology, DSIR has put in place a scheme that supports (a) Technology Absorption and Adaptation, and (b) Indigenous Development of Capital Goods.

Technology upgradation in small scale industry sector

India has a very dynamic and vibrant SSI sector producing over 7000 items, valued at over Rs. 2 trillion; its share in the country's industrial export is over 40 per cent. However, technology in SSI Units is a mixed bag - while some units, particularly in emerging industries have state-of-art technologies, most units generally have obsolete technologies.

A separate office of the Development Commissioner SSI functions in the

Ministry of Industry to coordinate the programmes and policies of the sector. It assists the SSI sector with S&T inputs through 28 Small Industry Service Institutes, 30 Branch Institutes, 37 Extension Centres, four Production Centres, four Regional and 19 Field Testing Stations besides specialised institutes for Hand Tools, Tools, Electrical Measuring Instruments, Foundry & Forge, Sports Goods etc. Presently technology upgradation is an area of major attention for the government.

A reoriented programme of modernisation and technological upgradation to improve productivity, efficiency, product quality and cost effectiveness in SSIs is being vigorously pursued. Specific industries in large concentrations/clusters have been targeted for identification of technology needs; Indian Institutes of Technology and selected Regional Engineering Colleges and other leading engineering colleges are being harnessed to serve as Technology, Information, Design and Development Centres in their respective command areas. Industry Associations are being encouraged and supported to establish quality counselling and common testing facilities and Technology Information Centres. In a recent initiative, NSIC, CSIR and APCTT have joined hands to assist SSIs in technology upgradation and modernisation; as a result SSIs now have access to the technological capabilities and technologies of CSIR and the technological information bank of and technology transfer assistance from APCTT, and the various support schemes of the NSIC for acquisition of machinery and plant and raw materials and finance and marketing etc. Government is in the process of mounting a major initiative on modernising the SSI sector.

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Annexure

Case Study on Development and Diffusion of Pesticides Technology by CSIR, India

Early history

The use of pesticides in India made its small beginning by import of DDT for malaria control and BHC for locust control in 1948. The pesticides use in agriculture began only in 1949. The indigenous pesticide industry was started in 1952 with the setting up of a unit for the production of BHC in the private sector followed by setting up of two units in the public sector by Hindustan Insecticides Limited (HIL) for manufacturing DDT. The use of pesticides in India grew in three phases. The first phase covering the period 1948 to 1965 witnessed the large scale usage of DDT, BHC and a few of chlorinated pesticides. The introduction of DDT revolutionised pest control, both in health and agriculture. The second phase covered the period 1966 to 1975. The green revolution introduced an intensive phase of agriculture based on high yielding crop varieties requiring large usage of pesticides. This was also the period during which environmental problems like soil persistence, bioaccumulation and pest resistance to organochlorinated pesticides surfaced and led to the development of comparatively safer organophosphorus (OP) pesticides in the western world and India also followed suit with the introduction of OP class of pesticides. This resulted in a rapid growth of the Indian pesticide industry. The total installed capacity of the industry which was only 6,600 MT in 1960-61, increased to 41,250 MT in 1971-72.

The present scenario

The third phase was from 1977 onwards. It can be truly described as a period of fast growth for the pesticides industry in India. The period witnessed further growth of sophisticated organophosphorus pesticides and the introduction of synthetic pyrethroids. India has now emerged as the second largest manufacturer of basic pesticides in Asia after Japan. The current installed capacity is around 100,000 TPA and production is around 75,000 TPA. The country has not only become self-sufficient in its requirement for most of the pesticides but also exports pesticides worth around Rs. 2 billion annually.

Technology development

In the early sixties and seventies pesticides production in India was largely by international companies based on their technology. But from the seventies onwards there was a dramatic change in this situation. The government of India in 1971 set up the National Committee on Science & Technology (NCST) to prepare a comprehensive S&T plan for all the vital sectors of industry. The Pesticides Planning Group of NCST in 1973 submitted a status report on the pesticide industry highlighting the technology needs/gaps and areas of indigenous technology development. Subsequently an Inter-ministerial Study Group, set up by the Ministry of Chemicals and Fertilisers which included representatives of industry and R&D institutions further refined upon the report of NCST with regard to requirements of the pesticides and the technology.

In 1975 CSIR took up an integrated programme of technology development for around 40 pesticides, out of about 80 pesticides identified by the inter-ministerial group for accelerated technology development. The strategy adopted was to develop process packages which would enable several products within a group to be manufactured in a single plant with minor additional equipment. Thus, by the end of 1976, process technology for 17 pesticides falling under four broad categories, chlorinated hydrocarbons, organophosphates, carbamates and others were more or less ready. At that time CSIR advertised for and invited entrepreneurs to collaborate with it for commercialising the CSIR developed technology. Over 30 parties responded from which the CSIR selected only four for licensing the knowhow; the main criteria being the past track record, marketing capability and above all that the collaborator had no foreign equity tie-up. CSIR not only provided the process technology but also did the basic engineering and detailed engineering design. CSIR laboratories continuously interacted with the 'pioneering licensees' to help them overcome the initial teething problems. The result of this strategy was that a large number of the technologies developed for many sophisticated pesticides by CSIR, particularly of the organophosphorus group, have been successfully commercialised. Later work was done to develop cleaner technologies for these pesticides which avoided the use of poisonous and hazardous chemicals and process operations. Today there are 25 CSIR licensees producing pesticides valued at over Rs. 1 billion annually. Some of the important pesticides being manufactured with CSIR technologies are : monocrotophos, phosphamidon, quinalphos, diazinon, chlorpyriphos, DDVP, butachlor, dimethoate, ethion, MBC and nicotine sulphate.

New initiatives

In a continuous effort to serve the industry, CSIR has now initiated programmes for development of target specific chemicals and biological methods of pest control that do not have adverse effects on the ecosystem. Thus CSIR has synthesised pheromones, pest sex-attractants, which are non-toxic chemical substances that help to trap the pests at one place. Pheromones have been developed for a range of insects of cotton and sweet potato. Plant-based pesticides are becoming popular as they are more eco-friendly. Also two CSIR laboratories have developed technologies for extraction of azadirachtin from kernels of neem and neem oil which is used as an insect antifeedant for insect control. Development of active molecules derived from plant sources for use as pesticides is also in progress. The focus of future R&D programmes on pesticides is to develop technologies for optically pure, biodegradable and environmentally less toxic and less hazardous agrochemicals for use by Indian farmers for cereals, pulses and cash crops. Recognising the strength of CSIR in pesticides R&D some of the well known agrochemical companies in USA are collaborating with CSIR in its search for new molecules for pesticidal activity. Thus by proper integration of S&T in the sector, India has become self-sufficient in this critical input for its agricultural sector.

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Indonesia

Status and trends of economic and industrial development

Indonesia is the world's biggest archipelago, comprising about 13,700 islands, covering an area of 1,912,04 sq. km. and territorial waters nearly four times that. With an estimated present population of about 190 million, Indonesia is the world's fifth most populous nation. Throughout the eighties the population growth rate has been around 2 per cent. The bulk of the population resides on three islands namely Java, Sumatra and Bali, whose combined land area is only 7 per cent of the total land area of Indonesia.

Indonesia is endowed with rich natural resources such as oil and natural gas, gold, silver, tin, copper and nickel. The agricultural produce, besides foodgrains, includes rubber, palm oil, coffee, tea, cocoa, sugar spices etc. The country has large resources of timber and rattan.

The country has demonstrated dramatic economic growth during the last 10 years. The GDP at current market prices has increased 3.8 times in the last decade and stood at Rp. 227 trillion in the year 1991. Thus, the GDP has grown at an average rate of 7 per cent, after accounting for inflation. The country's GDP performance along with contribution to it by major sectors are presented in Table 1.

With a view to shift the economy base to the manufacturing sector, the government of Indonesia introduced new policy reforms in 1986. As a part of this, the Rupiah was devalued by 31 per cent vis-a-vis the US dollar with a view to pushing up exports of manufactured products; controls were lifted; the economy was opened up. As a direct consequence of these measures the country's economy started looking up. Foreign investment approvals have spurted to US $ 8.8 billion in 1991 and domestic investment approvals have been in excess of US $ 18 billion. Ever since economic liberalisation, the country has been attracting significant amounts as direct foreign investment. For example, during the year 1992, US $ 1.77 billion had come in as direct investment. Similarly, the per capita assistance from bilateral and multilateral sources has increased from US $ 5.9 in 1982 to $ 10.3 in 1991. In absolute terms, it accounts for US $ 1.877 billion for 1991, of which 38.01 per cent is received as grants.

Table 1 : GDP at Current Market Prices (in Billion Rupiahs)

	1982	1988	1989	1990	1991
Total GDP	59,633	142,105	167,185	196,919	227,163
Selected sectors					
Agricultural including	15668	34228	39164	42149	44218
forestry & fishing	(26.2)				(19.4)
Mining & Quarrying	11708	17162	21822	25488	30901
(19.6) (13.6)					
Manufacturing	7681	26252	30323	40030	48336
	(12.8)				(21.3)
GDP per capita (in '000 Rupiahs)	397	818	957	1105	1250

(Figures in brackets indicate percentages)

The impact of the policy reforms has already been felt on the GDP; the GDP per capita has increased from Rp 397,000 in 1982 to Rp 1.25 million in 1992, the share of agriculture sector including forestry and fishing has decreased from 26.2 per cent to 19.4 per cent and Mining & Quarrying from 19.6 per cent to 13.6 per cent and the share of manufacturing sector increased from a low of 12.8 per cent to 21.3 per cent over the same period. The growth of the manufacturing sector is more impressive during the period 1988 to 1991, registering an overall increase of over 85 per cent. A recent World Bank supported study states that the output of large and medium manufacturing establishments in Indonesia increased at an average annual rate of 25 per cent. Over half of the 1990 output of Indonesia's manufacturing took place in three industries : food (24 per cent), textiles (16 per cent) and wood (11 per cent). However the contribution of industries producing products with a high technology content has been small, only about 5 per cent of the total manufacturing output, and has for the most part grown more slowly than that of industries producing products with a medium or low technology content. Thus, manufacturing industries have been steadily increasing their contribution to economic growth and helping the country to shift from a predominantly agriculture based economy to a manufacturing economy. Prominent, among the industries experiencing the most rapid growth rate are motor vehicles (32 per cent), paper (27 per cent), basic metals (27 per cent), food (24 per cent) textiles (21 per cent) and wood (21 per cent).

Historically, Indonesia exported mostly primary materials such as petroleum crude, natural gas, wood etc. In 1992, the exports (f.o.b.) accounted for US $ 33.9 billion whereas imports for the same year were of the order of US $ 27.3 billion. Thus, Indonesia enjoys a favourable trade surplus. Table 2 and Table 3 give details of external trade during the period 1982 to 1992.

As can be seen from Table 3, the exports largely consisted of raw materials such as crude petroleum and natural gas (27 per cent) wood including plywood (13 per cent), rubber (3.3 per cent). After accounting for inflation, the value of Indonesia's manufactured products exports grew at an average annual rate of about 7.5 per cent between 1981 and 1991. The increase has however been even higher since 1985, averaging over 10 per cent in real terms particularly for textiles and wood products. Of Indonesia's manufacturing exports, a very small proportion (about 3 per cent in 1991) are classified as having a relatively high-tech content.

Table 2 : External Trade

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Exports (f.o.b.)	22328	21146	21188	18587	14805	17136	19218	22159	25675	29142	33967
Imports (c.i.f.)	16859	16352	13882	10259	10718	12370	13249	16360	21837	25869	27305
Overall Trade Balance	1853	184	981	510	-1003	630	-113	449	2251	1529	2069

Figures in million US $

Imports consist of a wide variety of items with capital goods accounting for over 11 per cent of the imports in 1992. The value of manufactured goods imports has increased steadily since 1985 at an average annual rate of over 17 per cent before inflation. The increase in imports of manufactured products has been concentrated in products with a relatively high or medium technology content. Thus, in contrast to the country's performance in trade, there has been a substantial trade deficit in manufactured products. Although the country is industrialising rapidly, the contribution of the manufacturing sector to exports is yet to pick up.

The steady GDP growth, accompanied by a high rate of domestic and foreign investment, a stable exchange rate, large per capita income ($500 in 1991) and a rate of inflation that has been maintained at under 10 per cent are all indicators of a sound economy that Indonesia has been able to establish.

S&T policy framework

The Indonesian science and technology is mainly directed to support the growth of national economy based on industrialisation. Thus, the government S&T policy approach, formulated by the National Research Council, stresses the urgent need to prioritise the research areas to optimally utilise the limited resources available for S&T and in doing so encourages crossing the sectoral domains as well as interdepartmental barriers. The S&T policy interalia seeks to : (a) strengthen the national S&T capability in accordance with the needs and priorities of national development; (b) improve the working climate for researchers, to stimulate the development and application of S&T; (c) encourage and support the research institutions in solving problems related to national development; (d) increase the capability of research institutions by improving the quality and quantity of manpower and physical facilities; and (e) encourage application of appropriate technology, including traditional technology.

