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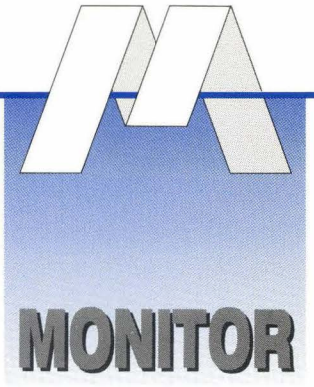

MONITOR - SAST ACTIVITY
STRATEGIC ANALYSIS IN SCIENCE AND TECHNOLOGY

THE NEEDS AND POSSIBILITIES FOR COOPERATION BETWEEN SELECTED ADVANCED DEVELOPING COUNTRIES AND THE COMMUNITY IN THE FIELD OF SCIENCE AND TECHNOLOGY

(Sast Project N° 1)

COUNTRY REPORT ON THAILAND

by
Dr. L. Cuyvers, Faculty of Applied Economics
University of Antwerp (RUCA), Belgium

Dr. K. Ramanathan, School of Management
Asian Institute of Technology, Bangkok

January 1991

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FOREWORD

This report has been prepared for the Strategic Analysis in Science and Technology Unit (SAST) of the Directorate-General for Science, Research and Development of the Commission of the European Communities. SAST activities are part of the MONITOR Programme which aims to identify new directions and priorities for Community research and technological development (RTD) policy and to help show more clearly the relationship between RTD policy and other Community policies.

For questions already identified as of interest for the development of Community policy, SAST projects provide an investigation of the perspectives opened up by science and technology. SAST projects thus serve as an input to the process of policy formulation. In the case of the SAST project to which this report contributes, "The needs and possibilities for cooperation between selected advanced developing countries and the Community in the field of science and technology", the context of policy questions includes the evolving economic relations between the Community and these countries, the interest to the Community of promoting international cooperation in science and technology with various types of countries, and the Community's role in European science and technology.

This report is one of a set of country studies carried out for the project. The set comprises the Republic of Korea, Thailand, other ASEAN countries, the People's Republic of China, India, Brazil and Mexico. An overall strategic review will also be available in 1992.

It should be borne in mind in reading the country studies that the fieldwork on which they are based was carried out almost entirely in the country concerned. The points of view of European industrialists/researchers/policy makers were not explicitly sought for this part of the project. (They will be sought as part of the work for the overall strategic review.)

SAST presents this report as a stimulus to reflection and debate within the European Community on the best strategies to adopt towards a group of increasingly important countries. It must be stressed, however, that the orientation and content of reports prepared for SAST cannot be taken as indicating the considered opinion of policy advisors within the Commission services.

TABLE OF CONTENTS

ANNEXES

LIST OF TABLES (with page references)

REFERENCES

INTRODUCTION AND READERS' GUIDE

The Strategic Analysis of Science and Technology (SAST) Project No. 1 initiated by the European Community (EC) is entitled, "The needs and possibilities for cooperation between selected advanced developing countries and the Community in the field of Science and Technology". The aim of this project is to provide a decision base for policy-makers in developing S&T cooperation between the European Community and a number of selected advanced developing countries of which Thailand is one.

The term decision base, as mentioned above is used to indicate that the SAST Project No 1. consists of an analysis of the many factors that could be considered for decision-making in the area, but is not by any means to be associated with the decision process itself. The decision base is expected to include a description and analysis of the S&T situation in the countries in question against the political and economic background and the signalling of the most relevant facts and developments.

This report on Thailand has been prepared with the objective of providing some basic inputs to this decision base.

In the preparation of this report available publications related to the S&T situation in Thailand were used and the findings were supplemented by having discussions with key Thai officials and researchers in the field of S&T. The number of such interviews that were possible were also constrained by the fact that some of the senior officials whom we would have liked to meet were not available during the period set aside for the interviews. The interviews were conducted by Prof. Dr. Ludo Cuyvers, Dr. G.K. Janssens and Dr. K. Ramanathan. An attempt was also made to meet an investor from Europe, preferably in the small/medium sector, and get his views. This attempt met with succes and this report presents a brief write up of this investor's experience in Annex 2. Annex 3 presents a list of the individuals interviewed at the various S&T agencies and organisations in Thailand.

The two research associates at the Asian Institute of Technology (School of Management) who assisted in the preparation of this report are Mr. P. M. Nishantha Sanjeeva and Mr. Nipon Chantharawarathit.

The findings with strategic implications for the EC of the study on Thailand are described in the first part. The decision base of part II is divided in the following sections:

Section 1 : Evolution of the Economy of Thailand
Section 2 : Science and Technology Policies and Plans of Thailand
Section 3 : Institutional Framawork for Science and Technology in Thailand
Section 4 : An Evaluation of S&T Capabilities of Thailand
Section 5 : Scope for Cooperation Between Thailand and the EC in the Field of Science and Technology.

EXECUTIVE SUMMARY

A corner-stone for EC strategies in the Far East

More than the other Newly Exporting Countries of ASEAN (possibly with the exception of Malaysia), Thailand offers large advantages for foreign direct investment with few government interferences. Thailand should become a corner-stone for the global competition strategy of Europe and the European companies in the Far East. A number of EC companies are already present, but the weight of Europe has to increase, so that interventions of the EC and the member countries can benefit from economies of scale. By concentrating our actions on a few countries in the South-East Asian region, rather than dissipating the efforts on many small initiatives in various countries, the EC intitiatives could reach a "critical mass".

The economy of Thailand has been booming for the past three years. The investment promotion incentives of the Board of Investment, the remarkable political stability of the country and its strategic location in the region, among other factors, have attracted many foreign investors, particularly from Japan and the Asian Newly Industrialising Countries (South Korea, Taiwan, Hong Kong, Singapore). Japan and the NICs are considering Thailand as a "battlefield" as well as a "springboard" in their global competitive struggle. The European Community, however, has not taken advantage of this situation : in one decade the share of the EC in total foreign investment in Thailand came down from 20 percent to about 9 percent.

Special attention to EC direct investment promotion

The dependence of Thailand on multinational corporations, particularly from Japan, for technology, capital goods and intermediates, has obviously consequences for the S&T situation and plans of the Thai government, and opens interesting opportunities for the EC for mutually beneficial cooperation with Thailand. The EC has to seize these opportunities quickly if it wants to stay present in the region in a more than marginal or symbolic way. Therefore, the EC should devote special attention to promoting European direct investment in Thailand by significantly lowering the thresholds and barriers to entry for Europe, and by removing some of the major structural disadvantages of European companies compared to Japanese firms. Among our main recommendations (see also our ASEAN report) we list e.g. well-focused financial incentives, "trouble shooting services" dealing with the bureaucracy in Thailand and other investment support services (business information and intelligence, consulting network, etc.)

The EC can use Thailand as a bridgehead for the markets of the Asian-Pacific rim and in the global competitive struggle against Japan and the NICs. The competitive edge the EC can acquire in Thailand is still substantial. The EC has to give suitable incentives to European and Thai (or other ASEAN) business partners to enter into economic and S&T cooperation, now that there is still room for succesful competition in various sectors. The long-term position of the EC in the Far East and South-East Asia is the main reward against which the European Commission and the EC member countries should evaluate the benefits Thailand will get from cooperation.

Viewed from this perspective, the economic situation in Thailand creates highly interesting opportunities for the European Community to enter into economic and S&T cooperation.

Weaknesses of Thailand's S&T situation

While there is tremendous potential for the application of S&T in the overall development of Thailand, it is not exaggerated to say that the scientific and technological capability necessary to utilise this potential is not adequate and has several weaknesses. This does not mean that there is no technological capability. In a relative sense, Thailand's technological capability is certainly higher than many of the countries in the Asia Pacific region. However, it is not adequate at present to help achieve Thailand's aspiration of quickly catching up with technologically advanced NICs.

In general, it appears that in Thailand there exists a good technological infrastructure which could serve as a foundation to build on but there is inadequate technological capability to carry out R&D, technology transfer and effective industrial production required by the changing structure of the economy.

The reasons for the low level of technological capability in Thailand are :

- shortage of skills in key S&T areas,
- inadequate information services,
- inadequate technical services (testing, calibration, standardisation, consultancy, etc.)
- lack of raw material supplies and supportive industries,
- lack of specialised technology centers,
- lack of R&D and innovative incentives,
- inadequate S&T policy and legal support.

The popular feeling in Thailand is that the S&T policy and plans developed so far have not produced the desired results. Our discussions with S&T key-persons in Thailand revealed factors such as bureaucracy, inadequate funding, shortage of skilled manpower, lack of political will, duplication of activities of the various institutions and insufficient coordination. Moreover, only 0.3 percent of GDP is spent on R&D (1985), and less than 3 percent of the total national R&D expenditure is spent by the private sector.

Interesting opportunities

These serious shortcomings and weaknesses of the S&T situation in Thailand offer, however, interesting opportunities for future S&T cooperation, as well as for supportive activities for potential EC investors, if the EC is prepared to combat the competition of Japan and the Asian NICs on their own "playground", namely the ASEAN region and particularly Thailand.

The following strategic recommendations should be taken into account by the EC, apart from a number of more general guidelines listed in our ASEAN study. These recommendations are much influenced by the Japanese strategies in Thailand.

The reasons for the low level of technological capability indicating several areas for mutually beneficial cooperation between the EC and Thailand, the EC/European institutions/firms have the opportunity to set up commercially-oriented institutions in Thailand in the fields of training, information services, technical services and specialized technology centers.

The S&T institutional framework in Thailand is quite complicated with a certain overlap in the activities of different institutions. When embarking upon any program of activity, the EC should ensure, following the Japanese experience, that all institutions involved in that type of activity (e.g. standardization) are consulted and involved if necessary in the program.

There exist considerable R&D capabilities in selected areas such as agriculture and health. As a first stage, the EC should embark on joint R&D activities in these areas and not on industrial R&D. The EC may wish to associate itself more closely with the three special national centers that are likely to play a major role in guiding future development in the fields of biotechnology-based industries, material technology-based industries and electronics and information technology-based industries.

The EC should adopt longer term views

As part of its economic strategy in South-East Asia, the EC could assist the Thai Government in developing long-term measures to foster the R&D capabilities of Thai industry by taking a bold step which may, however, not bring immediate benefits in the short run, but is almost certain to yield benefits in the longer term. Active EC involvement in establishing and operating Technology Parks, e.g., may be welcome by the Thai Government.

To spot the opportunities available due to changes in the S&T policies of Thailand, the EC has to devise a method for continuously monitoring the policy environment of Thailand and highlight attractive opportunities that may arise. The Japanese agencies in Thailand did considerable monitoring and analysis of the S&T policy environment and disseminated the information quickly to Japanese firms, thereby enhancing their preparedness and negotiating capacity. The EC should evolve a strategy along similar lines to elicit a quick and confident response from EC firms interested in investing in Thailand.

In the future, if suitable policies are implemented to make in-house R&D attractive in Thailand, it is certain that the Japanese firms will take advantage of such policies. R&D activities on adaptations and incremental improvements can still be carried out without industrial or commercial disadvantage even if there is inadequate protection of intellectual property in Thailand. Therefore, with EC support and guidance, in some specific sectors (e.g. automotive spare parts and accessories) could start cooperation with Thai firms, testing the IPR situation in Thailand, the improvement of which should be the main condition for later investment and cooperation in other sectors.

PART I : STRATEGIC REVIEW

I.1. - INTRODUCTION

I.2. - EVOLUTION OF THE ECONOMY OF THAILAND AND THE POSITION OF THE EUROPEAN COMMUNITY

I.3. - S&T POLICIES AND PLANS IN THAILAND AND IMPLICATIONS FOR THE EUROPEAN COMMUNITY

I.4. - IMPLICATIONS FOR THE EUROPEAN COMMUNITY OF THE S&T CAPABILITIES AND CAPACITIES IN THAILAND

I.5. - CONCLUDING REMARKS

I.1. INTRODUCTION

Thailand appears to be Asia's latest economic success story. Its GDP growth rate in 1988 is estimated to have reached 13.2 % and the 1989 growth rate is expected to exceed 12 %. These growth rates are among the highest in the world. Reputed institutes in Thailand such as the Thailand Development Research Institute (TDRI) and TISCO Securities Research have predicted that the Thai economy will record 8-10 percent annual increases over the next five years and Thailand is expected to move towards Newly Industrialized Country (NIC) status during this decade.