On the technology front the policy specifically emphasises the role of S&T in the industrial transformation viz : (a) Facilitate understanding of manufacturing processes through import of technologies; (b) Improve and integrate the technologies mastered through design and engineering in order to produce improved and better quality goods and processes; and (c) Develop new technologies to produce goods and processes, yet to be introduced in the markets.

The country does not make any sharp distinction between basic/ pure or applied research; consequently the development of science and technology in Indonesia has been geared through a national matrix, encompassing (i) basic human needs (ii) natural resources and energy (iii) industrialisation (iv) national security and defence and (v) social,economic, cultural, legal and philosophical aspects. All research and development programmes performed by various government agencies and private sector should be identified and accommodated in such a matrix for prioritising and evaluation.

Table 3 : Imports/Exports - Selected Commodities

(Figures in million US$)

	1988	1989	1990	1991	1992
Imports					
Rice	8.6	75.9	14.1	53.1	172.6
Medicines & Pharmaceuticals	102.3	99.9	124.0	122.0	159.7
Iron/Steel Pipes	172.8	262.5	340.7	413.7	611.5
Prime movers	156.1	96.9	108.4	213.9	596.3
Machines & Equipment	900.5	1597.7	2740.8	3605.6	3154.5 (11.5)
Exports					
Rubber	1134.0	1035.1	892.2	981.2	1124.7 (3.3)
Wood & lumber	810.4	1089.2	601.3	789.0	950.3 (2.8)
Plywood	2073.7	2351.9	2725.6	2870.8	3230.2 (9.5)
Petroleum crude	4334.5	5140.4	6219.9	5675.7	5397.7 (15.9)
Petroleum products	954.5	919.9	1183.9	1018.7	1221.2 (3.5)
Natural gas	2413.6	2377.2	3356.6	3831.1	3702.4 (10.9)
Garments	795.8	1169.2	1657.3	2290.1	3188.6 (9.3)
Copper ore	231.1	305.8	374.4	478.5	731.1 (2.1)

(figures in brackets indicate percentage)

Included in the main programme of basic human needs are food and feed, shelter, education, health and clothing. In the main programme of natural resources and energy, areas such as renewable and non-renewable resources are included.

Industrial policy : Every establishment in Indonesia requires a licence to establish its operations. The licences are issued by the Investment Coordinating Board (Badn Koordinasi Penanaman Modal - BKPM), the one window agency for all domestic and foreign investors, and these relate to manufacturing operation, raw material processing, limited domestic purchase, and duty exemption facilities etc., besides expatriate work permits and exploitation and concession rights (applicable to mining). BKPM publishes an Investment Priority list, popularly known as the DSP (Daftar Skala Prioritas) List, which specifies areas open to the domestic, foreign and small enterprises. The list is revised once in three years. It also contains a negative list, which specifies industry sectors closed to further investment. However, the negative list does not apply to export oriented projects which undertake to export a minimum of 65 per cent of their production. To stimulate industrial growth, the Indonesian government has lowered tariffs, and removed non-tariff barriers across a wide range of commodities while at the same time opening a number of business areas previously closed to new investors including foreign firms. The general policy continues to accord high priority to capital goods, intermediate goods, industrial raw materials and resource based industries. Some incentives are provided for setting up new projects in notified industrially backward areas. Licencing policy is also more flexible for projects proposed in these areas. Though the large number of licences required and bureaucratic delays have been major irritants in the past, the number of licences have now been cut drastically through the new policies.

Environmental policies : Though the Indonesian laws pertaining to environmental concerns are stringent by any standards, governmental awareness is fairly high. A separate Ministry of Environment has been set up to address the problems related to the environment. In 1987, a new legislation was enacted, making it mandatory for new industrial enterprises to submit a preliminary environmental impact analysis for any proposed development activity with a potential impact on the surrounding environment. The guidelines formulated by the 'People's Consultative Body' interalia states that "national resources which occur both on land, in the sea or in the air, which may take the form of soil, water, minerals, flora, fauna and their germplasms must be managed and properly utilised while maintaining the perpetuity of the carrying capacity of the environment in order to generate maximum benefits for the welfare of the people at present as well as for the future generations".

Intellectual property protection : Indonesia is a signatory to the International Convention for the Protection of Intellectual Property, the Paris Convention. Accordingly, both products and processes can be patented in Indonesia. In August 1991, the government enacted a comprehensive new legislation providing specifically for the protection of patent rights in Indonesia by establishing a system for filing, processing and granting fully protected patents.

Trademarks are well protected in Indonesia and adequate legal provisions exist for ensuring exclusivity of trademarks. Copyright is available for 25 years in case of publications and 15 years for photographic and cinematic work. There is a Directorate of Patent and Copyright under the Department of Justice which handles all matters related to patents, trademarks and copyrights.

National S&T capabilities and status of industrial R&D

Starting with practically no S&T capabilities and no qualified manpower when the country got independence in 1945, Indonesia has come a long way in building a recognisable S&T base to cater to the diverse needs of the nation. Indeed, the real S&T development started only in 1965 with the government recognising S&T as a means for economic development. The Indonesian Institute of Sciences (LIPI) was created by consolidating various research activities and organisations formerly controlled by the Council of Science. This was followed by other establishments such as BPPT (Agency for Assessment and Application of Technology), PUSPITEK (National Centre for Research, Science and Technology), BATAN (National Atomic Energy Agency), LAPAN (National Institute of Aeronautics and Space) etc. A separate Ministry of Research & Technology was established and entrusted with the overall responsibility to create a Science & Technology base for the country. Among others its main functions are to prepare and plan the government S&T policies and building the national S&T capabilities in tandem with the industrial and economic policies of the country. Besides,the Ministry also coordinates the activities of the non-departmental government Institutions (LPNDS). The ministry is supported by an advisory body - National Research Council - whose members are drawn from academia, industry, R&D establishments and others.

In the first five year plan (1969 - 73) emphasis was placed on short term R&D in agriculture, industry and mining as well as better utilisation of available natural resources; the scope was further enlarged in subsequent plans to include building up of physical facilities for scientific and technological research and also in increasing the number as well as the quality of scientists and research personnel. Thus, with the active support of government, the S&T sector has consolidated its position with successive five year plans.

Broadly, the R&D institutions in Indonesia can be classified into four categories:

Institutions under government departments - there are over 82 such institutions in Indonesia, catering to the needs of the respective functional ministries and carrying out R&D activities within a specified area;

Non-department government institutes (LPNDS) - there are over 30 such institutes engaged in diverse fields of research catering to the manufacturing sector as well as the country's needs at large;

University R&D centres - there are over 58 such centres of excellence in specified research areas;

Private R&D centres - the exact number of such centres is not available. However they work basically on industrial technologies of interest to their companies.

Among these, the non-departmental government institutions are the ones that provide a strong S&T base in almost all spheres of science. Some of these specialised institutions have developed excellent facilities and capabilities over the years. Fox example:

BPPT, a relatively young organisation, plays an important role in national S&T development. In principle, BPPT ensures that government policies and technological developments work in tandem. It employs over 3000 personnel, of which nearly 50 per cent are engaged in research activities; over 100 of them hold a Ph.D. and Master's degree; while the rest are B.Sc. degree holders. Its research areas cover industrial processes, energy conversion and conservation, electronics and informatics, efficient utilisation of available natural resources, aerodynamics, and propulsion systems.

LIPI has 19 research institutes and employs around 5000 personnel, of which

5 per cent are Ph.D. & M.Sc. and around 1000 B.Sc. degree holders. R&D activities cover biology, oceanology, biotechnology, geotechnology, applied physics, applied chemistry, telecommunications, strategic electronics, materials and components, informatics and computer science, electric power and mecatronics and metallurgy. One of its centres namely, Centre for Analysis for Science & Technology Development monitors the country's progress in S&T.

PUSPITEK has been set up on a 850 acre plot in the designated Science City of Indonesia, 15 miles south-west of Jakarta with assistance from France, Italy, The Netherlands, Japan and Germany with the objective of carrying out applied research. It will have eleven large scale laboratories engaged in research activities on subjects ranging from nuclear energy to meteorology. Currently five of these laboratories are operational. One of these laboratories has a 30 megawatt multipurpose nuclear reactor, the third largest neutron producing facility in the world - designed to produce radio-isotopes and undertakes various research projects for medical, pharmaceutical and agricultural applications.

Indonesian researchers publish about 60 research papers each year. These have not been particularly active in the science citation index. The bibliornetric data indicates that indonesian publications are concentrated in clinical medicine and biology. Further disaggregation of these articles into detailed subfields of science reveals that within clinical medicine the largest subclass is tropical medicine. In the biological sciences, Indonesian researchers were relatively active in the agriculture and food sciences and in botany.

The bulk of Indonesian patents were registered to foreign inventors, however, during the 1980s, provisional applications by domestic inventors had begun to increase. Of the provisional applications that were classified according to the International Patent Classification (IPC), over half are in either IPC Class B (Performing Operations, Transportation) or Class C (Chemistry and Metallurgy),covering processes in chemicals and metals industries. The third largest patent class are patents in IPC Class A (Human Necessities) which includes pharmaceuticals.

In 1992-93, several special sectoral R&D surveys were conducted in Indonesia. Based on this information, it is estimated that Rp 500 billion was spent on R&D activities in Indonesia in 1991 or 0.2 percent of the country's gross domestic product. Indonesia's R&D/GDP ratio may be low in relation to those of even newly industrialised countries, but it is not substantially different from those of many developing countries in the early stages of their technological development. The government provided roughly 80 per cent (Rp 400 billion). The industry provided the rest of the nation's R&D expenditure.

In 1991 the government accounted for about 60 per cent (Rp 310 billion) of the nation's estimated R&D expenditure. About one-half of the government's R&D total was spent in government departments; the rest was spent in the Non-Department Government Institutes (LPNDs). The relatively high levels of support to the institutes is an indication of the government commitment to S&T. Public universities accounted for the remaining 5 per cent (Rp 25 billion) of R&D performed in Indonesia in 1991.

In Indonesia, manufacturing industries are in the early stages of development and thus R&D is of low priority. Figures were also not readily available on how many R&D establishments are currently in existence in Industry. There is a traditional small scale sector, which provides significant employment in the manufacturing sector, and a new small scale sector geared to export markets based on imported technologies. Both these sectors are not in a position to carry out R&D. Large enterprises depend mainly on technology acquisition from abroad. Large firms have not developed local suppliers and subcontractors and relied largely on overseas suppliers. Further, there are no incentives for local partners to attempt process change or source the parts/components locally which can stimulate the R&D activities. Small firms on the other hand are handicapped by lack of technical capability and infrastructure, so they cannot become competitive suppliers to large firms. In general small and medium sized firms lack R&D support. About 21 per cent of Indonesia's mid-sized and large firms employ one or more scientists and engineers with an educational level of a post secondary degree - less than a four year university degree. Two thirds of these industries have five or fewer scientists and engineers. In crucially important areas such as food, textiles and wood, which have large export implications, only one out of 200 employees has a scientific or an engineering qualification. There is lack of middle level technical and managerial skills.

The industry accounted for about 35 per cent (Rp 165 billion) of Indonesia's (1991) total R&D; of which the government was the source of about one-half. The major R&D spenders were the fabricated metals industry and the chemicals and petroleum industry, which together conducted over half of Indonesia's total industrial R&D performance.

Technology transfer mechanisms

Indonesia has attracted large scale foreign investment along with technology ever since direct private investment from abroad was permitted. The manufacturing sector is the largest beneficiary of this investment. The other sectors which have been benefited are plantations, mining, trade, transportation and communication. In terms of origin, Japan is the largest investor in Indonesia, followed by USA, Hong Kong and The Netherlands. The role of private industry in developing technologies is negligible. Technology transfer mechanisms are yet to be developed and the technology transfer problems and issues are yet to be understood. There is no organisation in Indonesia which can plan, coordinate and facilitate technology transfer to monitor changing demands. Generally the industry's skills in negotiating the technology transfers appears to be poor. Thus, for the time being technology transfer of imported foreign technology is expected to be the predominant delivery mechanism in Indonesia. Recognising the deficiency, the government is mounting a concerted effort in this critical area to build the necessary capabilities.

However, technology payments, which include royalties and license fees for technology and technology transfer are good indicators to show the direction in which the flow of technology into Indonesia is taking place. According to BKPM, during 1990, Indonesian establishments paid some US $ 11 million in license fees to overseas recipients. Of this amount US $ 10.8 million, was paid out by high and medium technology-intensive manufacturing industries. Over half the payments were made by enterprises in the pharmaceutical industry; most of the rest were by establishments in the basic chemicals industry. Thus a strong domestic industry may be developing in these two sectors, as Indonesia has certain resource endowments, in particular, access to crude and refined petroleum feedstocks.

Another important feature of the foreign investment now taking place in Indonesia, particularly in the manufacturing sector is that it is increasingly directed towards the export markets rather than the domestic market. The level of technology in certain sectors such as textiles, oil and gas is comparable to international standards. In electrical machinery, electronics and communications, due to the nature of the operations - which are purely assembly in character - inputs have come entirely from abroad.

Consultancy and marketing assistance to SMEs

In the field of Engineering and Management Consultancy, there are many international consultancy firms side by side with Indonesian consultancy organisations. The services offered range from market research, feasibility studies and project engineering to project implementation.

A typical good Engineering Consultancy firm in Indonesia maintains a staff of over 50 professional planners, engineers, architects, economic experts and supporting technical personnel. Many of them provide a range of comprehensive services.

Technology assimilation and adaptation

An Indonesian firm's ability to absorb, adapt and build upon the technologies that have been already imported is generally poor. There are no incentives for technology absorption, adaptation and diffusion. Most of the corporations in Indonesia are of a Joint Venture (JV) form and (a) the JV structure is such that decision making, with respect to products and production process, is normally under the control of foreign partners; and (b) the firm's operations are mostly limited to assembly operations based on imported technologies and parts/components which are supplied by the foreign partners. Thus with easy options available for acquisition of proven technologies from foreign sources as well as to import the components, the manufacturing private sector in Indonesia neither has the desire to build R&D capabilities nor place a demand on the local S&T institutions.

But the scenario is likely to change soon. First, Indonesian industries have reached a point where demand for higher level technologies is steadily on the rise; secondly, the acquisition of technologies is likely to become difficult and expensive, forcing the local industries to develop their own R&D capabilities; thirdly, the country's expertise in unpackaging the technology and capabilities in design engineering are growing. Cumulatively these factors would influence the industrial sector in creating their own R&D capabilities. Moreover, with the changing international scenario, Indonesia cannot afford to have the technological needs of the strategic industries perpetually met through foreign sources and sooner or later it will have to catalyse the R&D capabilities within the industrial sector.

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Nepal

Status and trends of economic and industrial development

Although Nepal is a landlocked mountainous kingdom and covers an area of only 147,181 sq.km. yet the topography of the kingdom has variation, leading to diversity of climatic zones. Nepal thus experiences mesothermal, microthermal, taiga, tropical and tundra types of climates. Nepal has a population of 18.5 million (1991) with an annual growth rate of 2.1 per cent. In Nepal, the literacy rate is 40 per cent wherein male and female ratio is 63:37. Nepal remained a closed country till the late forties; modernisation efforts started only after 1951. It continues to be among the industrially least developed countries although significant economic development activities have been carried out over the years. The agricultural sector contributes about 55.5 per cent to the country's GDP which was of the order of 121 billion rupees at current market prices (1991-92); cottage industry with a contribution of about 11 per cent is the next important sector while the manufacturing sector contributes a mere 6 per cent. The growth of GDP and sectoral value addition is given in Table 1.

In the 1970s, although the government's objectives did not differentiate among the three possible approaches to industrial development (import substitution, basic materials production, and export processing) yet in practice, most of the policies were clearly geared towards the promotion of import substitution industries in the form of relatively capital intensive, public manufacturing enterprises which however, did not lead to rapid industrial expansion.

In 1980 Nepal sought to accelerate its economic growth through an expansionary public expenditure policy which was mainly financed by domestic bank borrowings. It became unsustainable, as the fiscal and external deficits reached record levels; these are major sources of concern. The saving rate of Nepal continues to be one of the lowest in the region.

The balance of external merchandise trade has been negative all through (Table 2). In 1992, the output of the agriculture sector increased by only 0.5 per cent while growth in the non-agriculture sector was around 7 per cent; industrial production increased 30 per cent in 1991 and again by 16 per cent in 1992. The ratio of investment to GDP fell sharply to 17.8 per cent in 1992 from 20.1 per cent in 1991.

Table 1 : Growth of GDP and Sectoral Value Addition

Amount in million Rs. at 1991/92 prices

Description	1991/92		1996/97		Average Annual Growth Rate
	Amount	Share	Amount	Share	%
GDP at market price	121062	155160			5.1
Total Value Added (At factor cost)	113024	100	142992	100	5
Agriculture, Irrigation & Forest	62712	55	75364	53	4
Non-agriculture	50312	44	67628	47	6
Industry and Mining	7283	6	12169	8	11

The saving rate edged up to 6.9 per cent from 6.5 per cent over the same period as overall expenditure was reduced. In consequence, the resource gap narrowed considerably in 1992.

Table 2 : Selected Economic Indicators

		1990	1991	1992	1993	1994
Gross Domestic Product	% change	6	5	3	3	6
Agriculture	% change	7	3	0.5	0.1	5
Non-Agriculture	% change	4	10	7	6	7
Gross Domestic Investment	% of GDP	18	20	18	20	20
Gross Domestic Saving	% of GDP	6	6	7	8	8
Merchandise Exports	$ million	181	231	313	376	432
	% change	9	28	35	20	15
Merchandise Imports	$ million	644	727	751	855	896
	% change	00	13	3	14	5

In Nepal the pace of industrialisation has been very slow; there was practically no industry prior to 1950. The first industries to come up were basically agro-based namely rice husking, oil extraction, jute and tea processing etc. A very limited range of import substitution industries was established in late 1960s which were mainly in the public sector domain producing consumer goods like beverages, cigarettes, textiles, matches and soaps and some simple agricultural tools and building materials. The agricultural sector accounted for an average of 67 per cent of GDP during the period 1970-77, while the industrial sector's share was less then 10 per cent of GDP, with approximately half of it attributable to the various cottage industries. Now various industries are in operation in Nepal in different sectors. There are about 856 small, medium and large industries in operation of which more than 50 per cent are located in the central region mainly around Kathmandu. The major industry segments include food & allied products; beverage industry; tobacco manufacturing; textiles; leather & leather products; footwear; wood & wood products; paper & paper products; rubber products; plastic products; non-metallic mineral products; iron & steel based industries; electricals; industrial machinery; apparatus and appliances. The composition of production index of manufacturing industries over the years is given in Table 3.

A new industrial policy has been adopted in Nepal since June 1992 and one of its main objectives is the delicensing of major industrial activities. Industrial licensing has been abolished for all new and modernisation projects, except those pertinent to national defence and security (five categories), and public health and the environment (26 categories). The registration procedures have been simplified and industries have been assured of registration within 21 days from date of application.

Also in May 1992, a new trade policy was announced which aimed to encourage exports and integrate the economy with that of the world. It has been designed for gradually moving towards a fully liberalised exchange rate system. The rupee was devalued in July 1991 as a measure to enhance export competitiveness and gradually reduce imports. In July 1992 similarly, a dual exchange rate system was introduced under which exporters could exchange 75 per cent of their total foreign exchange earnings to rupees at the free market rate. And after that full trade account convertibility was announced in February 1993. Import licensing for most of the goods has been abolished. The policy also aimed to improve the export incentive scheme and thus strengthened the bonded warehouse scheme by extending such facilities to all industries that were exporting more than 90 per cent of their output; improved the duty drawback scheme by instituting new procedures, including the use of input-output coefficients; and simplified the export documentation procedures.

Table 3 : Index of Manufacturing Industries

Base : 1986/87=100

Major Industry Groups	Weight %	1987/88	1988/89	1989/90	1990/91	1991/92	1992/93
Food Manufacturing	19	112	96	134	190	209	189
Beverage Industries	4	148	142	159	180	207	217
Tobacco Manufacturing	20	107	100	109	113	118	130
Textiles	18	97	86	77	95	86	39
Leather & Leather	2	51	57	97	114	55	16
Footwear	0.41	177	274	615	834	1264	788
Wood & Wood Products	2	63	54	9	17	30	21
Paper & Paper Prod.	0.85	177	217	195	233	236	188
Rubber Products	0.65	131	164	175	221	212	147
Plastic Products	1	119	156	214	423	369	452
Non-metallic Mineral Products	17	121	120	57	93	129	138
Iron & Steel based Industries	3	74	101	105	132	173	176
Electricals, Indl. Machinery	2	122	99	94	92	154	77

At present the main concerns in Nepal are the decline of agricultural productivity, the failure of government measures to raise agricultural output and the unsatisfactory development of the industrial sector. Both internal and external factors are perhaps responsible for the current economic problems of Nepal. One of the main internal factors is the failure of economic growth to keep up with population growth. The relatively large investments allocated to infrastructure in previous plans meant that no real increase in production and improvements in living standards were achieved. The major external factor has been the energy crisis, resulting in high costs of capital and manufactured goods, added to which are the transit problems and high transport costs, limiting the capacity to produce and market goods competitively.

S&T policy framework

The investment in R&D has been inadequate since the 1950s. Nepal spends only about 0.13 per cent of its GNP on R&D activities which is the lowest among SAARC countries where generally it is of the order of about 0.2 per cent.

The S&T policy in Nepal has come into force since May 1989 with the objective to improve the country's S&T capability for overall development and scientific creativity. This will include: (a) development of technologies and services for priority areas of socio-economic development; (b) fulfillment of people's basic needs; and (c) qualitative development of human resources. The emphasis is on the integration of planned S&T development with the nation's overall development efforts and orderly relationship and coordination between the S&T community and social and economic sectors. The S&T development approach is to be four pronged: research and development, technology transfer, qualitative human resource development and promotion and dissemination. The S&T policy is considered adequate as a Technology Policy. It deals with the issues of technology transfer, technology choice, framework for negotiations for technology acquisition, and assimilation and adaptation of imported technology. The National Planning Commission with the assistance of the National Council for Science & Technology (NCST) has been assigned a major role in S&T policy guidance, formulation of plans and programmes, and monitoring and coordination of their implementation as well. The ministries and organisations concerned have been assigned responsibility for programme formulation, implementation, coordination and evaluation in their respective sectors. The Royal Nepal Academy of Science and Technology has been entrusted with rationalisation, coordination and monitoring of S&T research and development and regular assessment of the S&T status of the nation.

National S&T capabilities and status of industrial R&D

Nepal has a limited number of S&T institutions engaged primarily in technology development. These can be broadly categorised into two major groups : (a) technical institutes of Tribhuvan University and (b) publicly funded specialised institutions. The Tribhuvan University has five academic institutes which are also engaged in R&D in the fields of engineering, medicine, agriculture, animal science and forestry. The university also has a institute of science and technology which conducts academic programmes up to the Doctorate level. The university has four specialised centres solely devoted to research and development. Among these, the centre for Applied Science and Technology is engaged in development of appropriate techniques, processes and equipments for exploiting local raw materials and resources.

The publicly funded specialised institutes undertake research in the field of agriculture, mining, geology, forestry, medicine and public health. Agriculture research has been the top priority since the beginning and the sector has a well developed research infrastructure. Agricultural research has been targeted to increase food grain production and productivity of the land. There are a number of experimental research stations and laboratories spread throughout the country. The Khumaltar research complex located in Kathmandu valley has excellent experimental and diagnostic facilities to provide back up services. The Agriculture Research Laboratories Complex (ARLC) at Khumal set up in 1957 is another well equipped research institution under the umbrella of Dept. of Agriculture. ARLC carries out original as well as adaptive research, basically with the objective of testing and propagating new practices and materials. Special National Development Programmes have been taken up on : (a) cotton; (b) maize; (c) oil seeds; (d) rice ; (e) wheat; and (f) sugarcane. Many of these are in cooperation with international research centres such as the International Rice Research Institute (IRRI) in the Philippines, the International Centre for Maize and Wheat (CIMMYT) in Mexico, the International Centre for Agricultural Research in Dry Areas (ICARDA) in Syria, the International Crops Research Institute for Semi-Arid Tropics (ICRISAT) in India, the International Potato Centre (CIP) in Peru, the International Soyabean Programme (INTSOY) in the USA and the Suwan Maize Farm of Kasetsart University in Thailand. These programmes have some linkages and coordination with the All-India Coordinated Crop Improvement Programmes in most crops.

Another noteworthy feature of Nepal is that there are four R&D institutions under the department of Medicinal Plants viz. the Royal Drug Research Laboratory (RDRL), the Royal Botanical Garden (RBG), the Botanical Survey and Herbarium and the Herbal Farms. RDRL has been engaged in R&D on local medicinal and aromatic plants and traditional medicines. The laboratory has pilot plant facilities which are utilised for scale up studies and demonstration of processes. RDRL was actively involved in the establishment of the country's biggest and most modern pharmaceutical company, the Royal Drugs Ltd. The Royal Botanical Garden is an advanced Centre for botanical research. They are actively involved in development of new plant varieties and improvement of germplasm as such. The work related to plant survey, collection, ecological studies and maintenance of herbarium has been carried out by the Botanical Survey and Herbarium. The Herbal Farms are involved in experimental cultivation of various aromatic and medicinal plants in different agro-climatic regions.

The Research Centre for Applied Science and Technology (RECAST) established in 1977 has been engaged in developing appropriate technologies for rural development including new construction material, improved stoves, water mills, solar dryers etc. and in identification and utilisation of national resources.