When compared to Japan, the Asian NICs and the USA, the European Community does not seem to have taken advantage of this economic boom in Thailand. While Japanese exports to Thailand have increased from approximately 40 billion baht in 1980 to 149 billion baht in 1988 (25 baht equals approximately 1 US$), the European Community exports have gone up from about 25 billion baht in 1980 to 79 billion baht in 1988. In fact, in 1988, while Thailand had an adverse balance of trade of 84.5 billion baht with Japan, it enjoyed a trade surplus of 4.45 billion baht with the European Community.

The foreign direct investment pattern in Thailand also indicates that Japan, the USA and the Asian NICs have taken greater advantage of the investment opportunities in Thailand, when compared to the European Community. In 1980 out of a total foreign direct investment of 3,878 million baht, the US, Japan, the Asian NICs and the European Community accounted for 18.9, 23.3, 36.2 and 20.0 percent respectively. In 1989, the estimated percentages, however, were 14.2, 50.2, 20.2 and 9.3 foreign direct investment of 17,133 million baht.

During the course of this study on "The S&T Situation in Thailand and the Scope for Cooperation with the EC", when we interviewed several key Thai government officials, analysts and researchers, we got the distinct impression that they were puzzled by the lack of enthusiasm of the European Community in entering into mutually beneficial cooperation schemes with Thailand. They argued that if Japan and the Asian NICs are finding it possible to benefit by trading with and investing in Thailand, they see no reason why the European Community cannot do the same. In fact many of them welcomed European Community involvement on a mutually beneficial basis as a means of reducing what they perceived as over-dependence on Japan for technology-based development.

We will first review in Part I.2., the evolution of the economy of Thailand and establish the strategic importance of Thailand for the European Community in ASEAN and in the Asian and the Pacific region (ESCAP region). The consequence of this is that S&T cooperation between the EC and Thailand has to be stimulated and increased. We will therefore consider and assess in Part I.3. the S&T policies and plans of Thailand, in order to draw the attention to some implications for the EC strategy and approach of Thailand. Part I.4. is devoted to some considerations related to the S&T capabilities in Thailand and its implications for the EC. In a final section, and taking due account of the foregoing, the scope for cooperation between Thailand and the EC in the field of S&T will be reviewed. We also refer to the strategic implications and recommendations in our study on cooperation between the EC and the ASEAN countries, where a general cooperation framework and a number of guidelines, observations and recommendations are given, which will not be repeated here. The following recommendations for S&T cooperation between the European Community and Thailand should be viewed as an elaboration of some of the observations and recommendations on ASEAN countries.

I.2. EVOLUTION OF THE ECONOMY OF THAILAND AND THE POSITION OF THE EUROPEAN COMMUNITY

The rapid economic development of Thailand over the last decade is attributed mainly to the diversification of the national economy and a dynamic export drive. While the agricultural sector contribution has come down from 25.4 % to about 16 %, in absolute terms it is still strong enough to ensure Thailand's ranking as a leading food exporter in the world. The manufacturing sector with a GDP share of about 24 % in 1989 is expected to lead economic growth in the 1990s. However, current development thinking appears eager to ensure that manufacturing is not favoured at the expense of agriculture. It is felt that Thailand has acquired a fairly high level of technological capabilities in agriculture and the greater recognition and promotion of the role of agriculture in its economy could yield greater benefits. In fact it is often stated that instead of shooting for NIC status, Thailand should really try to achieve NAIC (Newly Agro-Industrialised Country) status.

The importance of foreign direct investment (FDI) has been emphasized by the Thai government right from the 1970s. The FDI net flows had only been 1 % of the annual private capital formation in 1960, and has now come to a level of 4.25 % and 9.62 % in 1987 and 1988 respectively. Several factors have contributed to this rapid increase. These include the following :

- The maturation of the Japanese and Asian newly industrialised countries (NICs) economies has led to rising costs and appreciating currencies in those countries, along with quotas imposed on many of their exports to Europe and North-America. In response, investors from these countries have sought low-cost manufacturing sites not yet affected adversely by quotas so that they can maintain their export competiveness and momentum, Thailand appears to meet these criteria.

- The Taiwanese and South Korean governments have eased restrictions limiting investment abroad. This has led to their increased investment in Thailand in the light of the maturation of their economies. Additionally, fears over political changes in Hong Kong after 1997 have led to increased foreign investment in Thailand from the crown colony.

- Political instability in the Philippines and continuing concern over the political climate in China have also narrowed the list of countries in the ESCAP region suitable for substantial investment. Even though foreign investment in Malaysia and Indonesia has been increasing there still seems to be greater preference for Thailand.

- The low wage and interest rates, artificially low oil prices and tax benefits available to investment projects promoted by the Board of Investment (BOI) are positive attractions, but the stable political environment and favourable attitude towards business appear to be key factors in attracting investment.

- The devalued baht (since the end of 1984) which has facilitated the competitiveness of exports by reducing production costs.

Other reasons which attract foreign investors to Thailand are :

- Political stability of the country which is attributed mainly to the respect and support enjoyed by the constitutional monarchy.

- Availability of a cheap and hard working labour force which can be easily trained.

- Rich natural resource endowment.

- Positive attitude of the Thais towards foreigners and foreign investment since they have not experienced colonialism.

- Presence of a well-entrenched private sector.

- The strategic and central location of the country in the region.

However, there appears to be a feeling that the surge of investment in the period 1987-89 is unlikely to be repeated although there is no reason to expect a significant fall in investment levels. Some of the reasons given for the likely drop include the following:

- Developments in Eastern Europe will attract some Asian attention, especially from Japan, thereby diverting some investment away from Thailand.

- Some of the consequences of Thailand's recent successes will make new investment less profitable, at least in the short term. One of the important consequences is the sharp rise in the salaries of skilled workers and professionals who are in short supply. Furthermore, the Thai Government has decided to raise the minimum wages in 1990.

- Oil prices are expected to rise in Thailand to near the world level during 1990, thereby raising the cost of production.

- Interest rates are also likely to increase in Thailand in 1990, thereby leading to higher costs of operation.

- The congestion around Bangkok and shortage of infrastructure facilities may be disincentives to new projects.

- Land speculation and construction material shortages can hinder and delay infrastructure development and construction activities.

- The proposed introduction of a new value-added tax (VAT) by January 1991 may lead to the elimination of tax exemptions that have previously been offered to investors.

Attempts are being made by the Thai Government to ease traffic congestion by improving the road and rail networks. The Government has also designated special Investment Promotion Zones, away from Bangkok, where promoted industries, if located, could become eligible for special tax and duty privileges. It is envisaged that the spreading out of industries could ease the pressure on the infrastructure in Bangkok and its surroundings.

The Thai Government also plans to establish a Data Processing Zone (DPZ) by 1991. The DPZ would be a high-security area which would offer state-of-the-art data processing, software development and telecommunication facilities. It is envisaged that corporations such as commercial banks, airlines, credit card companies and multinational companies could put up their data processing centres at the DPZ. The Thai Government views the establishment of the DPZ as a quantum jump in improving the information technology infrastructure in Thailand. It is felt that the DPZ would also help to overcome many of the

problems faced by foreign and local investors with respect to inadequate telecommunication facilities.

Japan, the USA, the EEC and the Asian NICs are the major foreign investors in Thailand. The Japanese share of investment in Thailand has increased since the 1980s and has now become the single largest source. In 1988 and 1989, Japan accounted for over 50 % of the total foreign investment (Total FDI of about 28 billion baht in 1988 and an estimated value of 40 billion baht in 1989). The share of the USA has been declining since 1985 and accounted for only 11 % in 1988. The EEC and the Asian NICs averaged about 9 % and 24 % respectively during 1986-1988. Among the NICs, Taiwan and Korea appear to invest increasingly.

According to the Bangkok Post Economic Review of 1989, the Japanese Chamber of Commerce predicts that the Japanese, being the largest group of investors in Thailand, feel very confident about the continued growth of the Thai economy. The survey results of this investigation show that Japanese businessmen feel that the economy of Thailand will continue to do well as at present.

Being regarded by Japan and the Asian NICs as most promising, profitable and stable host country among the ASEAN countries (apart from Singapore), Thailand evidently should be considered in the same way by the European Community. Among the ASEAN Newly Exporting Countries, Thailand offers large advantages for FDI with few government interferences. From a strategic point of view, Thailand appears to us the country in the South-East Asian region which is best suited for European business to combat the competition of Japan and of the NICs (South Korea, Taiwan, Hong Kong and Singapore).

The EC can use Thailand as a bridgehead for the markets of the Asian-Pacific rim and in the global competitive struggle against Japan and the NICs. In saying this, we are not just referring to the markets in Japan, South Korea, Taiwan, Hong Kong and Singapore, but also to the ASEAN markets, Australia and New Zealand, and to the promising future market potentials for the EC in Vietnam, Cambodia and Laos. Thailand is aware of its vital importance as future bridgehead for the latter three neighbouring countries, where anti-US sentiments are still widespread.

Viewed from this perspective, the economic situation in Thailand creates highly interesting opportunities for the European Community to enter into economic and scientific cooperation. We refer to our recommendations on EC-ASEAN S&T cooperation for the necessity to stay present in the ASEAN region in a more than symbolic way. Therefore, the EC should promote and provide more incentives to European companies through the existing Cheysson Facilities or an ASEAN-EC Development Corporation (see our recommendations on EC-ASEAN cooperation), to establish European joint ventures in Thailand with Thai or other non-EC partners. We particularly would recommend the creation of this ASEAN-EC Development Corporation as a joint venture between private and public EC and ASEAN financial interests, that would enable the EC to provide substantially more and better focussed financial support to EC-ASEAN joint ventures in both the industrial and service sectors.

The following points have important implications for the EC:

- Thailand welcomes mutually beneficial schemes of cooperation in the field of S&T with the EC. Such schemes are seen as one way of reducing Thailand's dependence on Japan for technology. The current overdependence of Thailand on Japan for technology is perceived as not being in the interests of Thailand in the long run.

- Various external factors and prudent national policies have led to export-oriented growth in Thailand. The Japanese and to a lesser extent also the Taiwanese, appear to have taken advantage of this economic boom. The Thais feel that the EC has failed to make use of this opportunity to make its presence felt in Thailand.

- The Thais are not sure how Thailand is viewed by the EC vis-à-vis Eastern Europe from an investment point of view. The 1992 single European market is also viewed by the Thai Government with some apprehension especially due to the protectionist pressures that some of its exports are facing in the EC.

- The percentage of technology-intensive products in Thailand's exports is gradually increasing. One of the reasons could be that transnational corporations (especially Japanese-owned) are shifting the labour-intensive stages of their production chain to Thailand to take advantage of the cheap labour in Thailand. There are several high-tech areas in which Thailand is either having or showing an improved revealed comparative advantage. EC companies in these areas may wish to take advantage of these possibilities.

  Capital goods and intermediates account for a very large portion of Thailand's imports. Considerable incentives are likely to be given in the future for the establishment of import-substituting industries in these areas. The EC companies in these areas may wish to review this option as a means of entering the Thai market and using it as a base to expand their exports to other countries in the ESCAP region.

- Although Thailand is regarded by the industrial countries (particularly the USA) with suspicion because of many infringements upon intellectual property rights (counter-feiting of watch brands, casual wear brands, automobile parts and accessories, etc.), this should not be too much a concern, because these infringements are encountered in many other advanced developing countries. More serious seems to us the general observation of many experts, that the court system in Thailand is not sophisticated enough to enforce IPR legislation.