In the energy sector a number of institutions are involved in R&D activities including the Water and Energy Commission and RECAST. Several other institutions are engaged in the development of micro-hydel power development, fossil fuel deposits, biogas and biomass as a source of energy. The support facilities for such R&D activities are however inadequate and often weak.

The R&D set-up in the communications sector is not well established. The transportation sector too does not have any exclusive unit carrying out scientific and technological R&D activities.

A number of institutions provide scientific and technological support services in the country. Libraries and documentation centres of the Tribhuvan University and specialised public institutions provide various S&T information services. The National Computer Centre provides the mainframe facilities while a number of institutions are going ahead using their own micro computers. The Bureau of Standardization and other related laboratories provide the standardisation testing and quality control services. The Agricultural Projects Service Centre and the Industrial Services Centre as well as a host of other engineering firms provide various consultancy and extension services.

With regard to S&T manpower, Nepal has still to depend on foreign countries for training its people at higher levels of science and engineering/technology, and induction of foreign experts as may be necessary. S&T personnel on jobs were about 8200 in 1992 according to a field survey made by NCST. In 1993 Tribhuvan University enroled 150,000 students in various educational faculties, 16 per cent of which belonged to pure science and other technical subjects.

Technology transfer mechanisms and other related issues

The diverse ministries and departments of government are responsible for the planning and implementation of S&T activities related to their respective sectors. The National Planning Commission is responsible for ensuring that the programmes of various ministries and departments are as per the overall objectives and targets of national development. But the "Royal Nepal Academy of Science and Technology (RONAST)" could be considered as the "National Technology Authority" although it is a fully autonomous organisation and has no direct linkages with the government.

There is no organised system for technology transfer and support to indigenous technology development and promotion. Technologies developed by R&D set-ups mostly fall in the social service sector and entrepreneurs don't come forward to take/utilise these technologies. In the manufacturing sector as the indigenous technologies need to be tested on a pilot scale and due to the absence of any arrangement for risk capital and pilot plant facilities the tendency is again to look for already tested technology abroad. However, RECAST has played an active role in establishing linkages between technology generators and users.

Patent protection in Nepal is given under a revised and updated Patent, Design and Trademark Act 1965 which replaced the earlier law. The Department of Industries is the agency in charge of enforcing the provisions enunciated under the Act. Under the present Act, patents granted in foreign countries, can get an exception in so far as the need for examination is concerned; on the condition that "such patent has already been registered by the inventor in his own country and three other countries in accordance with the law of patents prevalent therein". The term of registration of a patent runs for a period of 15 years, renewable for a maximum of two further terms, each of another 15 years, at the discretion of His Majesty's Government.

The Department cf Industry also registers designs and trademarks and issues certificates to respective designers and proprietors of assignee of the trademarks. The procedures and provisions in respect of registration of designs or trademarks are almost similar to those in respect of patents. Priority is by the date of first registration irrespective of prior use in the country or elsewhere. Unlike in the case of patents, there is no provision for renewal of such registrations.

Consultancy and marketing assistance to SMEs

Consultancy organisations to assist industry are not well developed, and SMEs by and large have to use their own resources for marketing arrangements.

Financial incentives and innovative mechanisms for commercialisation of R&D results

In the agriculture sector which has significant R&D activity, the Agricultural Development Bank and the Nepal Industrial Development Corporation have started supporting indigenous technologies in a small way. They have been instrumental in promoting locally developed technologies like biogas, improved water wheels, small knitting machines etc. by subsidising in the beginning the installation of the pilot unit in the fields and later liberally financing the promotion of such small-scale indigenous technology.

Issues concerning technology choice - national priorities and concerns

The Eighth Five Year Plan (1993-1997) is aimed at promoting a more open and market oriented system with increased reliance on the private sector for the production of goods and providing services while the public sector is to focus on developing the necessary infrastructure. The government is implementing reforms in various areas of the economy which include foreign investment, trade and industrial sectors. Various stabilisation measures have been adopted and a comprehensive package of reforms including privatisation to overhaul public enterprises and the public administration is being developed. Development of cottage industries export promotion has been emphasised. However, within the broad objectives no clear cut priorities have been established to determine the allocation of resources in the industrial sector.

Institutional mechanisms for technology monitoring and acquisition

The requirements for technology are to a large extent met by way of imports under different forms. Foreign aid has played a major role in the source and volume of technology imports including those in the manufacturing sector. Much of the technology transfer under this category has been the turn-key type.

In the communications sector, for instance, there is heavy reliance on imported technology with very little adaptation. Besides, there is little exercise in the assessment of the suitability of the technology and no control on the diversification of systems, thus leading to a condition for perpetual dependence. Similar is the situation in the transport sector, where the country depends upon imported machinery and technology. In some cases, due to inappropriate alignments, the country pays heavily for maintenance of the roads as well as the vehicles that run on them.

In the agricultural sector, there has been considerable investment for proper technology importation and adaptation. However, if the agricultural production and productivity of the country are considered as indicators of the technological achievements the results have so far been rather disappointing. The same could be said in the case of other sectors like forestry, construction,etc.

In the manufacturing sector, contractual transfer of technology involving both public as well as private enterprises are few in number and are of recent origin. Technical assistance, marketing and management and patents are the different types of contractual transfer.

Thus the national capacity to select and to evaluate technology for import is low and technological research and development activities for adaptation of the imported technology are very limited. The country possesses little bargaining power and has difficulty in assimilating the imported technologies.

Status of technology assimilation and adaptation in different sectors

As indicated, substantial import of technology has taken place in packaged/turn-key form. The presence of foreign technical personnel has assisted in acquiring operational competence. However, it does not seem to have led to development of indigenous capabilities for technology innovation and upgradation.

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Pakistan

Status and trends of economic and industrial development

Pakistan is a country of nearly 120 million people (1992) with an annual population growth rate of 3.1 per cent. The overall literacy rate is 26 per cent, female literacy being 15 per cent; 2 per cent of the age groups (18-23 yrs.) are enrolled at university level. Pakistan had a Gross Domestic Product (GDP) of Rs.1211 billion at current market prices (1992), giving a GDP per capita of around Rs.10,000. The composition of GDP in different years has been given in Table 1.

Table 1 : Composition of GDP

	1992	1990	1988
TOTAL GDP (Billion Rs.)	1211	856	675
% Share			
Agriculture, Hunting, Forestry and Fishing	23.3	23.00	23.1
Manufacturing	15.4	15.4	15
Mining and Quarrying	0.6	0.6	0.7
Construction	3.6	3.8	3.7
Others	57.1	57.2	57.5

The structure of the GDP seems to have remained unchanged over the years although the Seventh Five Year Plan (1988-93) had envisaged the share of manufacturing in GDP to rise to 20.5 per cent. The balance of external trade had been negative for each year during the period 1982 to 1992; the figures for three years are given in Table 2 along with the share of major manufactured items of exports.

Starting with practically no industries in 1947, Pakistan today has a diversified industrial base. Besides a number of agro-based industries, heavy and basic industries have been established in a wide spectrum of sectors, e.g. steel, cement, fertilisers, basic chemicals, sugar, railway carriages, shipping and industrial machinery and equipment. About 80 per cent of industrial investment in manufacturing comes from the private sector - up from about 50 per cent in the early 1980s.

Table 2 : External Trade

Year	1992	1990	1988
Imports (Billion Rs)	235.3	160.1	118.7
Exports (Billion Rs)	183.6	121.3	81.3
	% Share of Exports		
Cotton Yarn	15.9	14.8	11.7
Cotton Fabric	11.1	9.9	10.5
Readymade Garments	6	3.9	4.6
Leather	3.3	4.9	6.2
Footwear	0.5	0.4	0.4
Woollen Carpets	3	4	5.4

Policy framework

The recognition of the role of science and technology (S&T) in development and economic growth is relatively recent in Pakistan. A comprehensive National Science and Technology Policy was announced in 1984 with the aims and objectives of cultivation and promotion of S&T in society; directing the S&T system towards achieving welfare of the people, sustained economic growth and country's security; realising a modem engineering and technological base to achieve self-reliance and promoting export of value added manufactured products; speedy development of technological capability through planned promotion of indigenous technologies as well as import, assimilation and adaptation of advanced technologies for increasing GNP and ensuring optimum exploitation of natural resources; ensuring regular supply of high quality R&D manpower and creation of a conducive environment; developing an effective information network for S&T and engineering and popularisation of S&T at the grass root level. The Industrial Commission in its Report of 1988 suggested the formulation of a comprehensive technology policy which was evolved with the assistance of the World Bank, UNDP, UNCTAD and APCTT and announced in November 1993. It envisages a market driven framework with a leading role for the private sector, with the goal that by the end of the century Pakistan becomes a contributor to the international technology : 'Instruments of technology policy' include (i) a liberal regime for technology transfer and means to attract foreign investment, (ii) effective mechanism for assessment, selection and induction of technologies (through MOST), (iii) rationalisation of R&D system so that the R&D programmes are directly related to the needs of Pakistan industry and to further economic development (expenditure is aimed at 2 per cent of GNP on R&D by the year 2000, up from 0.5 per cent, at present) and (iv) commercialisation of R&D. The legal framework for protection of intellectual property rights will be improved and trade and tax policy will be utilised as instruments of technology development. Development of technical manpower receives emphasis.

Besides S&T policies, the industrial policy and the intellectual property regime have a close bearing on the development of technology in a country. The Industrial Policy has been evolved with assistance of IMF/World Bank and favours deregulation and liberalisation, specially since 1982-83. Later in 1989 an Industrial Policy Package was announced that has significantly influenced the direction and climate for industrialisation in the country. Privatisation is being promoted and sick public units are being closed down while duty on raw materials for the engineering industry has been waived or reduced significantly. World Bank Credits have been helping to restructure the industrial financing system and develop the credit market. The indigenisation policy seeks to promote linkages between large industries and the small/medium units.

Industrial property rights in Pakistan are protected under the Patents and Designs Act and the Trademarks Act. The life of a patent is for 16 years extendable according to circumstances. Copyright is granted for five years, extendable for two further periods of five years each. The grant of license for working a patent or using a design against payment is permissible. The Protection of Rights in Industrial Property Ordinance, 1979, provides that no industrial property will be compulsorily acquired without the authority of law and adequate compensation within a reasonable time.

National S&T capabilities and status of industrial R&D

Pakistan has a reasonably diversified institutional infrastructure for R&D. There are about 170 R&D organisations in the public sector. The Ministry of Science and Technology (MOST) of the federal government has, inter alia, under its wings the following research councils: Pakistan Council of Scientific and Industrial Research (PCAT); Pakistan Council for Science and Technology; Pakistan Science Foundation; Council for Works and Housing Research (CWHR); Pakistan Medical Research Council; Pakistan Council for Research in Water Resources; and Pakistan Council for Appropriate Technology. In addition to these, there are four National Institutes - for Electronics; Silicon Technology; Power; and Oceanography (NIE; NIST; NIP; NIO).

The PCSIR has a network of laboratories : multipurpose laboratories at Lahore, Karachi and Peshawar and special purpose laboratories, viz., a National Physical and Standards Laboratory (NPSL) at Islamabad; a Fuel Research Centre (FRC) and a Leather Research Centre (LRC) at Karachi; a Solar Energy Research Centre (SERC) at Hyderabad. The PCSIR had developed about 450 processes, taken 300 patents and published more than 2500 papers by 1991. The range of R&D areas being pursued under PCSIR is wide : ores and minerals; drugs; glass and ceramics; polymers; solar energy; agricultural and industrial chemicals; food technology; leather; fuel; oils and fats.

Besides MOST, other socio-economic ministries of the federal government have S&T/R&D establishments for subject matters of their respective concems viz., Ministry of Food, Agriculture and Cooperatives has Pakistan Agricultural Research Council, Pakistan Forest Institute and Zoological Survey of Pakistan; Ministry of Defence has Defence Science and Technology Organisation, Geophysical Research Centre and Institute of Meteorology and Geophysics; Ministry of Health and Social Welfare has National Institute of Health, Jinnah Post-Graduate Medical Centre, Drug Research Laboratories; Ministry of Industries has Cotton Textile Industry R&D Centre; Ministry of Communications has Telecommunications Research Centre; Ministry of Planning and Development has National Transport Research Centre; Ministry of Petroleum and Natural Resources has Hydrocarbon Development Institute; Ministry of Production has Fertiliser Research Institute, Cement Research Institute, Plastic Technology Centre; Pakistan Atomic Energy Commission has Pakistan Institute of Nuclear Science and Technology, Nuclear Institute of Agriculture and Biology, Nuclear Institute of Food and Agriculture and National Institute of

Genetic Engineering and Biotechnology. There is also the Pakistan Space and Upper Atmospheric Research Commission, directly under the Cabinet Division. Major industries have set up quality control laboratories which also undertake limited R&D activities. Among the technology support services, special mention may be made of S&T information, standardisation and quality control services. The Pakistan Scientific and Technological Information Centre (PASTIC) at Islamabad with four sub-centres, one in each province namely Karachi, Lahore, Peshawar and Quetta offers a comprehensive range of information services, including patent information and environmental. There is also a National Centre for Technology Transfer, which has a Technology Information Services Division. The NCTT offers Library & Documentation Services besides having a Technology Information Data Bank. There are also sector specific information units.

For testing, quality control and standards again there are several active organisations : National Physical Standards Laboratory (NPSL) maintains national standards of measurement and materials; Pakistan Standards Institution (PSI) lays down national standards for industrial products and certifies products as conforming to standards; two Central Testing Laboratories (CTL), one at Karachi and another at Lahore, for analysis and testing of industrial goods and materials; Pakistan Industrial Technical Assistance Centre (PITAC); Textile Industry Research and Development Centre (TIRDC); Metal Industry Research and Development Centre (MIRDC); and laboratories of the Pakistan Council of Scientific and Industrial Research. An overarching Pakistan Standards and Quality Control Authority (PSQCA) provides the standardisation, quality control services, inspection and certification of goods, applied industrial research and testing facilities, metrology education, promotion and training.

The availability of trained professionals appears to be inadequate as an APCTT report placed the number of S&T manpower engaged in R&D, in 1991, as only 8000, which was only about 52 per cent of the minimum required for such pursuit according to the UNESCO norm for countries with a per capita GNP between US $100 and $ 200. By and large research in science and technology has been at a low key in the university system in Pakistan; the country has had to depend on advanced countries for the training of its high level S&T manpower. The country has 22 universities of which four are engineering universities, three agricultural, one medical (private sector) and one for management studies. The enrollment for the degree or higher level courses in 1987-88, in the nine professional universities was about 23,500 of which about 21,000 were for the first degree level and 235 for the post-Master's level and very few for Ph.Ds, that too mostly in agricultural sciences. In the period 1947-1990, only four candidates were awarded Ph.D. in Engineering & Technology. Pakistan had identified two major deficiencies in the education and training of R&D scientists and technologists as (a) poor foundation in science and mathematics at the school level and (b) lack of significant research degree programmes at the university level. To improve matters, several Centres of Excellence in science and technology have been established under various universities; the MOST has launched a concerted programme of scholarships to pursue post-graduate and doctoral programmes abroad in selected high-tech fields e.g. lasers, fibre optics, genetic engineering and biotechnology, material sciences, computer sciences and engineering etc. Sub-professional skilled manpower is also in short supply; a shortage of 64,000 skilled workers per annum is the estimate. However, this has been receiving attention of the authorities. Under National Vocational Training Programmes (NVTP) an intake capacity of about 12,600 has been created under 37 centres. Technical training centres and government vocational institutes offer two-year full time, and one-year (or less) duration courses in 25 trades; apprenticeship programmes in 84 trades are operated in 400 industrial establishments. In NVTP, Phase II, 31 new Vocational Training Centres are being developed; it will also cater to the training of over 75,000 trainees within the industry.

Engineering and management consultancy services are being promoted. It is proposed to create an R&D Consultancy Corporation to fully harness the S&T potential available in the wide network of research institutions.

Conversion of R&D results to commercial products has not been particularly strong. Lack of industry interest and consumer preference for imported goods have contributed to this state of affairs.

Technology transfer mechanisms

A National Centre for Technology Transfer (NCTT) has been established under the MOST to advise on technology transfer to industries, both in the public and private sectors and to disseminate information on indigenous and imported technologies.

A Scientific and Technological Development Corporation (STEDEC) has been established with Rs. 20 million as seed money to commercialise indigenous technologies and to adopt and adapt foreign technology.

Its strategy is essentially based on four elements : (a) the marketing approach; (b) direct technology transfer; (c) joint venture or collaborative efforts; (d) consultancy and other awareness services. The STEDEC aims to offer integrated service to the industry, comprising consultancy research, marketing and technology transfer.

There is also an Inter-Ministerial Coordination Committee (IMCC) for the utilisation of indigenous technology, headed by the Minister for Finance/S&T, and with representatives from the ministries of industry and commerce, relevant S&T organisations and chambers of commerce and industries.

Although Pakistan has relied heavily on imported technology for industrialisation it has recognised that importing technology as a package or in the form of turn-key plants has not resulted in any real transfer of technology. Thus greater emphasis is now being laid on the fullest use and involvement of indigenous technological capabilities in technology transfer and appropriate policy measures have been designed to stimulate demand for technology and facilitate acquisition of foreign technology.

Consultancy and marketing assistance to SMEs

The government is keenly promoting local consultancy services as a key element in technology-led industrialisation. A number of consultancy organisations, in diverse fields have come up over the years, some of them acquiring international credibility, particularly in the construction sector. An R&D Consultancy Corporation is proposed to be established in pursuance of the recommendations of the National S&T Policy to organise scientific consultancy services in various fields, including R&D, in the public sector on commercial lines. The fields to be covered initially are computer software, energy, minerals, chemicals, standards and quality control.

Financial incentives and innovative mechanisms for commercialisation of R&D results

Import policies have been reviewed to stimulate demand for locally manufactured goods and indigenously developed technologies. Suitable institutional arrangements are proposed to be created to support with risk capital: (a) promising scientific projects based on indigenous research; and (b) innovative entrepreneurs wishing to commercially exploit indigenous technology.

Greater attention is being paid to better project selection and project planning. It is not possible to get government approval for a project or sanction of loans unless it is supported by a sound feasibility study. This has enhanced the commercialisation and diffusion possibilities of indigenous technologies. Other fiscal incentives for promoting technological indigenisation include the exemption from/reduction of duty on raw materials for the engineering industry, as also for assembly/manufacturing units and their vendor units under certain obligations of indigenisation. In order to encourage use of locally manufactured machinery, industrialists are provided loans at a concessional rate. Other facilities/incentives include special, low interest funds for DFIs, special incentives for private sector investment in R&D, tax relief on investments in R&D and training, venture capital companies etc.

Issues concerning technology choice - national priorities and concerns

Science and Technology received due emphasis in the Seventh Five Year Plan (1988-93), which defined the goals as increasing the national productivity; competitiveness in agriculture, industry and mining; provision of improved services with reduced unit costs in areas such as transportation, energy, health care, sanitation and drinking water; and productive exploitation of indigenous natural resources while emphasising resource conservation and replenishment. The Industrial Policy of 1989 welcomes import of technology in key industries e.g. engineering and high-tech industries such as fibre optics, solar energy, biotechnology, fertilisers, computer hardware and software and electronics; it also stresses modernisation of agro-processing industries. Import of machinery and equipment are exempted from customs duty, if such items are not manufactured locally, for dairy, farming, livestock farming, horticulture, agriculture, cement, metal products, and drugs.

Also several incentives are given for setting up industries in rural areas under the Rural Industrial Policy of 1990. With regard to foreign investment government permits 'foreign private investment' in any industrial undertaking which does not exist in Pakistan or which is not being carried on in Pakistan on an adequate scale, or which will contribute to the development of capital, technical and managerial resources or the discovery, mobilisation and better utilisation of the national resources, among other things. The government has declared certain areas as priority areas for foreign investment. These include agro-based industries; chemicals; mechanical engineering items; metallurgical products; machinery and equipment; electrical/ electronics.

Institutional mechanisms for technology monitoring and acquisition

Functions of the Ministry of Science and Technology include 'monitoring and serving as a clearing house for all available information on scientific and technological research conducted at home and abroad', as also 'evaluation and monitoring of imported technologies'.

Technology plans are implemented through concerned ministries/departments /organisations. The processing of development projects, their monitoring and evaluation is done by the Planning Commission. The Board of Investment (BOI) headed by the Prime Minister monitors the progress of industrialisation. Under the BOI, there is a Committee of Investment (COI) headed by the Minister of Industries which monitors the progress of projects in between the meetings of the BOI. There is also the Investment Promotion Bureau whose professional role includes 'monitoring and one-window facility'.

A Special Technical Cell (STC) under the Ministry of Production carries out technical monitoring and assists the Ministry in performance evaluation of corporations/units particularly for upgrading technology, increasing capacity utilisation, import substitution, quality assurance and R&D.

Status of technology assimilation in different sectors (private, public and multinational companies)

Pakistan has depended substantially on imported technology though indigenous/indigenised technology is used in some production sectors. Besides a large network of agro-based industries, heavy and basic industries have been established, e.g., steel, fertiliser, cement, basic chemicals, sugar, railway carriages, ships, machinery and plants for sugar, cement, vegetable ghee, rice and ginning factories; in automobiles it is moving from assembly to manufacturing. Defence related industries are in the public sector as also, largely, the industrial machinery and plant production.

Agriculture: Mechanised farming practices are established and increasing: by 1992 the number of tractors in use was of the order of 265,000; there are five tractor manufacturing plants, two in the public sector and three in the private sector. Nearly 500 units produce 30 different kinds of farm implements and machinery, mostly of indigenous designs, of which about 15 are large, 40 medium & the rest small.

Manufacturing: The public sector has eight holding corporations under the Ministry of Production: Federal Chemicals and Ceramics Corporation Ltd., National Fertiliser Corporation Ltd., Pakistan Automobile Corporation; Pakistan Industrial Development Corporation Ltd (sugar, woollen products, wood products, textile products, steel pipes); State Cement Corporation; State Engineering Corporation (producing a wide range of heavy and light capital goods, plants requirement such as sugar and cement plants, road rollers, boiler pressure vessels, drilling machines, electric motors, galvanised steel pipes, ring spinning frames etc.), State Petroleum Refining and Petrochemical Corporation; Pakistan Steel.

Communications: Two production establishments have been set up as joint ventures of the Pakistan Government with M/s Siemens AG of Germany, viz. Carrier Telephone Industries which manufactures a wide range of long distance telecommunications equipment, and Telephone Industries of Pakistan which manufactures telephone instruments and exchange equipment. There is also a National Radio Telecommunication Corporation in the public sector manufacturing radio and telecom equipments including HF/VHF/UHF radio transreceivers. There are also Central Telecommunication Research Laboratories, set up in 1987, under Japanese technical assistance.

Construction: Modem construction technologies have been acquired through joint venture projects with foreign organisations, often executed in foreign countries and through innovations and highly trained manpower. Pakistan Environment Planning and Architectural Consultants Ltd., established in 1974 by the government, as a private limited company, provides integrated services for 'built environment'.

Energy: Pakistan has a number of research institutes in the energy sector: Hydrocarbon Development Institute of Pakistan (HDIP); Fuel Research Centre (primarily dealing with coal); Solar Energy Centre. However, R&D in the energy sector is considered to be marginal. Two nuclear power plants were proposed to be set up with assistance from France and China; this competence builds up on the experience of the earlier nuclear power plant KANUP, set up in 1974, with 137 MW energy supply.

Transport: Due to liberal imports, the latest models of different types of vehicles are on the road, and the demands of a growing economy for infrastructural facilities generate a pressure for improved road construction technologies. The Transport Research Centre is working towards this end. A locomotive factory is being set up to acquire self-sufficiency in manufacturing of rolling stock, in collaboration with Japan. Ship and vessels are being manufactured with technology imports. Improved air traffic and control systems and communication systems have been introduced.

Thus a rather liberal import of technologies has given a modern industrial base to Pakistan; the operational capabilities have been developed. However, the capabilities to generate competitive technologies indigenously have been rather limited.

Technology upgradation in SSI sector

The entire SSI sector is in the private domain and contributes around 30 per cent of value added manufacturing and around 5 per cent of GDP. SSI receives due attention of the government. Provincial Small Scale Industrial Corporations/Boards/ Directorates 'provide technical assistance, run workshops, develop industrial estates' among other things. Assistance has been coming, under various schemes, from international agencies like IDA, World Bank, Asian Development Bank to strengthen/support SSI sector. The Punjab Small Industries Corporation has developed several small industrial estates; it is running a large number of carpet-weaving centres, readymade garments and hosiery knitting training and handicrafts development centres; it has established a Design Centre for carpets and handicrafts. The Sind Small Industries Corporation also runs several industrial estates, artisan colonies/workshops, an institute of handicrafts and a light engineering service centre. Similarly, the other two provinces, the NWFP and Baluchistan, are promoting the growth and development of SSI through various schemes;

training is receiving particular attention besides provision of infrastructure and facilities and guidance to entrepreneurs.

Specific strategies to promote industrial growth and sustainable development

Privatisation has been recognised as a key element for industrial growth; it includes "deregulation, decontrol, denationalisation and divesture." The list of specified industries needing govemment clearance has been reduced to seven items only. Projects costing less than Rs. 1 billion do not require government sanction provided the amount is raised from private sources and the foreign equity component is less than 50 per cent. A four year tax holiday was allowed to key industries set up during the Seventh Plan. Income tax incentives were provided for higher value added exports, key industries exempted from customs duty on imported machinery if it was not manufactured locally. Capacity constraints have been removed from industries under the indigenisation programme. The procedure for approval to set up new enterprises has been greatly simplified. The requirement of government sanction has been dispensed with in respect of projects (a) involving import of second hand machinery, (b) involving foreign equity below 50 per cent and (c) where cash requirement for import of machinery was more than Rs.60 million. The approval procedure now involves only one authority, BOI or COI. Preference is given to industries which are capital intensive, or involve sophisticated technology or strengthen the balance of payments. Package deals with foreign firms involving capital, technology and marketing are encouraged. No discrimination is made between local and foreign entrepreneurs in incentives and concessions.