- Faced with intensified protectionism, Thailand is keen to diversify away from its conventional markets and seek trade links with other countries. EC countries which do not have strong trade ties with Thailand at present may wish to use this opportunity to explore mutually beneficial trade possibilities.

- Several infrastructural inadequacies are likely to affect the future inflow of foreign direct investment into Thailand. To overcome some of these inadequacies the Thai Government is planning to take steps in the near future. This offers scope for potential cooperation between the EC and the Thai Government. The expertise of some of the EC nations in the field of telecommunications could be put to good use in the proposed Data Processing Zone.

I.3. S&T POLICIES AND PLANS IN THAILAND AND IMPLICATIONS FOR THE EUROPEAN COMMUNITY

Although the need for S&T policy and planning has been highlighted in Thailand explicitly since the Fifth National Economic and Social Development Plan (1982-1986), the popular feeling is that the policies and plans developed so far have not produced the desired results. Our discussions with Thai Government officials, S&T policy analysts and researchers brought out the following major points related to S&T policy, plan formulation and implementation in Thailand.

- Development of S&T in Thailand has been affected always by two barriers, namely bureaucracy and inadequate funding.

- In the Thai S&T system there appears to be some misunderstanding about the nature of science and technology and their interrelationships. Some individuals think only of science when referring to S&T, while others think only of technology when talking about S&T.

- Some argue that Thailand spends too much money on science and not enough on technology. Others express the opposite view. One conclusion that may be drawn in the light of Thailand's aspirations is that if the country is to achieve self-reliant economic development then far more efforts are required in the fields of both science and technology.

- Formulation of S&T policies and plans and their implementation become very difficult because S&T activities cut across many ministries and organizations. Even within the Ministry of Science, Technology and Energy (MOSTE) there are many institutes which can set up their own policies. This very often leads to duplicity of activities and poor use of scarce resources.

- The future economy will be "knowledge-based" where technological know-how may well be more critical than capital and labour. Thailand is aware of the necessity to prepare itself for this future economy by stepping up its R&D efforts which at present are dismally low by world standards.

- Technology upgradation efforts in the private sector, on which the Thai economy relies heavily, have to be stepped up if Thailand is to achieve competitive advantage in the international market place. Many manufacturers find it convenient to buy (international transfer) technology, rather than generating it in-house. The S&T policies have not been able to change this attitude.

- There are two reasons why the private sector shows disinterest in in-house R&D. Firstly, they view money spent on R&D as an expenditure and not as an investment. Secondly, the private sector is in business to make profits and not achieve "technology supremacy" per se. They will therefore select a technology upgradation route which is most profitable. The S&T policies have not adressed these issues seriously.

- Even if the government formulates S&T policies to make in-house R&D attractive, there is a serious shortage of skilled manpower at present. On the one hand, a sizeable number of Thai professionals studying abroad do not return, while on the other, highly qualified personnel from universities and public sector R&D institutes

are increasingly taking up higher paid managerial jobs in the private sector. The output of scientists, engineers and technicians from the universities and technical institutes is also inadequate to meet the increased demand for S&T personnel due to the establishment of a large number of FDI industries in recent years. S&T policies have failed to deal with these problems effectively.

- Most of the R&D activities in Thailand are carried out by public sector organizations. There seems to be a widely held view that, with some exceptions, most of these institutes have failed to adopt a "demand-pull" approach in formulating R&D projects. The "supply-push" approach taken by them at present often leads to the development of technology not wanted or with little commercial value. Promotion of contacts between industry and government research institutions has not received adequate attention in S&T planning.

- There seems to be a lack of political will to enact major legislation related to S&T. Such enactments can eliminate many of the constraints currently faced in the implementation of S&T policy in key areas. For instance, it is felt that the establishment of a National Council for Science and Technology with a strong inter-ministerial character can help in the coordination of S&T activities and harmonize the efforts of the numerous bodies involved in S&T. This recommendation appears to have gone unheeded for several years. Another example is the lack of appropriate legislation to promote R&D in the private sector. While several recommendations have been made, no major steps have yet been taken.

It was also pointed out that at present the Thai Government is really a coalition of several political parties. Since ministers occupying key ministries often come from different political parties, inter-ministerial coordination of efforts for S&T policy formulation, planning and implementation proves to be very difficult. This could have led to some of the difficulties mentioned above.
Although a proposal to give more power to the Science and Technology Development Board has passed the Cabinet in Summer 1990, the most likely scenario is that the proposal will get stuck in a special Parliamentary Committee that will be established. In a coalition government like the present Thai government it is highly improbable that one party or minister will be allowed by the others for having unacted changes in the S&T institutional framework like these at issue.
Both the presence or absence of sound S&T policies offer opportunities for countries which wish to pursue mutually beneficial cooperation with Thailand in the field of S&T. In this context the following observations may be relevant to the EC.

- Inappropriate policies to encourage R&D appear to have led to an overwhelming dependence of Thai firms on foreign sources for technology to implement both the import substitution and export-oriented growth strategies. In the recent past the Japanese, through the mechanism of FDI, have provided the technology required and reaped rich rewards. The EC seems to have let this opportunity slip. However, such opportunities may still be available and the EC should explore such possibilities aggressively both in sectors where Japanese FDI is already present and others. It is, however, necessary that a number of structural disadvantages of EC companies vis-à-vis the Japanese competitors should be dealt with by EC initiatives, particularly in business information and intelligence, and financial backing (see our recommendations for ASEAN).

- In the future, if suitable policies are implemented to make in-house R&D attractive, it is certain that the Japanese firms will take advantage of such policies. R&D

activities are needed not only to achieve radical innovations and major breakthroughs but also for carrying out adaptations and incremental improvements. The latter category of R&D activities can still be carried out without disadvantage even if there is inadequate protection of intellectual property in Thailand. This is one aspect of commercial R&D that the EC may wish to prepare for, and take advantage of, if the R&D oriented policies formulated in the future prove to be attractive.

- Even if the EC firms wish to set up operations in Thailand and carry out in-house R&D, they will still have to face the problem of the shortage of skilled manpower at all levels. Serious consideration must be given by these firms to the mode of recruiting, training and retaining skilled manpower.

- To spot the opportunities available due to changes in the S&T policies of Thailand, the EC should devise a method for continuously monitoring the policy environment of Thailand and highlight attractive opportunities that may arise. During our discussions the Thai officials often expressed their admiration for the Japanese agencies in Thailand which did considerable monitoring and analysis of the S&T policy environment and disseminated the information quickly to Japanese firms. It was pointed out that when Japanese investors came for negotiations, they were well prepared and at times knew even more about the policy environment and Thailand's technological needs than their prospective Thai counterparts ! Thus, the EC may wish to evolve a strategy along these lines to elicit a quick and confident response from EC firms interested in investing in Thailand. More information and intelligence responsibilities should be given to the Delegation of the Commission of the European Communities in Bangkok, and within the European Commission the various existing general and sectoral information on Thailand and other ESCAP countries should be brought together in computerised databases accessible to the EC business community. In order to keep these databases updated it is highly advisable for the European Commission to command regularly both sectoral studies and more general policy-oriented studies, and to develop a cooperation network of research institutes in the EC and Thailand.

I.4. IMPLICATIONS FOR THE EUROPEAN COMMUNITY OF THE S&T CAPABILITIES AND CAPACITIES IN THAILAND

The S&T institutional framework in Thailand is quite complicated with a certain degree of overlap in the activities of different institutions. Some of these institutions were referred to as mere "intellectual playgrounds" by some of the analysts we interviewed. The following aspects may be of relevance to the European Community in considering its future strategy.

- When embarking upon any program of activity, the EC should ensure that all institutions involved in that type of activity (e.g. standardization) are consulted and involved if necessary in the program. While this can be cumbersome, it appears to be the only way to deal with the existing situation. Again, the Japanese appear to have understood this well. In their program to upgrade testing and calibration facilities (which are indeed required for the Japanese companies operating in Thailand) they have managed to get both the Thailand Industrial Standards Institute (TISI) and the Thailand Institute of Scientific and Technological Research (TISTR) involved although these come under different ministries. Therefore, in matters related to foreign direct investment, the EC should liaise with the Office of the Board of Investment (BOI), but in specific circumstances also the Technology Transfer Centre at the Ministry of Science, Technology and Engergy (MOSTE) and the Science and Technology Development Board (STDB) should be contacted. For S&T information system development, the MOSTE, STDB and the Thailand Development Research Institutes (TDRI) are the nodal points in the Thai S&T system.

- The three special centers - the National Center for Genetic Engineering and Biotechnology (NCGEB), the National Electronics and Computer Technology Center (NECTEC) and the National Center for Metal and Material Technology (NCMMT) - are likely to play a major role in guiding future development in the fields of biotechnology-based industries, material technology-based industries and electronics and information technology-based industries. The Japanese have already associated themselves with the activities of NCGEB and NECTEC, and the US with that of NCGEB. The European Community may wish to associate itself more closely with these centers to enhance its presence in these industries and the R&D activities associated with them.

With respect to the S&T capabilities in Thailand, the following implications from the point of view of the EC can be listed.

- The R&D capability of Thailand is quite low. Considerable changes are needed in the Thai S&T environment to enhance this capability. However there exist considerable R&D capabilities in selected areas such as agriculture, biotechnology and health. As a first stage, the EC may wish to embark on joint R&D activities in these areas and not on industrial R&D.

- From a long-term perspective, the R&D capabilities of Thai industry have to improve. The EC may wish to assist the Thai Government in developing measures to foster such capabilities by taking a bold step which may, however, not bring immediate benefits in the short run. The Thai Government is very keen to set up Technology Parks to enhance innovative activity in the Thai industry. At present, the MOSTE is carrying out feasibility studies in this regard. Five such parks are

expected to be established. Active EC involvement in establishing and operating such parks may be welcome by the Thai Government. However, as stressed above, this may not lead to immediate returns but is almost certain to yield benefits in the longer term.

- The dissatisfaction with the Japanese firms with regard to technology transfer may make it easier for EC firms to transfer technology to Thailand. However, such potential transferors will have to take note of the aspirations of the Thai transferees with regard to the transfer of "core" technology, its assimilation and eventual indigenization. Failure to take note of such legitimate aspirations will not facilitate mutually beneficial cooperation on a sustained basis. On the other hand, the IPR situation in Thailand demands some caution. We think it would be a good strategy for the EC to give special attention to a few industrial sectors (e.g. the production of specialty chemicals, or the production of automobile parts and accessories) for the transfer of "core" technology, aiding EC and Thai partners to solve any emerging IPR problem. The experience could later be used in other EC-Thai partnerships.

- The reasons for the low level of technological capability indicate several areas for mutually beneficial cooperation between the EC and Thailand. EC institutions/firms have the opportunity to set up commercially-oriented institutions in Thailand in the fields of training, information services, technical services and specialized technology centers. We refer to our recommendations on EC-ASEAN S&T cooperation.

- EC firms may also wish to establish downstream and upstream industries in Thailand in the fields of biotechnology-based industries, material technology-based industries, and electronics and information technology-based industries.

- The S&T policy area in Thailand is considered to be unsatisfactory and is considered to have hampered the growth of technological capability. The EC may wish to provide expertise to the Thai Government in this area based on the extensive experience they have accumulated. We refer to our recommendations on EC-ASEAN S&T cooperation in the field of S&T management support services and consultancy.

- There is need for cooperation in "demand-pull" R&D, by cooperation with the Science and Technology Development Board (STDB), or by providing venture capital (through the use of the existing Cheysson Facilities or by the proposed EC-ASEAN Development Corporation) to EC-Thai R&D joint ventures, with Thai individuals and universities, for the commercialisation, development and exploitation of R&D results. There are good prospects in the field of biotechnology, entailing cooperation with the Thai National Centre for Genetic Engineering and Biotechnology (NCGEB).