An area of strategic emphasis is rationalisation of the R&D system, which will include massive reorganisation of R&D institutions, multidisciplinary collaboration and a drive to attract overseas Pakistani experts. Commercialisation of R&D becomes an area of priority : R&D will be market driven and have commercial criteria. In a major departure from tradition the leadership of R&D institutions may go to engineers rather than scientists/academicians. Increasing private sector involvement is sought in product-oriented R&D. Collective R&D by a number of private units will be encouraged as in leather and cement sectors. There will be financial incentives for R&D including low interest funds. Self generation of revenue will be expected from R&D institutions; they will be permitted to borrow funds. Private sector involvement is sought through representation on Boards and Research

Advisory Committees. Venture Capital Companies would offer financial support for R&D and its commercialisation. Pakistan aims to join the world economy as a Newly Industrialised Country by the year 2000.

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Sri Lanka

Status and trends of economic and industrial development

The Democratic Socialist Republic of Sri Lanka, formerly known as Ceylon, the "Pearl of the Orient", is a compactly shaped island at the south-east tip of the Indian subcontinent covering an area of 65,610 sq. km. The population of Sri Lanka is about 18 million and the growth rate is 1.4 per cent; the life expectancy at birth is 67.8 years for males and 71.7 years for females.

Sri Lanka, though a small island nation, is not constrained by the debilities that characterise some of the isolated island nations of the southern hemisphere. Its natural resource base, manpower potential and indigenous technological capability more than matches the scales of economy.

The strong recovery of the Sri Lankan economy in 1990 when GDP increased by 6.2 per cent up from 2.3 per cent in 1989 and continued in 1993 although with a slightly reduced growth of around 5.5 per cent due to poor performance of the agricultural sector where the growth rate fell to 3.5 per cent from 8.5 per cent in 1990. The industry and services sectors continued to maintain the 1990 growth rate in the subsequent years due to the continued increase in the output of mainly textiles, garments, foods, beverages etc. in the private sector. The country witnessed a decline in the inflation rate from a high of about 20 per cent in 1990 to a single digit inflation in 1993 and 1994. The performance of various sectors in the last five years is reflected in Table 1.

Following the enactment of the State Industrial Corporation Act No.49 of 1957; a crucial change was seen in the industrialisation efforts with an emphasis on the state in the ownership of industries with some basic or strategic industries being reserved for the state sector, and the private sector being allowed to operate only in others. Industries were categorised into three schedules; Schedule 'A': basic and strategic industries reserved the state sector; Schedule 'B': consumer goods industries mainly for the joint sector and Schedule 'C': small scale industries open to the private sector.

Table 1 : Major Economic Indicators : Sri Lanka

Indicator	Parameter	1990	1991	1992	1993	1994
GDP	% change	6.2	4.8	4.6	5.7	5.4
Agriculture	% change	8.5	2.9	0.1	3.5	2.5
Industry	% change	7.7	3.9	6.0	7.0	6.5
Services	% change	4.3	6.1	6.1	6.0	6.1
Inflation rate	% change	21.5	12.2	11.0	9.0	8.7
Merchandise exports	$ billion	1.8	2.0	2.3	2.6	3.0
	% change	23.1	8.4	13.9	14.0	13.5
Merchandise imports	$ billion	2.3	2.5	2.9	3.4	3.9
	% change	13.2	6.8	18.8	16.0	13.1
Current account	$ million	-298.5	-267.6	-501.0	-582.0	-637.0
balance	% change	-3.8	-3.0	-5.1	-5.4	-5.3
External debt	$ billion	5.8	6.6	7.1	7.6	7.9
Debt service ratio	% of export	13.9	14.1	14.0	13.8	13.4

Based on constant 1982 factor cost

Thus 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 in the previous years. The government also gave a high degree of fiscal and tariff concessions to private sector industries especially those for import substitution. Hence 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. By the early 1960's with deteriorating terms of trade, further import restrictions were imposed, and by 1965, foreign exchange budgeting become a regulatory measure in the economy. Thereafter, imports of raw materials were based on licenses, resulting in industries often operating below the installed capacity.

After 1965, emphasis was given to agriculture and the industrialisation that occurred was to "stimulate agricultural development". The policies favoured agro-based industries, dependent on local raw materials and indigenous technology, and also with a potential for export.

The Industrial Policy was reversed in 1970 with the emphasis once again on the public sector, especially on heavy industries and the Five Year Plan was then directed to investments with low capital intensity and regeneration of the rural sector through a programme of agro-based and other small scale industries. An Industrial Development Board (IDB) was established as a supportive policy measure, to act as the promoter and "facilitator" of small and medium scale agro-based industries as it was then estimated that 77 per cent of employment and 40 per cent of value addition in the industry sector was contributed by the small scale sector.

In mid 1977, the industrial policy was once again changed with a more important role accorded to the private sector viz: (a) a Free Trade Zone to promote foreign investment and large scale transfer of technology and capital goods towards export-oriented industries was established; (b) a scheme for liberalised imports of both raw materials and finished goods and fiscal tax concessions to lure investments in the private sector was put in place; and (c) tariffs were used 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. Although the economic reforms of 1977 were well received the industrial growth averaged only 5.7 per cent during 1978 to 1985, improving slightly to 5.8 per cent during 1986-1990. The basic indicators of the industrial sector are given in Table 2.

Table 2 : Industry Sector Indicators in 1990

		Rs. Mln.	As % of GDP
1.	Value Addition	50226	17.3
a)	processing of Tea, Rubber & Coconut	8740	3.0
b)	Factory Industry	30084	10.7
c)	Other Industry	3404	1.2
d)	Mining and Quarrying	7998	2.4
2.	Share of Mfgd. goods in Exports	(%)	52.2
3.	Employment		
a)	Manufacturing*	(%)	11.5
b)	Mining & Quarrying	(%)	1.4

* Estimates

Table 3 gives the trends in industrial production. The industrial output was earlier dominated by three sub-sectors: food, beverages and tobacco; textiles and garment; and chemicals; however, a change in the importance of these sectors was witnessed in the 1990s with the output of textile, garments and leather products increasing in comparison to the other two sectors.

In 1987, a new Industrial Policy Statement was announced with the objectives of providing employment and income opportunities to a growing population through industrialisation as well as making industry internationally competitive for import substitution and exports.

Table 3 : Structural Distribution of Industrial Production

Sector	1978	1988	1991*
1. Food, Beverages & Tobacco	29.5	27.1	26.9
2. Textiles/Apparel & Leather products	11.4	33.6	34.5
3. Wood & Wood Products	1.4	1.2	0.8
4. Paper & Paper Products	4.3	2.8	2.2
5. Chemicals & Chemical Products	37.0	25.3	20.4
6. Non-Metallic Mineral Products	6.7	4.2	8.4
7. Basic Metal Products	2.5	0.9	1.3
8. Fabricated Metal Products, Machinery & Transport Equipment	6.7	4.6	5.1
9. Manuf. Products not elsewhere specified	0.6	0.3	0.4

* Estimates

Within these broad objectives, emphasis was on: (i) balanced regional growth, with industries dispersed throughout the country; (ii) encouraging small and medium sized industries; and (iii)appropriate technology suited to the needs of the country and the industry.

However the development of the industrial sector was constrained due to the scarcity of capital, lack of entrepreneurship and skills, low standards of physical infrastructure, and absence of technology. In an effort to overcome these debilities a new Investment Policy Statement was issued in November 1990 and an Industrial Promotion Act was enacted in December 1990. The Act provides for the establishment of the Industrialisation Commission, the Advisory Council for Industry and the Regional Industry Service Committee. The Government also adopted the One-Stop-Shop concept for promotion and approval of foreign private investment, for which the Greater Colombo Economic Commission (GCEC), now known as the Board of Investment (BOI), was established. The GCEC was the key agency to set the pace for an export oriented economic growth. Its aim was to attract export oriented industries into industrial promotion zones within its operation and thereby promote induction of new generation technologies, create employment and increase foreign exchange earnings. In order to ensure the success of the industrial strategy a new National Export Policy, was announced with the major features of maintaining the exchange rate at realistic values to ensure competitiveness of exports; permitting exports unrestricted and duty/tax free access to imported inputs; according priority to exporters in the provision of public utilities and services; and providing finance at internationally competitive rates.

Some of these features facilitated the "backward integration" strategy for the readymade garment industry, where during 1992, some 200 new readymade garment units were set up. However as most of the technology in local industry is of an old vintage and could hardly stand up to international competition, a substantial flow of technology-related foreign investments was witnessed in Sri Lanka.

The year 1994 for the Sri Lankan economy has turned out to be one year of slow down and cooling off. In 1993, the country had achieved creditable growth in most sectors; however, the recent political uncertainties and changes of government have had a serious effect on the economy.

S&T policy framework

Soon after the establishment of the Ministry of Scientific Research and Housing in January 1968 an effort at formulating a national science policy was made and the National Science Council (NSC) was set up in 1969. In August 1969, NSC formally presented two documents to the Minister of Scientific Research and Housing, one titled the "National Science Policy Statement" and the more elaborate second document titled, "Aspects of a National Science Policy". However due to change of government the documents could not be formally accepted. Ten years later, a new initiative was taken to evolve a national S&T policy by the appointment of a working committee on Science Policy Research by the National Science Council. A National Science and Technology Policy Statement was evolved and promulgated by the President in December 1978. However, as the policy was not supported with the requisite legal and financial provisions it did not really become operative. The third initiative towards the formulation of a national S&T Policy was taken in 1984 by a consultative process involving about 125 hand-picked scientists representing nine broad economic sectors. However the lobby against the initiative was so strong that the third attempt for evolving a national S&T policy was also aborted.

The most recent move was made in 1991 when a Presidential Task Force for Science and Technology Development was appointed. The recommendations of the Task Force inter alia were: to use S&T as an integral part of the effort to achieve rapid economic development, improved quality of life and poverty alleviation; to foster S&T for developing self reliance in scientific and technological capability; to allocate a reasonable proportion of the GNP for S&T activity; to support the development of indigenous technology, at the same time promote the adaptation and assimilation of imported technology for rapid industrial growth; to ensure that institutions of higher education nurture scientists, technologists and technicians of the highest calibre; to cultivate among the people an appreciation of the value of science, scientific methods and technology as an essential aspect of a modern society; to disseminate the benefits of S&T activity widely; to encourage and strengthen cooperation in S&T both within and outside Sri Lanka.

National S&T capabilities and status of industrial R&D

In Sri Lanka, research and development is undertaken mostly by state organisations under different ministries. Although there is no assigned body for the overall planning and coordination of science and technology activities, plurality and diversity of organisational structures have not been a major barrier for the implementation of science based programmes.

Sri Lanka's expenditure on research and development (R&D) increased tenfold from Rs. 45 million in 1975 to Rs. 474 million in 1989. However Sri Lanka's commitment to R&D as a percentage of GDP has declined from 0.2 per cent in 1975 to 0.18 per cent in 1989. In 1985, the private sector contribution was only 7 per cent to the country's R&D budget though, in 1989, the private sector contribution increased to 14.4 per cent (Table 4) which was due mainly to the massive commitment by a single multinational firm for a short term R&D project, an exception, as by 1990 again the private sector contribution dropped sharply to 2.0 per cent of the total commitment to R&D.

It is significant that while agriculture continued to be the major consumer of R&D funding, commitments to industrial research increased from 16 per cent in 1984 to 31 per cent in 1989 (Table 5).

There was also a change in direction in research funding from the general service sector to the productive sector. Thus the general trend in research funding seems to be in step with the new economic policies of the government (Table 6).

Table 4 : Gross National Expenditure on R&D by Sector

	1984		1989	
	Total R&D Expenditure (Rs. million)	As Percent	Total R&D Expenditure (Rs.million)	As Percent
State	239.4	93	414.87	85.6
Private	17.4	7	59.68	14.4
Total	256.89	100	474.46	100

Sri Lanka possesses a high literacy rate (around 90 per cent). This has been achieved through a number of radical reforms in the education system. The budgetary expenditure on education as a percentage of GDP during 1978 to 1984 fell to 2.3 per cent from 3.4 per cent of 1970 to 1977; however, the government plans to increase the budgetary allocation to 3.5 per cent of GDP. Higher technical education in Sri Lanka is currently provided by three institutions, the University of Peradeniya, the University of Moratuwa and the Open University. The turnout of graduates in the area of natural sciences is the highest followed by engineering, medical and agriculture. There are no precise estimates of demands available for higher level scientific and technical personnel to meet the needs of rapidly growing industrial sector. Thus the output from the institutes of higher education inevitably mismatches the scientific and technological capability needs of the country.