- The shortage of skills is almost certain to affect adversely all forms of EC cooperation with Thailand in the field of S&T. The EC should explore ways - both commercial and non-commercial - to alleviate this problem. It may be of interest to note that Japan started helping Thailand to acquire and upgrade vocational and technical skills almost 20 years ago (when there was hardly any Japanese investment in Thailand) by establishing vocational training institutes and providing funds for training. Our discussion revealed that Japan is planning to establish more such institutes to provide training in areas where there is an acute shortage of skills. It is envisaged that some of these institutions may eventually be upgraded to Colleges of Technology.

I.5. CONCLUDING REMARKS

As we also point out in our study on S&T cooperation potentials with the ASEAN countries, the European Community should concentrate its actions in order to reach a "critical mass" of intervention. More geographical concentration of EC actions in the field of S&T cooperation on Thailand, rather than to disperse it over the whole Sout-East Asian region, is imperative (see in this respect the guidelines of the Commission of the EC of June 1990) [24]. Consequently, EC-Thai bilateral S&T cooperation should be increased considerably.

In section 5 of Part II we examine the scope for cooperation between the EC and Thailand based on an identification of the technological needs of Thailand. While an exhaustive list of possible areas of cooperation has not been drawn up, some important areas have been highlighted based on discussions with some key members of the S&T community in Thailand.

The scope for enhancing EC investment in Thailand has been looked at by drawing attention to some of the reasons why Japan has succeeded so admirably in raising its level of investment in Thailand. It is evident that unless the foreign investor adapts his investment strategy to suit the Thai environment he is unlikely to succeed.

During our discussion with the Thai officials, analysts and researchers in the field of S&T, we asked them to give their reasons as to why the EC had not been able to make its presence felt in Thailand to the extent that the Japanese have. Their views were quite revealing and these included the following.

- The EC has a fundamental problem in the sense that it is group of nations which have fairly complex arrangements among themselves. Thus they are unable to coordinate their efforts and respond as rapidly as the Japanese can.

- The Japanese monitor the S&T situation very carefully in Thailand and quickly seize opportunities which create goodwill and also facilitate the performance of the Japanese firms in Thailand. For instance the Japanese Government has played a supportive role by helping Thailand to develop its S&T infrastructure by providing vocational training centres, training equipment, fellowships etc. This made the life of the Japanese investor easier because he could draw upon skilled trained labour who were already influenced by the Japanese way of doing things. At present the Japanese seem to be investing heavily in standardization activities. It may be useful to note that Japanese Government support along these lines dates back to almost 20 years ago and is not something recent in origin. The Japanese Government appears to have considered this investment as one that would yield rich dividends in the long term and this approach seems to have worked. The Technological Promotion Association (Thai-Japan) receives an annual grant of almost 15 million baht from Japan with "no strings attached" (as mentioned by its General Manager) to be spent on providing technical services and training to Thais. The TPA plans to set up colleges and perhaps even universities of technology with Japanese support. On the contrary the EC takes a myopic view of the S&T situation and is reluctant to make investments which are likely to yield results only in the long-term.

- The Japanese are prepared to accept shortcomings in the Thai system - red tape, infrastructural problems, inadequate patent protection etc. - as constraints within which they have to work. They therefore adapt their strategy to cope up with these problems. On the other hand the investor from the EC is reluctant to make changes

> in his way of doing things and expects the Thai environment to adapt itself to suit his way of doing things. The EC investors who have succeeded are those who have had the patience and a good understanding of how the Thai system works.

It may therefore be reasonable to say that if the EC is to make significant progress in Thailand its cooperation programs must be implemented based on a strategy that incorporates these perspectives.

There is also a need for continued monitoring of the S&T situation in Thailand, considering the fact that significant developments are likely during the implementation of the 7th Plan especially with regard to laws which can change the functioning of the S&T framework in Thailand.

These developments also imply that the EC will require timely and accurate information to ensure that S&T cooperation between EC and Thailand can be suitably adapted taking into account international cooperation programs between Thailand and countries such as the US, Japan and other industrialized countries. A mechanism to harmonize EC - Thailand S&T cooperation with the bilateral cooperation programs of member countries of the EC with Thailand needs to be developed to ensure optimal utilization of funds in conformity with the guidelines of the Commission on Cooperation with the developing countries of Latin America and Asia [24].

PART II : DECISION BASE

II.1. - EVOLUTION OF THE ECONOMY OF THAILAND

II.2. - SCIENCE & TECHNOLOGY (S&T) POLICIES AND PLANS OF THAILAND

II.3. - INSTITUTIONAL FRAMEWORK FOR SCIENCE AND TECHNOLOGY IN THAILAND

II.4. - AN EVALUATION OF S&T CAPABILITIES OF THAILAND

II.5. - SCOPE FOR COOPERATION BETWEEN THAILAND AND THE EC IN THE FIELD OF SCIENCE AND TECHNOLOGY

II.1. EVOLUTION OF THE ECONOMY OF THAILAND

Thailand appears to be Asia's latest economic success story [15, 31, 44, 56]. As can be seen in Table 1, its GDP growth rate was 11 percent in 1988 and 1989 is considered to be an equally spectacular year with a growth rate of 10.4 percent. In fact the National Economic and Social Development Board (NESDB) has recently revised (in March 1990) the 1988 growth rate upwards to 13.2% and is currently revising the 1989 growth rate of 10.4%. This kind of "bullish" growth performance is viewed by analysts not as an isolated chance occurence, but as a continuation of the economic upswing that began in Thailand in the early 1980's. In fact institutes such as the Thailand Development Research Institute (TDRI) and TISCO Securities Research have predicted that the Thai economy will record 8-10 percent annual increases over the next five years. According to the Bank of Thailand, "the Thai economy today exhibits high potential and its ability to expand is unlimited". TDRI too expects Thailand to be moving towards New Industrialized Country (NIC) status during this decade.

However, one of the worrisome signs in the economy is inflation. It is popularly believed that the government estimates of inflation in the range of about 5% is low. Some estimates put inflation, at the end of 1989, at about 7% nationwide and at least 10% in Bangkok. In late 1989 the Council of Economic Ministers recommended the following steps to combat inflation:

- Reduce restrictions on material imports to bring down production costs.
- Reduce or eliminate the deficit in the 1991 budget.
- Tighten money supply and issue new Bank of Thailand and state enterprise bonds while attempting to maintain a 15% ceiling on lending rates.
- Speed up the public listing of large public sector organizations such as the Electricity Generating Authority of Thailand (EGAT), Thai Airways International (THAI) and the Telephone Organization of Thailand (TOT).
- Curb stock speculation by stricter enforcement of cash payment requirements.
- Curb property speculation by revising land-use zoning.

The rapid economic development of Thailand over the last decade is attributed mainly to the diversification of the national economy and a dynamic export drive. Table 2 shows the contribution of the different sectors of the national economy to GDP. While the agricultural sector contribution has come down from 25.37% in 1980 to about 16%, in absolute terms it is still strong enough to ensure Thailand's ranking as a leading food exporter in the world. The manufacturing sector with a GDP share of about 24% in 1989 is expected to lead economic growth in the 1990's. However, current development thinking appears eager to ensure that manufacturing is not favoured at the expense of agriculture. It is felt that Thailand has acquired a fairly high level of technological capabilities in agriculture and that greater recognition and promotion of the role of agriculture in its economy could yield greater benefits. In fact it is often stated that instead of shooting for NIC status, Thailand should really try to achieve NAIC (Newly Agro-Industrialised Country) status.

In international trade Thailand has maintained a bullish trend in exports. In 1988 exports reached almost 400 billion baht (approx US$ 16 billion) and the estimated figure for 1989 is about 520 billion baht (approx US$ 20.80 billion) - an almost 30% increase (refer Table 3)! Along with an increase in and diversity of exports, there has been an expansion of export markets. Thailand now trades with about 150 countries thereby enabling it to overcome trade protectionism more effectively. Imports of capital goods and intermediate goods and raw materials (excluding fuel) accounted for almost 75% of the total imports in

1989 [14]. Out of total imports capital goods accounted for 39%. Most of the production that this investment will generate has not started yet but it is expected that once new production comes on line, exports will, within the next four years, move ahead of imports. The large volume of imports of intermediate goods and raw materials also reflects the dependence of Thailand on imports for promoting its exports. For instance in the footwear industry it is estimated that Thailand imported nearly two thirds of the raw material used. The need to depend on imported materials which can be produced in Thailand - especially agro-based materials - is causing concern to the Thai Government.

It is recognized that Thailand is dependent heavily on foreign money, technology, raw materials and capital goods for its economic development. It is estimated that the stock exchange is one third powered by foreign money on a daily basis. Foreign direct investment and portfolio investment accounted for almost 66% of Thailand's net capital inflows between 1986 and end 1988. In 1988, the Board of Investment (BOI) of Thailand approved projects worth 158 billion baht in foreign investment. In 1989 this went up to 205 billion baht. In fact in some quarters of the government there appears to be a view that foreign investment must be slowed down and that investment policies should open up more projects to local firms.

One of the areas in which the government is particularly anxious to promote domestic investment is in production of intermediates using local raw materials and capital goods. Examples such as the imports of intermediates which can be produced locally (cf. shoe industry example mentioned above) and heavy dependence on imports of capital goods are cited for promoting domestic investment.

At a cursory glance the Thai economy appears to be in robust health. However, there appear to be certain unique features associated with the development pattern. In the rest of this chapter the main objective is not to go into all these aspects but to examine two key areas which have played a major role in the growth of the Thai economy, namely, international trade and foreign investment.

II.1.1. INTERNATIONAL TRADE

Thailand's international trade grew quite rapidly in 1988 and 1989 (Table 3). Favourable international conditions are considered to be one reason for this favourable performance. Some of the favourable conditions, as stated by GATT, include the following:

- Weak oil prices
- Improvements in the functioning of markets due to deregulation, and denationalisation
- Action by major central banks to stop the recurrence of high inflation
- Increase in the number of joint ventures and mergers
- Increase in interdependence among financial markets throughout the world
- Economic reforms in the Soviet Union, China and certain East European countries.

However, Thai exports performed well not only because of favourable international conditions but also because of government policies. The foreign exchange policy of maintaining the value of the baht at an appropriate level vis-à-vis the currencies of the country's trading partners and rivals has proved beneficial. This has helped to improve the competitive edge of Thai exports in relation to some of its Asian competitors whose currencies have appreciated significantly.

In addition to maintaining a stable value of the baht, Thailand has also, during the last two years, pursued an increasingly aggressive marketing strategy. A large number of trade missions from other countries have been strongly urged to visit Thailand and a large number of Thai public/private sector missions have been despatched each year to seek new markets and expand existing ones. Trade fairs, some entirely for specific product categories, have been arranged within the country, while local entrepreneurs have participated in those held in other countries. These measures are believed to have helped increase exports.

Another factor that has helped to boost exports is the large number of export-oriented investment projects that have been steadily coming on stream. During the period 1986-1989, the BOI statistics show that 40%-50% of the projects submitted for approval intended to export 80%-100% of their output.

II.1.1.1. Analysis of Thailand's trade by commodities

Tables 4 and 5 show Thailand's imports and exports, during 1982-1986, by sections of SITC. The statistics show that Thailand is still heavily dependent on imports of machinery and transport equipment, manufactured goods, chemicals and mineral fuels. However, the percentage share of mineral fuels to total imports seems to have decreased steadily during this period. Increased indigenous production of natural gas, crude and condensate could be one reason. During the first three quarters of 1989 indigenous production was 128,100 b/d of crude oil equivalent which meets about 40% of Thailand's total energy demand.

The major imports of machinery and transport equipment in 1986 were as shown in Table 6 (values indicate percentage of total imports of machinery & transport equipment).

The major imports of manufactured goods in 1986 (given as percentages of total imports in this category) were shown in Table 7.

The major imports of chemicals in 1986 (given as percentages of total imports in this category) were as shown in Table 8.

An examination of the products being imported by Thailand indicates that the country is heavily dependent on imports for capital goods and other technology intensive products. This has important implications from the point of view of formulating investment policy especially with respect to the setting up of industries capable of producing capital goods which will be needed to sustain and enhance Thailand's economic growth.

When the export statistics of Thailand are examined it becomes clear that most of its exports have fairly low to medium "technology content". In 1988 the top 30 export products which accounted for 75.69% of total exports were as shown in the following Table 9. (the figures give the percentage of total exports) [39]

TABLE 6 : Imports of machinery and transport equipment, 1986

Electrical machinery, apparatus, appliances	31.29
- Power machinery, switchgear	22.50
- Distribution machinery	1.45
- Domestic electrical equipment	0.71
- Electromedical equipment	0.46
- Other electrical components	6.17
General industrial machinery (non-electrical)	17.30
Road vehicles and components	13.06
Telecommunication equipment	9.69
Office machines	9.30
Power machinery	5.94
Specialized machinery	4.46
Textile and leather machinery	3.41
Agricultural machinery	1.66
Metalworking machinery	1.53
Aircraft	1.22
Ships and boats	0.98
Railways	0.16
Total	100.00

TABLE 7 : Major imports of manufactured goods, 1986

Iron and steel products	38.00
Textiles	19.38
Non-metallic mineral manufactures	12.15
Manufactures of metals	10.22
Non-ferrous metals	9.26
Paper and paper products	7.59
Rubber manufactures	2.15
Leather and leather goods	1.05
Cork and wood manufactures	0.20
Total	100.00

TABLE 8 : Major imports of chemicals in 1986

Organic chemicals	27.47
Artificial resins and plastics	18.84
Fertilizers	13.08
Other chemicals (pesticides, starches, etc)	12.71
Dyeing, tanning and colouring material	8.42
Medicinal and pharmaceutical products	8.06
Inorganic chemicals	6.48
Essential oils & perfumes	4.32
Explosives and pyrotechnics	0.62
Total	100.00

TABLE 9 : Top 30 export products of Thailand, 1988

Apparel	11.29
Rice	8.19
Rubber	6.74
Gems and jewellery	5.86
Tapioca products	5.41
Canned seafood	4.98
Integrated circuits	4.67
Fabric and yarn	3.40
Computers and parts	3.10
Raw sugar and molasses	2.53
Footwear	2.39
Frozen shrimps and prawns	2.35
Furniture and parts	1.48
Frozen chicken	1.21
Canned pineapple	1.16
Rubber products	1.11
Frozen cuttlefish, squids and octopus	0.95
Maize	0.94
Plastic products	0.89
Ball bearings	0.86
Iron tubes and pipes	0.84
Frozen fish	0.79
Travel goods	0.70
Motor cars and parts	0.67
Toys	0.60
Tin	0.59
Natural gas	0.53
Artificial flowers, foliageand fruit	0.50
Ceramic products	0.50
Leather products	0.46
Total	75.69

These figures once again indicate that the exports of Thailand are in general not of a technology-intensive nature. Of the 30 items listed above those which may be considered to be technology intensive are integrated circuits (4.67%), computers and parts (3.10%), ball bearings (0.86%), iron tubes and pipes (0.84%) and motor cars and parts (0.67%). However most of these tend to be assembly operations where many components are imported and hence the "technology content added" in Thailand is likely to be very low. Thus, in this case the export of technology-intensive products do not really reflect the "technology content" of these industries in Thailand. Even in the case of exports of the above mentioned technology-intensive products, 1989 brought both good and bad news. While exports of computers and parts, and ball bearings (especially electronic bearings) registered increases, there was a drop in the exports of integrated circuits and iron tubes and pipes. The exact figures are not available at present but the year-end Economic Review of the Bangkok Post [14] put these variations at between 10-15% in all four cases.

Having looked at the general picture of Thai exports and imports it may be useful to examine the trade patterns of high and medium R&D intensive products based on the OECD classification and a recent study by Cuyvers [25]. These studies classify the technology intensity of selected products as follows:

High R&D intensive products

SITC	54 :	Medicinal and pharmaceutical products
	75 :	Office machines and ADP equipment
	76 :	Telecommunication, sound recording and reproducing equipment
	77 :	Electrical machinery, appliances and parts
	792 :	Aircraft and associated equipment, and parts
	87 :	Professional, scientific and controlling instruments
	88 :	Photographic apparatus, optical goods, watches etc.

Medium R&D intensive products

SITC	334 :	Petroleum products, refined
	51 :	Organic chemicals
	52 :	Inorganic chemicals
	56 :	Fertilisers, manufactured
	58 :	Artificial resins and plastic materials etc.
	59 :	Chemical materials and products nec
	62 :	Rubber manufactures nec
	69 :	Manufactures of metal nec
	7 :	Machinery and transport equipment (except 75, 76, 77, 792).

Based on this classification the exports and imports of these goods, during the period 1982-1986, for Thailand are shown in Table 10.

From the figures in Table 10 it can be seen that Thailand is a net importer of technology intensive products. Out of its exports, electrical machinery, appliances and parts accounted for 56.8% in 1982, 52.8% in 1983, 50.5% in 1984, 44.9% in 1985 and 52.5% in 1986. However, no conclusions can be drawn immediately on Thailand technological capability in this group of products because there are many transnational corporations operating in Thailand which produce components for re-export to their other subsidiaries. Thus while exports in this category may be "made in Thailand" they need not necessarily be "Thai made".

The only category in which Thailand seems to be a net exporter of technology intensive products is in manufactures of metals (SITC 69: structures, metal containers, wire products, etc.). Also in 1985 and 1986, Thailand has become a net exporter of rubber manufactures (SITC 62: materials of rubber tyres, etc.). These results are in agreement with Cuyvers' conclusion where he states that Thailand has a revealed comparative advantage (RCA) in the production of electrical machinery, appliances and parts, manufactures of metals and rubber manufactures.

Cuyvers' study also shows that Thailand has shown marked improvement in the RCA of SITC 52: inorganic chemicals, SITC 58: artificial resins and plastic materials, SITC 59: chemical materials and products, SITC 75: office machines and ADP equipment, SITC 88: photographic apparatus, optical goods and watches. Table 10 supports these conclusions. In fact the export-import ratios of these products in 1982 and 1986 are as follows:

	1982	1986
SITC 52	0.048	0.090
SITC 58	0.059	0.175
SITC 59	0.043	0.131
SITC 75	0.014	0.236
SITC 88	0.249	0.355

It may be said that while Thailand is still heavily dependent on imports for its technology intensive products, it has over the last few years acquired technological capabilities in certain categories which appear to have improved its competitiveness in the markets for these products. It is of course not clear whether such capabilities are a reflection of the operations of transnational corporations - which almost always bring in their own technology - or improvements in indigenous technological capability. Nevertheless, from a foreign investor's view point the specific categories of products, to which attention has been drawn above, are promising areas for collaborative ventures.

II.1.1.2. Analysis of Thailand's trade by countries

Tables 11, 12 and 13 show Thailand's exports, imports and balance of trade with its major trading partners during the period 1980-1988. The figures show that while Thailand has consistently had a favourable balance of trade with the EEC (except in 1985), it has transformed its adverse balance of trade with the USA and the Middle East to a favourable one since 1985/86. However, with the ASEAN trading partners its balance of trade has become negative since 1983 while with Australia it has always been negative.

However, the most striking feature that emerges from Table 13 is that Thailand's imports from Japan has increased dramatically especially in 1987 and 1988. Table 14 shows the composition of imports from Japan. From this it can be seen that capital goods, raw materials and intermediate goods and vehicles and transport equipment accounted for almost 88% of total imports in 1984. This has gone up to about 91% in 1988. Table 15 gives more details about important products imported by Thailand from Japan.

The high dependency on Japan for capital goods and intermediates appears to be mainly due to the great influx of Japanese Foreign Direct Investment in Thailand in recent years

and if this trend continues it is likely that Thai imports from Japan will continue to rise. The exports from Thailand to Japan also increased by almost 100% from 32.48 billion baht in 1986 to 64.41 billion baht in 1988. Table 16 shows the contribution of different categories of goods to the total exports to Japan.

The figures in Table 16 indicate that in spite of a large increase in exports, more than half of Thailand's exports to Japan are still agricultural products although the share has been decreasing steadily from 63.11% in 1984 to 51.00% in 1988. The increase in manufactured exports is attributed mainly to the increasing relocation of Japanese medium and small industries to Thailand which ship parts and accessories to their parent or affiliated companies in Japan. The share of Japan in Thai exports in the following categories (which accounted for more than 10% of Thailand's total export in 1988) are as shown in Table 17.

TABLE 17 : The share of Japan in the major exports of Thailand, 1988

Professional and scientific equipment	35.35 %
Furniture and fixtures	34.17 %
Beverage-alcoholic and non-alcoholic	33.60 %
Wood products	25.58 %
Paper and paper products	24.56 %
Non-metallic mineral products	23.77 %
Fertilizers and pesticides	21.09 %
Non-electrical machinery and equipment	18.52 %
Glass and glass products	16.44 %
Food products	14.11 %
Pharmaceuticals and toiletries	13.77 %

The major Thai exports to the USA and EEC countries are shown in Table 18. Here too it can be seen that the major exports are really of low technological level. Due to the quotas set on Thailand for the export of cassava to the EC, Thailand is actively seeking non-EC markets for its cassava. Egypt, Turkey and Yugoslavia are new buyers of cassava from Thailand. Thailand has become a major producer and exporter of canned seafood especially tuna fish and shrimp. However this industry seems to be facing several problems. For instance in 1989 France banned canned fish and shrimp from Thailand on the grounds that its canned seafood contained high levels of ethylene-diamino-tetra-acetic acid (EDTA). Although Thailand claims that the EDTA content does not exceed the Codex standard of 250 mg/kg, this apparently is still a problem [7].

However, Thailand appears to be keen on moving into the North American canned seafood market in a big way. A group of Thai canned tuna fish producers have acquired US-based Bumble Bee Co., the world's second biggest canned tuna producer. Thai exporters plan to use this company as a new channel for exporting their products to the USA. Also Canada has sent experts to advise Thai producers on new technology which will help canned seafood produced in Thailand to attain Canadian standard requirements [7].

Thai exports to the USA have increasingly been affected by trade protectionism. The United States Trade Representative (USTR) continues to retain Thailand on the "priority watch list"

under Section 301 of the US Trade Act. It is hoped by the Thai Government that in 1990 Thailand would be moved down to the "watch list". Faced with intensified protectionism in the US and to some extent in the EC, Thai exporters appear to be diversifying away from these markets. Thailand is actively seeking trade with European countries with whom it has so far not had strong trade ties. For instance during the first half of 1989, Thailand exported nearly 1.2 billion baht worth of goods to Austria and imported 0.5 billion baht from it. It is forecast that trade between Thailand and Hungary would exceed 2.5 billion baht by 1991 and Thailand has been urged to invest in Hungary and use it as a bridge for approaching the 1992 EC single market.

The valuable lesson that Thailand has learnt from its trade experience is the importance of aggressively going in for product and market diversification to combat protectionist pressures and the need for developing industries to produce intermediate and capital goods. The latter clearly requires intensified research and development and the upgradation of Thai technological capabilities.

II.1.2. DIRECT FOREIGN INVESTMENT IN THAILAND

The importance of direct foreign investment (FDI) has been emphasized by the Thai government right from the 1970s. The FDI net flows had only been 1% of the annual private capital formation in 1960, and has now come to a level of 4.25% and 9.62% in 1987, and 1988 respectively. Several factors have contributed to this rapid increase. These include the following [6, 9, 12, 14, 16]:

- The maturation of the Japanese and Asian newly industrialised countries (NICs) economies has led to rising costs and appreciating currencies in those countries, along with quotas imposed on many of their exports to Europe and North America. In response, investors from these countries have sought low-cost manufacturing sites not yet affected adversely by quotas so that they can maintain their export competitiveness and momentum. Thailand appears to meet these criteria.