Table 5 : Financial Resources Allocated for R&D in Sri Lanka

Sector	1984			1989		
	Re-current	Capital	Total (%)	Re-current	Capital	Total (%).
Agri. & Animal husbandry	102.5	29.4	131.9 (51.4)	198.23	35.13	233.36 (49.2)
Forestry & Fishery	3.7	9.0	12.7 (5.0)	13.38	Nil	13.38 (2.8)
Industry	19.2	22.6	41.8 (16.3)	113.75	34.36	148.12 (31.2)
Other	48.9	21.4	70.34 (27.4)	34.38	45.14	79.52 (16.8)
Total	174.3	82.4	256.7	359.76	114.64	474.39

(in million rupees)

Table 6 : Gross National Expenditure on R&D by Sector of Performance

Sector	1984 Total R&D Expenditure	As %	1989 Total R&D Expenditure	As %
General service	216.34	84	379.20	79.9
Productive	24.32	10	60.90	12.8
Higher Education	16.14	6	34.28	7.3
Total	256.79	100	474.39	100.0

(Rs. million)

The total scientific and technical (S&T) human resource potential in Sri Lanka was estimated to be around 21,500 in 1985 of which scientists and engineers comprised around 8000, but in 1990 the number of scientists and engineers had dropped to 4700 indicating an annual negative growth rate of 8.0 per cent.

The main features of the S&T human resource structures are that it comprises about 85 per cent of males and 15 per cent of females; and among scientists and engineers, nearly one out of four possesses post-graduate qualifications. Although studies have shown that scientific and technical manpower employment in scientific institutions had steadily increased with an annual growth rate of about 10 per cent, from 1978 (4600 scientists) to 1985 (8200 scientists) but a downward trend was evident from 1985 to 1990 due to the closure of the higher educational institution for nearly two years and the displacement and massive migration of educated youth from the northern and southern parts of Sri Lanka during 1983 to 1989.

The main features of the R&D institutional frame work in Sri Lanka are :

Agriculture and Veterinary Science : The Department of Agriculture is mainly responsible for the research and development and dissemination of information and new technologies for the small farm sector. Agricultural research is conducted primarily on a regional basis.

Forestry, Wildlife and Fishery : Forestry research in Sri Lanka has been less extensive. The Forest Department's research has mainly been silviculture, entomology and timber utilisation. The National Aquatic Resources Agency (NARA) is the research organisation for fisheries.

Health and Nutrition : The Medical Research Institute (MRI) has the biggest laboratory complex for serving the curative and prophylactic activities in the field of health sciences.

Atomic Energy : The Sri Lankan Atomic Energy Authority (AEA) was established in 1969. Its main function is to develop the necessary resources for the utilisation of atomic energy for economic development. With assistance from the International Atomic Energy Agency, it has awarded several research grants for work in the agricultural, medical and veterinary clinical fields using nuclear techniques.

Institutes for Technological and Industrial Development : Although a number of organisations are involved in industrial and technological development, the two main research institutions are the Ceylon Institute of Scientific and Industrial Research (CISIR), established in 1955, and the National Engineering Research and Development Centre (NERDC) established in 1974. The other research organisations associated with the industrial sector include the research institutes for tea, rubber and coconut, and organisations such as Rice Processing Research and Development Centre (RPRDC) and the farm Mechanization Research Centre (FMRC).

CISIR : The CISIR is a statutory body under the Ministry of Science and Technology and has 16 sections of which 13 are 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, Minerals Technology, Industrial Economics, Environmental Science and Technology, and Engineering Services), and three service divisions (Information, Instruments Centre and a Workshop).

NERDC : Like the CISIR, NERDC is also a statutory body also under the Ministry of Science and Technology. Its main policy-making body is its Board of Management. 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 three service sections (Workshops, Computer Centre, and Library).

The activities carried out by CISIR and NERDC are broadly of three types: (i) R&D activities leading to the development of new products/processes, (ii) services to industry, such as analytical work, consultancy, waste management, metrological services, quality testing, and repair and maintenance of equipment and (iii) training. The majority of the research projects carried out by CISIR (90 per cent) and NERDC (75 per cent) are in-house initiated.

In relation to the number of research programmes undertaken by the CISIR and the NERDC during the period 1982-1986, relatively few have been commercialised (Table 7).

Table 7: Projects Undertaken for Product/Process Development by NERDC and CISIR During 1982-1986 (Numbers)

R&D Institute	Projects Undertaken	Products/ processes commercia-lised	Projects completed but not yet commercia-lized	Projects at develop-ment stage
CISIR	19	2	5	12
NERDC	36	3	16	17

This discouraging performance is probably a result of a mismatch between the outputs of these institutions and the demand of the industry as a result of the changed economic scenario. The UNCTAD case study on the role of R&D Institutes in Technological Innovation in Sri Lanka, in its survey of 25 major industrial organisations also identified the diffused character of linkages of R&D institutions with the productive sector, as a major defect in the R&D system. According to the Report the failure of R&D institutes to commercialise 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. This is further supplemented by the study by Liyanage *et al.*, who had identified inappropriate project selection, rapid turnover and/or brain drain of trained personnel, technical infeasibility of the project, lack of pilot plant development and of proper communication and information flow between partners as being responsible for failure of indigenous technology development.

Whilst the research activities of CISIR and NERDC were not demand oriented, the fluctuating state polices were not conducive to fostering of linkages between users and producers of R&D in the industrial research system in the country. These policies not only facilitated the large scale import of raw materials 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. It then became evident that some of the earlier scientific and technical programmes of CISIR and NERDC were no longer compatible with the new thrust towards a market economy. In fact the few private sector organisations which had in-house research capability, and had initiated programmes for identifying and developing alternative industrial raw materials, processes/products, components and ingredients, abandoned these programmes in favour of the less troublesome and less costly alternative of direct import of the required raw materials, intermediates and products/ processes. In this context it is relevant to note that the tax concessions provided by the state for investing in R&D, and the incentives for research services had little impact on industrial process development/adaptation.

There are several other scientific and technological service organisations addressing specific sectors/services e.g. the National Building Research Organisation (NBRO), the Ceylon Engineering Consultancy Bureau (CECB), the Mahaweli Authority and its various agencies, Government Analyst Department, Telecommunication Department, Water Resources Board and the Ceylon Electricity Board.

Universities generally have a meagre budget allocation for scientific research, and are mainly geared to training of scientific talent in research methodology and hence mainly R&D is of academic nature. However, in recent years there has been an growing tendency for researchers in universities to establish linkages with industry for technical work and creative research.

Technology transfer mechanisms

There is no central organisation that advises on or monitors technology transfer mechanisms. Facilitating technology transfer is among the legally specified objects of the National Engineering Research and Development Centre (NERDC) and the Ceylon Institute of Scientific and Industrial Research (CISIR). However a review of NERDC activities shows that it has concentrated its efforts heavily on design, manufacture and testing prototype machinery and pilot plants only and has not been able to provide an effective mechanism for technology transfer. Inadequate qualified staff and budgetary allocations are quoted as reasons for this heavy bias. Technology Transfer is comparatively a recent addition to the list of objectives of the CISIR. The National Science Policy Coordination Committee (NSPCC) has recommended that there is an urgent need for an institute such as the National Research and Development Corporation (NRDC) of India to foster the implementation of locally developed technology. Though the functions of the existing Industrial Development Board (IDB) are similar to the institute proposed by the NSPCC, however, the present ineffectiveness of the activities of IDB, requires either its re-organisation or additional institutional machinery to supplement its activities or both.

Consultancy and marketing assistance to SMEs

Design and engineering consultancy services are not highly developed yet in Sri Lanka, however, adequate expertise is available both in govemment and public sector organisations. The Industrial Development Board (IDB) is the main extension services wing of the government with branches spread countrywide. It was established under the Industrial Development Act of 1969, and was under the Ministry of Industry dealing with major industries. Now it functions under the Ministry of Rural Industrial Development and provides a package of integrated services for small and medium scale industries covering: information; identification of industrial opportunities; identification of raw materials; marketing advice and assistance; product development; workshop and foundry facilities; and entrepreneurial development.

Financial assistance schemes for obtaining technological assistance from local R&D institutions are operated through the public sector banks namely, Central Bank of Sri Lanka, National Development Finance Corporation of Ceylon (NDFCC), Bank of Ceylon, People's Bank, Commercial Bank etc.

A grant, referred to as the Technology Transfer Fund established under a Small and Medium Industries (SMI) Project provides financial assistance on a grant basis to small and medium industries in their efforts to upgrade technology and solve technology related problems, training and acquisition of knowhow.

Other schemes, for example the US Aid Schemes like SMED (Small and Medium Entrepreneur Development) and AGENT (Agro Enterprise Development), offer financial assistance to the industrial sector for acquisition of technical knowhow from local research organisations, for human resource development and in the market development.

Financial incentives and innovative mechanisms for commercialisation of R&D results

The various mechanisms and schemes for supporting indigenous technology development and commercialisation are :

i. Protecting national intellectual and industrial property

The Code of Intellectual Property Act provides for the protection of copyrights, industrial designs inventions, trademarks and trade names. It defines each of these and specifies the conditions for obtaining the right to patents etc. The Registrar of Patents and Trade Marks, is vested with the general control and superintendence of the registration of industrial designs, patents and marks.

Sri Lanka is a signatory to the Patent Cooperation Treaty (the only Asian country other than Japan till recently). The Registrar of Patents thus receives summaries of international patent applications from the World Industrial Property Organisation (WIPO) on a regular basis.

Sri Lankan S&T personnel thus have ready and easy access to information on the latest technological developments that are taking place in important technological centres in the world.

ii. *Protection and promotion of indigenous technologies through tariff and other adjustments*

The govemment has accepted the following guidelines to protect local industry and thus to a certain extent indigenous technologies as well. All industrial goods capable of being produced locally (in terms of good quality, reasonable price, etc.) will be afforded adequate tariff protection; Steps will be taken through the instrument of tariffs to protect local industries from the effects of dumping; The tariff structure will be adjusted to ensure a free flow of essential raw materials and other imported inputs that may be required.

iii. *Risk and other capital for commercialisation of indigenously developed technologies*

Organisations that fund commercial application of technology are the banks, development finance institutions and finance companies. Their practices are however very conservative and they tend to fund only well-proven technologies and that too only where the entrepreneurs can offer sufficient collateral. These financial institutions are: The National Development Bank, The Development Finance Corporation of Ceylon etc.

The National Development Bank (NDB) : The NDB was established by the government in 1979 under the National Development Bank Act of Sri Lanka, to promote industrial, agricultural, commercial and other development activities of the economy. The NDB's primary business is lending. It expects to be an active equity investor in the projects, sharing with the sponsor the risk and rewards of ownership thus indirectly providing risk capital. The bank gives direct loans and has schemes for refinancing (especially for SME's) and for purchasing loans already made by other financial institutions. Most of the funds for refinancing SMEs loans have been derived from a soft loan granted by the World Bank.

iv. The Development Finance Corporation of Ceylon (DFCC)

The DFCC was formed in 1956 and operates on a similar basis to the NDB. Besides these agencies which are primarily responsible for technology financing, there are some commercial banks which have credit schemes for SMEs in agriculture, fisheries, industry, rural based industries etc. The Industrial Development Board (IDB) has set up the Sri Lanka Industrial Development Company (SLIDCO) as a fully owned subsidiary, with the objective of setting up industrial projects of a pilot nature which would ultimately be offered for sale to the public.

v. Promotion of exports by national enterprises using indigenous technologies

No differentiation is made between exports made using foreign collaboration or those made using indigenous technology. Thus, the support made available to export-oriented ventures are available to organisations using indigenous technology to produce export goods.

Other than this, no support is available to directly protect and promote indigenous technologies.

Status of technology assimilation and adoption

Industrialisation was achieved mainly through importation of technology obtained on a turnkey basis, wherein the 'package' included plant and machinery, engineering services for installation commissioning and operation for a prescribed period as well as management services. The government of Sri Lanka views technology import as desirable provided it satisfies the following conditions: Its import must be of relevance to investment sectors recognised for promotion by the government; It must lead to a genuine infusion of foreign capital in amounts not easily raised locally; Its import must help to raise the technical knowhow of local workers; Its import must open up markets (export) presently not available.

The investment sectors which are promoted by the government are agricultural production (cultivation of crops), agro-industry; fisheries; textiles and garments; building industry; tourism; processing and upgrading of primary export products etc.

The government provides incentives to an enterprise, depending upon whether it is located in the GCEC promoted zone, or approved by FIAC or is an export oriented enterprise. These incentives relate to tax exemption, equity holding by foreign investor, remittances of royalty profits and dividends, transfer of shares outside country, import duty on machinery, equipment etc. The extent of incentives depend upon the category of the enterprise.

As the capacity for adaptation of imported technology is dependent on effective R&D institutions and good engineering design skills and linkages between the R&D and productive sectors, the lack of these has affected the absorption and adaptation of imported technologies in almost all the sectors with the exception of agriculture. In the case of the agriculture sector remarkable progress has been made in adapting imported HYV (high yielding varieties) of rice to suit local conditions which has won international acclaim. Contributions of such importance of the national level are scarce in the manufacturing sector, exceptions are the manufacture of rice processing machinery and a variety of other agricultural machinery. Successful adaptation of imported technology are also found in the case of rubber-based industries where exceptional engineering capabilities have been demonstrated.