- The Taiwanese and South Korean governments have eased restrictions limiting investment abroad. This has led to their increased investment in Thailand in the light of the maturation of their economies. Additionally, fears over political changes in Hong Kong after 1997 have led to increased foreign investment in Thailand from the crown colony.

- Political instability in the Philippines and continuing concern over the political climate in China have also narrowed the list of countries in the ESCAP region suitable for substantial investment. Even though foreign investment in Malaysia and Indonesia has been increasing there still seems to be greater preference for Thailand.

- The low wage and interest rates, artificially low oil prices and tax benefits available to investment projects promoted by the Board of Investment (BOI) are positive attractions but the stable political environment and favourable attitude towards business appear to be key factors in attracting investment.

- The devalued baht (since the end of 1984) which has facilitated the competitiveness of exports by reducing production costs.

However, there appears to be a feeling that the surge of investment in the period 1987-89 is unlikely to be repeated although there is no reason to expect a significant fall in investment levels. Some of the reasons given for the likely drop include the following:

- Developments in Eastern Europe will attract some Asian attention, especially from Japan, thereby diverting some investment away from Thailand.

- Some of the consequences of Thailand's recent successes, will make new investment less profitable, at least in the short term. One of the important consequences is the sharp rise in the salaries of skilled workers and professionals who are in short supply. Furthermore the Thai Government has decided to raise the minimum wages in 1990.

- Oil prices are expected to rise in Thailand to near the world level during 1990 thereby raising the cost of production.

- Interest rates are also likely to increase in Thailand in 1990 thereby leading to higher costs of operation.

- The congestion around Bangkok and shortage of infrastructure facilities may be disincentives to new projects.

- The proposed introduction of a new value-added tax (VAT) by January 1991 may lead to the elimination of tax exemptions that have previously been offered to investors.

In summary, apart from BOI incentives and exchange rate policies it may be said that the huge jump in FDI, during 1987-1989, came largely because of external factors that are unlikely to be repeated. However, this has pushed FDI opportunities to a new level which Thailand would not want to lose. It is envisaged that Thailand's political stability, economic expansion, diversified economic activities, non-hostile social environment and geographic proximity to Asian investors will more than outweigh the short-term negative aspects such as shortages of skilled labour and infrastructure, rising oil prices and interest rates, and loss of some tax exemptions due to the introduction of VAT.

The subsequent sections in this chapter give more information on important aspects of foreign investment

II.1.2.1. Investment climate

The establishment of the Board of Investment (BOI) in 1960 in Thailand is considered to be a major step made towards the encouragement of foreign investment to Thailand.

The BOI grants investment promotion to enterprises which it deems are suitable to the economy and level of technology of Thailand, taking the following points into consideration:

- The adequacy of the market demand for such products, commodities or services to warrant the increased production.
- Whether the production cost is low enough to compete successfully with imports.
- The added value is not less than 20% of sales revenue, unless the production is mainly for export.
- The ratio of debts to registered capital/equity does not exceed 5:1.

- Level of utilization of national resources including capital and raw materials; foreign exchange and the amount of such remittances into Thailand; the technical level; and any other factors the Board deems appropriate.

The statistics obtainable from the Bank of Thailand shows that the size of direct investment has continued to grow at an increasing rate. There appear to be two distinct stages of growth of foreign investment in Thailand. The period 1980-87 shows an annual rate of 5.2% increase while in 1988 it showed a dramatic increase of 162.9% and an amount of 32,960 m Baht (Table 19). The net inflow figures also show a similar increase in the investment where a 212.3% growth rate was visible in 1988 (Table 20) while on the other hand, foreign registered capital grew at 166.9% and 281.5% in 1987 & 1988. (15,804 million baht in 1986, 57,198 million baht in 1987, and 139,454 million baht in 1988) [38]

One of the reasons for Thailand's success in attracting foreign investment is that the BOI has offered many incentives to foreign investors. The Investment Promotion Act of 1977 has played a key role in this regard by offering varying number of incentives as the follows:

(a) Guarantees

- Against nationalization
- Against competition of new state enterprises
- Against state monopolization of the sale of products similar to those produced by the promoted investor
- Against price controls
- Permission to export
- Against imports by government agencies or state enterprises with taxes exempted

(b) Protection Measures

- Imposition of surcharge on foreign products at a rate not exceeding 50% of CIF value for not more than 1 year at a time
- Import ban on competitive products
- Authority by the Chairman to order any assisting actions or tax relief measures for the benefit of promoted projects

(c) Permissions

- To bring in foreign nationals to undertake investment feasibility studies
- To bring in foreign technicians and experts to work under promoted projects
- To own land for carrying out promoted activities
- To take or remit abroad foreign currency

(d) Tax incentives

- Exemption or 50% reduction of import duties and business taxes on imported machinery
- Reduction of import duties and business taxes of up to 90% on imported raw materials and components
- Exemption of corporate income taxes 3 to 8 years with permission to carry forward losses and deduct them as expenses for up to 5 years
- Exemption of up to 5 years on withholding tax on goodwill, royalties or fees remitted abroad

- Exclusion from taxable income of dividends derived from promoted enterprises during the income tax holiday

(e) Additional Incentives for Enterprises in the Special Investment Promotion Zones

- Maximum reduction of 90% of business tax on the sales of products for a period of up to 5 years;
- Reduction of 50% of corporate income tax for 5 years after the termination of a normal income tax holiday or from the date of income earning
- Allowance to double the cost of transportation, electricity and water supply for deduction from taxable corporate income
- Allowance to deduct from the taxable corporate income up to 25% of the investment costs of installing infrastructure facilities for 10 years from the date of income earning

(f) Additional Incentives for Export Enterprises

- Exemption of import duties and business taxes on imported raw materials and components
- Exemption of import duties and business taxes on re-exported items
- Exemption of export duties and business taxes
- Allowance to deduct from taxable corporate income the amount equivalent to 5% of an increase in income derived from exports over the previous years, excluding costs of insurance and transportation

The protection measures mentioned sub b are not used frequently and, according to recent information, the exemption of import duties on imported machinery has been abandoned for heavy machinery.
In principle late-comers in Thailand are not benefiting less from BOI promotion, but the local-content requirements can imply minimum production capacities to be reached. There are some examples of the BOI refusing promotional privileges in cases production capacity of existing manufacturers is already sufficient to meet domestic demand (e.g.for sheet glass) [22, 34]. In addition recent plans to increase the local-content requirement for locally assembled passenger cars would favour Japanese car makers over their European competitors. Assemblers that cannot produce sufficient parts locally would automatically be forced to use the Japanese-supported local suppliers [21].

Other reasons which attract foreign investors to Thailand are:

- Political stability of the country which is attributed mainly to the respect and support enjoyed by the constitutional monarchy.
- Availability of a cheap and hard working labour force which can be easily trained.
- Rich natural resource endowment of Thailand.
- Positive attitude of the Thais towards foreigners and foreign investment since they have not experienced colonialism.
- Presence of a well-entrenched private sector in Thailand.
- The strategic and central location of Thailand in the region.

However, as pointed out earlier there are some factors which might act as barriers to foreign investment. In addition to the problem of rising wages, oil prices and interest rates, land speculation and construction material shortages can prove to be a disincentive to foreign investment. The Thai Government is attempting to deal with these problems on a priority basis.

The lack of quality infrastructure is another major concern for foreign investors. While attempts are being made to ease traffic congestion by improving the road and rail networks, the Thai Government has designated special Investment Promotion Zones, away from Bangkok, where promoted industries, if located, could become eligible for special tax and duty privileges. It is envisaged that the spreading out of industries could ease the pressure on the infrastructure in Bangkok and its surroundings.

The Thai Government also plans to establish a Data Processing Zone (DPZ) by 1991. The DPZ would be a high-security area which would offer state-of-the-art data processing, software development and telecommunication facilities. It is envisaged that corporations such as commercial banks, airlines, credit card companies and multinational companies could put up their data processing centres at the DPZ. The Thai Government views the establishment of the DPZ as a quantum jump in improving the information technology infrastructure in Thailand. It is felt that the DPZ would also help to overcome many of the problems faced by foreign and local investors with respect to inadequate telecommunication facilities.

These steps are viewed by the Thai Government as measures which are likely to eliminate some of the barriers to a steady flow of foreign investment.

II.1.2.2. FDI by country

Japan, the USA, the EEC and Asian NICs are the major foreign investors in Thailand. The Japanese share of investment in Thailand has increased since the 1980's and has now become the single largest source (Table 20). In 1988 and 1989 Japan accounted for over 50% of the total foreign investment. The share of the USA has been declining since 1985 and accounted for only 11% in 1988. The EEC and the Asian NIC's averaged about 9% and 24% respectively during 1986-1988. Among the NIC's Taiwan and Korea appear to invest increasingly.

A similar trend can be seen with regard to the applications approved and projects started (Table 21, 22). Table 21 also shows that during 1987-1989 foreign investors accounted for more than 60% of total BOI promoted investment in Thailand.

According to the Bangkok Post Economic Review, 1989, the Japanese Chamber of Commerce predicts that the Japanese, being the largest group of investors in Thailand, feel very confident about the continued growth of the Thai Economy. The survey results of this investigation show that Japanese businessman feel that the economy of Thailand will continue to do well as at present.

The Bangkok Post Economic Review also reports that Japanese direct investment in Thailand has risen by 243% in 1988 representing the largest increase in Japanese investment in any country. The Japanese investment in Thailand has been $ 1.992 billion in 1,685 projects from 1951-1988. This share is about 1.1% of all Japanese direct investment world wide.

Hong Kong manufacturers have selected Thailand as a favoured location for having a second production base to maintain their competitive edge in the world market. South Korea and Taiwan (which has become the second largest investor in Thailand), also hold similar views.

Table 23 shows that Japan's investment in 1987 and 1988 is mainly in the industry sector which represents 57.3% and 72.1% of its total investment, followed by construction and financial sectors having a share of 13.7% and 27.1% in 1987 and 4.7% and 9.1% in 1988. What is striking here is that there is a dramatic decline in the share of the latter sectors in 1988 compared with 1987. The share of the financial sector has dropped from 13.7% to 4.7% while the construction sector shows a decrease from 27.1% to 9.1% during this period.

The USA appears to have focussed mainly on industry followed by trade and services. The industrial sector accounted for 44.2% and 33.4% in 1987 and 1988 respectively while the trade sector contributed 25.4% and 27.5% and the service sector 14.0% and 21.4% respectively during the same period.

European investors focussed mainly on the manufacturing, finance, services and trade sectors. The share of the financial sector increased from 13% in 1987 to 24% in 1988 while the contribution of the industry sector decreased from 59.4% to 43.1%. A considerable improvement is also seen in the trade sector. Asian NICs concentrated on industry followed by the trade and service sectors. The industry sector has shown a big increase from 22.2% in 1987 to 56.9% in 1988.

II.1.2.3. FDI by sector

In Thailand, the share of FDI in the manufacturing sector was about 30% during the period 1980-1986. This however increased substantially to 53% in 1987 and then to 58% in 1988. (Table 24). The share of the trade and construction sectors increased during 1980-1985 but have now dropped substantially. FDI shares in the financial sector shows an increasing trend while the shares in the agriculture and services sectors show a fluctuating trend. The share of FDI in the mining sector shows a steady decline since 1980.

Bank of Thailand statistics show that within the manufacturing sector, electrical appliances, chemicals and food accounted for a substantial portion of the 53% in 1987 and 58% in 1988. In 1987 and 1988 there was also a noticeable rise in the share of equipment. The figures are summarized in Table 25.