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Thailand

Status and trends of economic and industrial development

Thailand, with a population of around 60 million, growing at a rate of 1.3 per cent, has a high literacy of 70 per cent and a GDP of 3100 billion Baht in 1993 and the per capita income is in the neighbourhood of US $ 2000. Since 1987, Thailand has been among the fastest growing economies of the world, the rate of growth of GDP last year being nearly 9 per cent, and inflation only 5 per cent; foreign exchange reserves are US $ 25 billion, and during the first quarter of 1994, exports grew by 18 per cent and imports by 14 per cent.

The composition of GDP has witnessed a significant shift from agriculture to manufacturing over the years as indicated in Table 1.

Table 1 : Composition of GDP

Sector	1975	1990
	% share	
Agriculture	26.9	12.4
Mining and Quarrying	2.2	3.6
Manufacturing	18.7	26.1
Construction	3.8	7.2
Other	48.4	50.7

Principal items of import are machinery, manufactured goods, chemicals, minerals, fuel and lubricants and crude material. Principal export items are textiles and clothing, rice, rubber, tapioca products, prawns, sugar, precious stones and in recent time manufactured products such as integrated circuits.

The balance of trade has been negative over the years, vide Table 2.

The share of manufactured exports in total export is high, of the order of 80 per cent. The country has an open market economy with the private sector playing a major role; the role of the government is, by and large, limited to providing infrastructural support and running public utility services like railways and communications and being a promoter and facilitator of private enterprise in preferred directions. Public investment in developing infrastructure has been receiving government's attention in recent years.

Table 2 : Balance of Trade

	1988	1990	1992
		Billion Baht	
Imports	513.114	844.448	1033.244
Exports	403.570	824.644	589.813

S&T policy framework

Although the recognition of the centrality of science and technology to economic development appeared in Thailand about four decades ago the formal government S&T policy was announced only in 1983. The policy had for its objectives: the acceleration of scientific and technological research, development and services with a view to achieving economic and social stability; R&D was to be directed to achieving agricultural and industrial development and use of natural resources with due regard to the environment. The goals of the National Development Plans have generally been the alleviation of poverty, raising the standard of living, and achieving self-reliant growth through, inter alia, application of technology. The industry-related objectives of the Seventh National Development Plan (1992-96) include:

(a) sustaining high rates of industrial growth and manufactured exports; (b) improving industrial competitiveness; (c) enhancing the qualitative aspects of industrial development, particularly ecological/environment and (d) reversing trends of growing disparities among regions and population groups.

These objectives are to be realised through three strategies: (i) industrial 'deepening', i.e. developing basic industries; strengthening inter-industry linkages and reducing the high degree of import dependence in the industry; (ii) industrial development of regions and halting of industry concentration in and around Bangkok; (iii) stricter regulations and controls for ensuring environment protection and emphasis on environment-friendly technologies.

National S&T capabilities and status of industrial R&D

Thailand's expenditure on R&D excluding defence has been low - about 0.5 per cent of GNP (till Sixth Plan 1982-91), almost all of it spent within the government sector; estimates of private sector spending on R&D are placed at a mere 0.1 per cent of its sales revenue.

R&D infrastructure

There is the Ministry of Science, Technology and Energy (MOSTE) responsible for overall policies, plans and projects related to science, technology, energy and environment; developing technology, supporting and providing services related to both internal and external technology transfer and information on Thailand's S&T and R&D activities. Thus MOSTE has (i) office of S,T and E Policy Planning; (ii) The National Research Council (NRC), which allocates government research funds to promote basic RD&E and inter alia, coordinates the research work of the public and private sectors; (iii) Technology Transfer Centre (TTC); (iv) Department of Science Services (DOSS) for testing, certification and information on patents and standards; (iv) Science and Technology Development Board (STDB); (v) Thailand Institution of Scientific and Technological Research (TISTR); and (vi) three specialised research centres to coordinate and promote the development of biotechnology, materials technology, electronics and computer technology.

There are several R&D institutions with every major socio-economic government department viz. the Ministry of Industry (MOI) has with it the Thailand Management Development and Productivity Centre (TMDPC) and the Metalworks and Machinery Industries Development Institute (MIDI), which provide technical and management consultancy to small and medium firms and the Thai Industrial Standards Institute (TISI).

Other support facilities for industry are in the field of Standards, Metrology, Testing and Quality Control. The STQC programme under the Science and Technology Development Board, is meant for : (a) Documentation standards, including product standards; and (b) Physical/metrological standards. Testing services are offered by several laboratories, which fall into three categories, viz. (a) Government Laboratories designated by TISTR; (b) Private

Laboratories; (c) Laboratories of private manufacturers, primarily meant for internal testing needs. To meet the growing demand for industrial testing services, a Testing Laboratory Accreditation Programme is in operation since 1988.

Total R&D personnel are estimated to be around 10,000 giving a figure of 0.17 per one thousand persons of population. Significant shortages of qualified S&T manpower exist at the level of professional engineers and researchers, i.e. university degree level in engineering and post-graduate and research degree levels in science, engineering and technology. A survey indicated that 0.2 per cent of S&T personnel had doctoral degrees, three per cent a Master's degree and 24 per cent, a bachelor's degree. At the sub-professional level i.e., vocational diploma-holders, the supply may be more than demand though certain specific sectors face shortages. Curricula do not reflect the changing needs of the industry either in terms of technical areas or in practical relevance. The need for proper manpower planning is, however, receiving the attention of authorities, including the need for flexibility in the education system to respond early to the emerging demands of trained manpower with requisite knowledge and skills. The number of engineering programmes, as also the number of candidates admitted to them, are being increased and a large number of scholarships are being arranged for higher studies abroad in science and engineering, using overseas resources. Overseas Thai nationals are being wooed to work in Thailand. The private sector is being encouraged to share the responsibility for generating the needed S&T manpower, and allowing use of their facilities towards their training. There is a severe shortage of teachers with industrial experience. However, several collaborative training programmes have been established by the industry and the educational institutes, for example, for the plastics industry at the King Mongkut Institute of Technology (KMIT), Thon Buri, and for the electronics industry at KMIT, Lad Krabang. Short-term refresher, and specialised courses are run for the industry by several organisations like Technological Promotion Association, National Institute for Skill Development of the Labour Development and the Thailand Management Development and Productivity Centre.

Overall it would appear that the indigenous technological capabilities are modest: R&D has been a neglected area in industry and foreign firms or joint-venture companies with foreign firms. look to R&D of the parent company; private indigenous firms spend little on R&D; technologies for modern industries have generally been imported on turnkey, packaged basis and remain embodied in the machinery; inter-industry linkages as also industry-R&D university linkages are weak; industrial support infrastructure is also weak such as casting, forging, plastic moulding, precision machinery etc.

Technology transfer mechanisms

Thailand depends heavily on technology imports, yet 'there is virtually no procedural involvement for technology imports'. 'Sourcing of technology/plant and machinery, selection of a particular process, technology fees/royalty payments are solely left to the choice of the entrepreneur. The technology acquisition has suffered from a poor information base on available technologies as also the limited ability of small enterprises to assess, acquire and negotiate for technology. The Technology Transfer Centre does disseminate some information for small scale industry but its impact has been limited. The Board of Investment (BOI) is the nodal agency for incentives and promotion to new enterprises going for technology transfers. A significant feature of technology import has been the insistence of the local entrepreneurs, even in a joint-venture, for foreign equity participation in the technology transfer deals. This has been seen as a guarantee to ensure that the technology works, as there are no other means to do so.

Consultancy and marketing assistance to SMEs

Engineering Consultancy Services are at a low key as the turnover of highly qualified engineers is low. However, there are reasonable sized consultancy firms mainly in the construction industry and water resources and agriculture, and a few in process engineering. There are management consultancies also, dominated by foreigners.

The Ministry of Industry, through its Department of Industrial Promotion, is responsible for providing technical and management consultancy in SME. The Thailand Management Development and Productivity Centre (TMDPC) provides consultancy services to manufacturers in the fields of marketing, management, production and quality control. The Ministry of Commerce provides information on potential export markets, identifying buyers. It also organises international trade fairs in Thailand and participates in them abroad.

Financial incentives and innovative mechanisms for commercialisation of R&D results

There are few institutions to finance technology development/commercialisation of R&D. Limited support is available for the purpose through the Science & Technology Development Board's company directed R,D&E programme, the Technology Transfer Centre's Revolving Fund, and the programmes of three specialised MOSTE Centres.

The financial system is conservative. A number of private venture-capital funds also tend to play safe, supporting commercially tested and proven technologies. However, new initiatives to remedy the situation are being put in place e.g. allocation of a substantial special fund (100 million Baht in 1989) to the Industrial Finance Corporation of Thailand (IFCT) to finance private sector R&D projects; business and technology incubators to help new firms get beyond a good idea for a new technology; technology funds to finance R&D and subsidise venture development funds, which finance development and commercialisation of innovative technologies in new Thai firms.

Issues concerning technology choice - national priorities and concerns

Based on a study commissioned by the Thailand Development Research Institute in 1989, the following three technological areas were identified as highly relevant for the country's industrial development, with due regard to the Technological capabilities of the industries at the firm level; sub-areas within each were also identified: (i) Biotechnology based industries genetic engineering; cell/tissue culture; hybridoma; immobilisation\enzyme engineering; cell culture; biospecific separation; biosensors; DNA/RNA probes; (ii) Materials technology based industries basic metals (steels); parts/components (automobiles, machinery); ceramics; plastics; rubber local minerals (tin,tungsten,antimony); machinery, machine tools and electric equipment); new materials; (iii) Electronics and information technology data processing (hardware/software); telecommunications; digital technology; software engineering; semiconductor IC technology; electronic materials.

The considerations that went into this choice pertained to the following factors: present status of industry and technology; future scenarios; level of automation required, while technology import would retain its important place in industrial development, there would be greater emphasis on technology adaptation and innovation capabilities.

Institutional mechanisms for technology monitoring and acquisition

Thai industry has depended heavily on imported technology, supported by an open and liberal policy of the government towards foreign capital, technology and collaborations. The Technology Transfer Centre (TTC) promotes and facilitates technology transfer from abroad.

It has concentrated on information dissemination and negotiations for fair technology transfer agreements. TTC collects information on technological contracts submitted to the Bank of Thailand and on sources of prices of machinery imported as a service to local firms. However, technology acquisition remains by and large a function of the individual firms.

Status of technology assimilation and adaptation in different sectors (private, public and multinationals)

Import of technology has not been so prevalent in the agriculture sector as most farming activities are on a small scale. Technical knowledge, skills and facilities in the public sector are high where most R&D work is done. In the private sector, particularly in the small scale, farm operations, technologies are either traditional or those received from the public sector. Design capabilities for agriculture machinery exist in modest measure in both sectors.

In all other sectors of industry e.g. manufacturing, mining, construction, automobile, transportation, communication, energy etc. the broad picture is liberal imports of technology, with technology information available with the supplier who may pass on further development to local units, low adaptive or innovative activity or capability. The situation does not change greatly with the nature of the sector, though the level of technological knowledge and facilities in the public sector is often quite high; even in joint ventures with leading MNCs, whether in the public or private sector, the indigenous innovative capabilities have seldom developed.

Technology upgradation in SSI sector

Cottage and small scale industries got special attention in the Sixth National Economic and Social Development Plan (1987-91) which, among other things, stated that priority would be given to strengthening capabilities of small scale provincial manufacturers and promoting widespread use of appropriate technology in production process.

The Department of Industrial Production (Ministry of Industry) provides managerial and technical assistance to SSI through technical information, extension and advisory services in such areas as industrial design and engineering, packaging, wood working, ceramics and agro-industries. The Metal Working and Machinery Industries Development Institute provides support to SSI through consultancy inspection and measurement services and a variety of courses on subjects like casting, welding, heat treatment, electroplating, machining and gear cutting. DIP also helps textile manufacturers through consultancy and training. There are also regional Industrial Promotion Centres, acting for DIP to assist cottage and rural industries.

Specific strategies to promote industrial growth and sustainable development

The Thai policy framework welcomes foreign technology and investment. No procedural hassles are encountered by foreigners in this regard. There are tax incentives for export oriented units and units set up in certain regions; the Board of Investment promoted projects carry special privileges mainly in terms of tax benefits. The tariff structure for import of plants and machinery is low and some select capital goods may be exempt from import duty.

Though industrialisation has emphasised the production of finished industrial products and exports, the growth of basic industries, particularly engineering based, has been neglected perpetuating technological dependence in the form of import of capital goods and intermediate products. However, corrective measures are receiving attention. Also along with the export orientation, the indigenous resource base for industry is also being emphasised. Export oriented units get several other incentives in terms of tax drawbacks, rebates, electricity rebates, warehouse facility etc., besides special financial support.

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