TABLE 25 : Importance of FDI in industry 1987-1988 (percentage)

Subsector	1987	1988
Food	4.8	4.4
Textiles	11.0	4.0
Metal-based and non-metallic	4.0	6.9
Electrical appliances	12.6	22.3
Machinery and transport equipment	1.8	2.6
Chemicals	9.6	6.9
Others	8.7	10.8
Total FDI share in industry	52.5	57.9

Source : Bank of Thailand

In the manufacturing sector Japan's FDI appears to be concentrated in electrical appliances, metal-based and non-metallic products, and chemical industries. The Asian NIC's focussed their FDI on chemicals, electrical appliances, textiles and food. The US FDI appears to have concentrated on processed food, electrical appliances and chemicals. The European FDI in the manufacturing sector was mainly in processed food, chemicals, textiles and metal-based and non-metallic products.(see Table 26)

Several key features emerge when FDI in Thailand is examined. Firstly Thailand, for many reasons already outlined, has become a very attractive place for FDI. It appears that the Thai Government has come to realize that there may be obstacles to the continued flow of FDI and is taking step to eliminate these. How well these measures will succeed remains to be seen. Secondly there appears to have been a major shift from import-substituting industries to export-oriented industries among promoted FDI. Japan and the Asian NIC's have played a major role in this regard. This export orientation also appears to have led to a declining trend of joint ventures as a proportion of total FDI projects due to the fact that 100% foreign ownership is allowed in export-oriented projects.

II.2. SCIENCE & TECHNOLOGY (S&T) POLICIES AND PLANS OF THAILAND

The recognition of the role of technology for national development can be traced back to the reign of King Rama IV, 120 years ago. During the reigns of King Rama V and King Rama VI, new inventions were brought in from western countries. Moreover, more people who had graduated from western countries started working for the government, the result of which was that the importance of S&T became more widely recognized. When foreign trade was interrupted during World War II and imported goods became scarce, attempts were made to manufacture locally previously imported products. The importance of technology became evident at this stage.

The development of S&T policy in Thailand began in 1949 when Article 65 in the 1949 national Constitution stated that, "The state should encourage research in arts and sciences". The same statement was repeated in Article 61 of the 1968 Constitution which stated that, "the state should encourage research in arts and sciences and promote the application of science and technology for national development".

Although S&T policy and planning was explicitly highlighted for the first time in the Fifth National Economic and Social Development Plan (1982-1986), which devoted a whole chapter to the utilization and development of S&T, reference had been made to the importance of S&T and its utilization in earlier plans in an implicit manner. Also the sixth plan (1987-1991) has gone one step further and formulated a science and technology plan.

The implicit reference to the utilization of S&T during the first four plans were mainly in the following areas:

- Introduction of new crops and livestock to boost agricultural development.
- Establishment of regional centres and research institutes catering to the needs of the crops, livestock and fisheries sectors.
- Improvement of public infrastructure in the areas of communication and transportation.
- Search for new natural resources and exploitation of existing ones.
- Establishment of major industries such as the chemical and smelting industries.
- Expansion of tertiary education with emphasis on fields such as agriculture, science, engineering and medicine.

Details of the explicit references to S&T and the policies and plans formulated during the fifth and sixth plans are briefly outlined in subsequent sections of this chapter.

II.2.1. S&T HIGHLIGHTS OF THE FIFTH NATIONAL ECONOMIC AND SOCIAL DEVELOPMENT PLAN (1982-1986)

During this plan period, it appears that the Thai Government seems to have arrived at a major conclusion that if S&T is to be used as a strategic tool for enhancing economic growth, its development should be by "choice" and not by "chance". This thinking seems to have led to the formulation of a set of explicit S&T objectives and guidelines. These are outlined briefly below. [45]

S&T Objectives

(a) To extensively distribute available technology, to select and modify imported technology to suit the local conditions, and at the same time to develop local technology in order to upgrade the production and utilization of national resources.

(b) To strengthen and upgrade the science and technology base by focusing on the development of manpower, research and development institutes, technology transfer centres, and science and technology data centres.

(c) To encourage private and state enterprises to judiciously use technology to boost their production capability and to urge the public to be aware of science and technology and to make use of it extensively whenever possible.

(d) To enhance international cooperation in science and technology through data exchange and to transfer and build up the science and technology capability of all needy countries.

Guidelines

In order to achieve the above objectives the following measures and guidelines were laid down:

(a) To conduct a survey to obtain basic data necessary for planning technology development.
(b) To encourage foreign technology transfer.
(c) To improve the efficiency of local science and technology research.
(d) To promote the mobilization of all resources particulary manpower for science and technology development.
(e) To improve product standards and quality control, including the national standards and testing methods.
(f) To develop local engineering consultancy services.
(g) To upgrade science and technology information systems.
(h) To promote the effective transfer and distribution of technology locally.
(i) To upgrade the process of science policy making.
(j) To enhance international cooperation in science and technology.
(k) To promote public interest in science and technology.

II.2.2. S&T HIGHLIGHTS OF THE SIXTH NATIONAL ECONOMIC AND SOCIAL DEVELOPMENT PLAN (1987-1991)

The sixth plan has the objective of using S&T to, "lay the foundation for upgrading national industrial capability, to a level comparable with or higher than those of other newly industrialized countries, with a view towards raising the standard of living of the people and enhancing the ability of Thailand to compete in world markets while simultaneously creating more jobs, increasing exports and uplifting the local economy". The operating guidelines for the sixth plan are as follows [45]:

(a) To enhance the role of science and technology in national development by focusing on the building of a solid technology base to serve future development, and developing the necessary human resources in line with the requirements of the future economic structure.

(b) To improve the science and technology infrastructure, including organizational development and revision of any laws and regulations that may be hindering science and technology development.

(c) To upgrade manpower for science and technology development by emphasizing the improvement of its quality and utilization, and increasing its supply to meet the rising demand.

(d) To promote research and development (R&D) activities by formulating suitable policies and allocating adequate budgets for research work in priority fields such as genetic engineering, biotechnology, metals and materials and electronics.

(e) To enhance foreign technology transfer beneficial to national economic and technological development.

(f) To develop a science and technology information system, with special emphasis on the establishment of an information network and the development of science and technology indicators for use in S&T policy formulation and planning.

(g) To encourage a greater role by the private sector in the development and the use of technology by offering tax incentives on investments in science and technology development activities.

II.2.3. THE DEVELOPMENT OF A LONG-TERM S&T POLICY AND MASTER PLAN

One of criticisms that have been levelled against the present way of formulating S&T policies and plans is that it does not deal with long-term aspects and focusses entirely on short and medium-term issues. The Ministry of Science,Technology and Energy (MOSTE) has commenced work on the establishment of a Master Plan for S&T which it hopes will overcome some of these shortcomings.

The objectives of this exercise, in which MOSTE plans to utilize not only the expertise available in the government and major S&T institutes but also that from the private sector, are as follows:

(a) To review and evaluate important past and present science and technology policies and schemes.

(b) To formulate a 20-year (1992-2011) science and technology master plan and lay down guidelines for its development in line with other long-term development plans in various other fields.

(c) To seek directions and methods for improvement of the organizational structure, including its basic infrastructure, for science and technology with a view towards enhancing its contribution to national development.

(d) To study and recommend the setting-up of important technology coordination centres, in the field of communication, laser technology, aerospace, and oceanography.

(e) To scrutinize legal procedures and regulations that influence science and technology development of both the public and private sectors.

The development of this Master Plan is expected to be completed by 1991 and will cover 6 aspects of science and technology namely research and development, manpower development, technology transfer, information transfer, international cooperation, and infrastructure for S&T, in the fields of agriculture, industry, energy, natural resources and environment, communication and transportation, medical and public health, education and basic sciences, and national defence. The MOSTE expects to work closely with the Thailand Development Research Institute (TDRI) which is working on a project entitled, "Thailand in the year 2010", in formulating the Master Plan.

II.2.4. SOME OBSERVATIONS ON THAILAND'S S&T POLICIES AND PLANS

Based on interviews with senior officials in the Thai S&T system and on studies by le Pair [33] and others, it may be useful to summarize some major points of relevance to the Thai S&T policy and plan formulation and implementation systems [see also 17, 18, 19, 20].

- Development of S&T in Thailand has been affected always by two barriers namely bureaucracy and inadequate funding.

- In the Thai S&T system there appears to be some misunderstanding about the nature of science and technology and their interrelationships. Some individuals think only of science when referring to S&T while others think only of technology when talking about S&T.

- Some argue that Thailand spends too much money on science and not enough on technology. Others express the opposite view. One conclusion that may be drawn in the light of Thailand's aspirations is that if the country is to achieve self-reliant economic development then far more efforts are required in the fields of both science and technology.

- Formulation of S&T policies and plans and their implementation become very difficult because S&T activities cut across many ministries and organizations. Even within MOSTE there are many institutes which can set up their own policies. This very often leads to duplicity of activities and poor use of scarce resources.

- The future economy will be "knowledge-based" where technological know-how may well be more critical than capital and labour. Thailand has to prepare itself for this future economy by stepping up its R&D efforts which at present are dismally low by world standards.

- Technology upgradation efforts in the private sector, on which the Thai economy relies heavily, have to be stepped up if Thailand is to achieve competitive advantage in the international market place. Many manufacturers find it convenient to buy

(international transfer) technology rather than generating it in-house. The S&T policies have not been able to change this attitude.

- There are two main reasons why the private sector shows disinterest in in-house R&D. Firstly, they view money spent on R&D as an expenditure and not as an investment. Secondly, the private sector is in business to make profits and not achieve "technology supremacy" per se. They will therefore select a technology upgradation route which is most profitable. The S&T policies have not addressed these issues seriously.

- Even if the government formulates S&T policies to make in-house R&D attractive, there is a serious shortage of skilled manpower at present. On the one hand a sizeable number of Thai professionals studying abroad do not return while on the other, highly qualified personnel from universities and public sector R&D institutes are increasingly taking up higher paid managerial jobs in the private sector. The output of scientists, engineers and technicians from the universities and technical institutes is also inadequate to meet the increased demand for S&T personnel due to the establishment of a large number of FDI industries in recent years. S&T policies have failed to deal with these problems effectively.

- Most of the R&D activities in Thailand are carried out by public sector organizations. There seems to be a widely held view that, with some exceptions, most of these institutes have failed to adopt a "demand-pull" approach in formulating R&D projects. The "supply-push" approach taken by them at present often leads to the development of technology not wanted or with little commercial value. Promotion of contacts between industry and government research institutions has not received adequate attention in S&T planning.

- There seems to be a lack of political will to enact major legislation related to S&T. Such enactments can eliminate many of the constraints currently faced in the implementation of S&T policy in key areas. For instance it is felt that the establishment of a National Council for Science and Technology with a strong inter-ministerial character can help in the coordination of S&T activities and harmonize the efforts of the numerous bodies involved in S&T. This recommendation appears to have gone unheeded for several years. Another example is the lack of appropriate legislation to promote R&D in the private sector. While several recommendations have been made no major steps have yet been taken.

The above mentioned observations highlight some of the important issues with regard to S&T policy and plan formulation and implementation. Discussions with officials in the S&T organizations in Thailand revealed that there is considerable awareness regarding these issues. It remains to be seen how the government intends to resolve these.

II.3. INSTITUTIONAL FRAMEWORK FOR SCIENCE AND TECHNOLOGY IN THAILAND

The establishment of the National Research Council of Thailand (NRCT) in 1956 is considered to be the beginning of formal science and technology policy formulation in Thailand. However, initially NRCT formulated and supported only policy for research. In 1973 the Science and Technology Advisory Sub-committee was formed, followed in 1975 by the appointment of the Science and Technology Sub-committee and the establishment of the Technology and Environmental Planning Division in the Office of the National Economic and Social Development Board which acted as the coordinator in science and technology planning.

The establishment of the Ministry of Science, Technology and Energy (MOSTE) in 1979 resulted in the creation of a body directly in charge of scientific and technological planning. The Ministry after its establishment has worked in close collaboration with the Office of the National Economic and Social Development Board and the National Research Council in science and technology planning for the 5th and 6th National Development Plans, and has continued to play an important role in science and technology policy formulation and planning.

The major institutions which are either directly under MOSTE or come under its purview as state enterprises or as institutes with autonomous status are as follows:

- Division/Offices Coming Directly Under the Office of the Permanent Secretary of MOSTE

  - Office of Policy and Planning (OPP)
  - Technology Transfer Center (TTC)
  - Department of Science Services (DSS)
  - National Research Council of Thailand (NRCT)
  - Office of the National Environment Board
  - National Energy Administration
  - Office of Atomic Energy for Peace

- Institutions Under the Purview of MOSTE but Enjoying Autonomous Status

  - Thailand Institute of Scientific and Technological Research (TISTR)
  - Science and Technology Development Board (STDB)
  - National Center for Genetic Engineering and Biotechnology (NCGEB)
  - National Center for Metal Material Technology (NCMMT)
  - National Electronic and Computer Center (NECC)

Another important organization working on science and technology policy is the Thailand Development Research Institute (TDRI) which was established in 1984. This non-governmental organization operates under a foundation, and is active in policy research in general, with emphasis on economics, agriculture, natural resources, industry, energy and other areas in addition to science and technology. This institute is expected to carry out independent analysis and propose options on policy matters of relevance to agencies both in the public and private sectors.

The Senate Commission and the House of Representatives Commission on Science, Technology and Energy of the Parliament play a major role in securing legislative support for S&T policies. The laws proposed by MOSTE for upgrading S&T has to go through these commissions to parliament.

The other ministries which influence S&T policies are as follows:

- Ministry of Agriculture and Cooperatives
- Ministry of Industries
- Ministry of University Affairs
- Ministry of Education
- Ministry of Public Health
- Ministry of Communication
- Ministry of Finance

In subsequent subsections it is proposed to review in somewhat greater detail the functioning of some of the key institutions mentioned above.

II.3.1. THE NATIONAL ECONOMIC AND SOCIAL DEVELOPMENT BOARD (NESDB)

The NESDB as the national planning agency has been entrusted by the Thai Government with the following major functions:

- To draw up national economic and social development plans;
- To study and analyze the economic and social conditions of the country;
- To study national income accounts;
- To analyze and evaluate development projects in relevant operating departments and public enterprises; and
- To perform such functions as may be resolved or assigned to it by the Cabinet of Ministers.

One of its twelve divisions, the Technology and Environment Planning Division, has the key task of integrating the science and technology plan with the National Economic and Social Development Plan. Another division, the Human Resources Development Division, also has a major role to play in science and technology planning due to the fact that it handles the important area of planning for the development of human skills. To incorporate the views of the various divisions a subcommittee on S&T Planning for the 7th National Economic and Social Development Plan has been set up with key persons from these divisions.

Discussions with senior officials in these two divisions provided valuable insights into the thinking that is going on at the NESDB with respect to the type of direction that is likely to be given to science and technology policy formulation in the 7th Plan (1992-1996). Key points that emerged during these discussions are summarized below.

- The major S&T issues that will have to be tackled during the 7th Plan are:

  - How to strengthen the technological capabilities of the private sector;
  - How to strengthen and align the activities of the public sector S&T institutes to meet the technological needs of the private sector; and
  - How to manage R&D activities in the country effectively.

- The "supply push" orientation of many public sector R&D institutes has made them mere "intellectual playgrounds"! Attempts must be made to encourage R&D in the private sector so that economically useful and viable technologies are developed. Grant awarding agencies have to play a major role in this regard.

- Unlimited foreign technology inflows inhibit local technology development. This can have an adverse impact on the economy in the long run. Great care has to be taken in defining the terms of such inflow.

- The country and the S&T community would benefit tremendously if foreign companies are encouraged to carry out some of their R&D in Thailand. The Board of Investment should encourage this and the right climate must be created to elicit a positive response from foreign investors.

- Technology development in the small and medium scale sectors have not received the kind of attention that they should have. Focussed efforts are needed in this area.

- The education system prevailing at present is not sufficiently responsive to economic needs. There is a mismatch between demand and supply of manpower. This aspect needs to be looked into and corrected by developing an education system that has a long-term orientation coupled with the capacity to respond quickly to changes in the environment.

- There is an acute shortage of well qualified engineers and scientists at the universities because of brain-drain to the private sector. Schemes to make university careers attractive are urgently needed.

- At present there is an acute shortage of S&T personnel in areas such as petrochemical technology, ceramic technology, microbiology, electronics, specialized areas in textile technology, plastic moulding and computer science. The universities should have the capacity to quickly move away from conventional well established areas into newer relevant areas. A futuristic orientation is needed in the higher education system.

- From a long term perspective S&T education needs to be strengthened at primary and secondary school level. Barriers such as inadequate budgets, shortage of science teachers and high cost of establishing laboratories have prevented the extension of S&T education to the provinces. Urgent action is needed in this regard.

It is envisaged that these issues will be debated during the formulation of the 7th Plan and suitable policies and plans will be formulated to overcome the shortcomings that have been highlighted.

II.3.2. THE MINISTRY OF SCIENCE, TECHNOLOGY AND ENERGY (MOSTE)

The MOSTE is the newest ministry in Thailand. It was set up in 1979 to serve as a government mechanism which would plan and coordinate national efforts in using science and technology for development. The functions of MOSTE are as follows:

- To formulate policies, plans, schemes and projects related to the use of science, technology, energy and the environment for national development;
- To guide, perform and monitor work related to science, technology, energy and environment;
- To evaluate work related to science, technology, energy and environment;
- To improve the plans, schemes and projects concerned so that they remain appropriate in a dynamic environment;
- To develop technology domestically which could enhance productivity while being commercially feasible;
- To provide services and promote both international and intranational technology transfer;
- To study, analyze, research and compile scientific and technological statistics; and
- To compile, collect and propagate information and research results related to science, technology, energy and the environment.

In this section, it is proposed to briefly outline the major activities carried out by some of the divisions/institutions of the MOSTE which are of special relevance to this study.

II.3.2.1. The Technology Transfer Centre (TTC)

The National Centre for Technology Transfer in Thailand was set up in 1983 as a division of the Office of the Permanent Secretary, Ministry of Science, Technology and Energy. This centre acts as a promotional, advisory and training agency in the activities related to technology acquisition, development, adaptation, licencing, negotiation and transfer. The functions of the Technology Transfer Centre can be divided into 5 categories:

(i) Scanning, screening and introducing technologies;
(ii) Serving as a centre for technology transfer;
(iii) Evaluating the appropriateness of the technology to be transferred;
(iv) Co-operating with international organizations in matters concerning technology transfer; and
(v) Arranging seminars and handling extension work.

The functions of the technology transfer centre also include:

- location of alternate sources of technology;
- evaluation of technology offers;
- assistance to local organizations in evaluation of technology transfer offers;
- negotiation of conditions in the agreement with the supplier; and
- monitoring of progress in the adaptation, digestion and absorption of the technology transferred.

The National Centre for Technology Transfer in Thailand is divided into 4 sections, namely Technology Transfer Information Section, Technology Analysis and Evaluation Section, Technology Transfer Promotion and Dissemination Section and General Administration Section.

One of the important activities that the TTC is performing is the administration of a "revolving fund" from which the private sector could borrow at concessional interest rates for developing indigenous technology. The revolving fund, when set up in 1984, was initially allocated Baht 15 million. This has now been increased to Baht 70 million.

Funds from the revolving fund are given to private sector organizations at concessional interest rates to be repaid over a period of eight years. A further two years grace period is allowed. Loans are awarded for activities in two major categories. The first is for setting up laboratory facilities for analysis and testing. The maximum size of the loan that can be awarded under this category is Baht 5 million and the interest rate is 4%. The second is for process or product improvement or commercialization of research results where the maximum size of the loan is Baht 10 million. The interest rate charged here is 6%.

In 1989 about 20 applications were received and usually only about 3-5 are selected. Some of the applications for revolving funds were for activities in the production areas of activated carbon, rubber weirs, hydraulic machines, circuit design for controlling multi-lift operations, leather tanning, pineapple concentrates and car brake linings.

Another area where the TTC is active is in recommending import duty exemptions on imports of materials/equipment for energy conservation or environmental protection. Under this scheme, import duties on these equipment can be reduced from 30% to 10% upon the recommendation of MOSTE. The importer has first got to pay the 30% duty, import the materials/equipment, install these and once these are operational the TTC inspects these and if convinced that the energy conservation and/or environmental protection objectives are met will recommend the refund of 20% of the import duty to the importer. However, this involves fairly complex bureaucratic procedures.

At present to enhance the activities of TTC it is being proposed that companies be requested to contribute to the revolving fund and that such contributions be exempted from taxation. The TTC is aiming at collecting Baht 10 billion through this scheme. The TTC through MOSTE is also proposing that imports of R&D equipment be exempted from import duty.

One of the successful cases of MOSTE funding in developing local technological capabilities is the support that was given to Kasetsart University to design a 32 bit microprocessor. A private sector company, Thavorn Co.,Ltd. is now using this in the production of personal computers under its brand name.

II.3.2.2. The National Research Council of Thailand (NRCT)

The main functions of NRCT are as follows:

- To formulate a national research policy by studying the present needs of research as directed by the Government, policies and plans of government agencies, the National Assembly's policy; in harmony with the National Economic and Social Development

Plan, and public requirements; to ensure that these objectives for research will help the attainment of the same goal.

- To promote and stimulate research work by providing funds to both government and private sectors. These funds can be divided into research grants for junior researchers, senior researchers, experts and university lecturers. In addition, some grants are available to research workers to carry out certain projects that are considered to be of high priority. With a view to promoting new inventions and research works, prizes with high remuneration are also awarded to outstanding inventors and researchers.

- To coordinate research work with international organizations through the exchange of research information and researchers, in order to obtain knowledge which should be valuable for national development.

- To serve as a Research Documentary Center where research work both in natural science and social science will be compiled and made available to all researchers. The Center is also expected to serve as a Clearing House for researchers so as to avoid duplication of efforts.

- To promote and support the establishment of research institutes or professional societies as a means to bring professionals in each field together.

- To ensure that the research work of the country can be carried out in harmony with national development efforts as well as to optimize the national expenditures in this regard. NRCT has appointed an investigation unit to examine the project proposals submitted for government financial support.

- To provide support and to facilitate research opportunities for foreign researchers who carry out research work in Thailand. In providing this service NRCT acts as a center for research coordination.

- To organize training courses for social scientists at a post-graduate level to expand the research community in this area and associated manpower in various government agencies.

- To undertake large and important research projects or coordinate with other concerned agencies. Some current projects under the coordination of NRCT include the Aerospace Programme, Water Quality Assessment Project, Mangrove Project and the Narcotics Project.

- To continue the exchange programme of scientists and researchers and cooperation with other national organizations on projects such as Japan Society for the Promotion of Science, the National Institute of Health and the National Science Foundation of the United States.

- To disseminate research results and information to the public.

- To carry out translation of research documents and disseminate them to the public to increase knowledge and new technology in the community.

- To operate Thailand LANDSAT ground receiving station, situated 40 km east of Bangkok in the Lad Krabang District. The reception area of the station covers most

countries in South and Southeast Asia including the Philippines, Indonesia, Malaysia, Sri Lanka, Nepal and Bangladesh. The ground facilities are equipped with data processing and reproducing systems to enable the production of LANDSAT data. These LANDSAT data products are then distributed to domestic and foreign users upon request. The application of LANDSAT data to natural resources survey in Thailand includes forestry, irrigation, land use, geology, water and mineral resources.

Table 27 gives some key statistics published by NRCT on budget allocations of research projects funded by Government agencies and enterprises. Table 28 shows the total financial resources available at the main S&T institutions in Thailand.

II.3.2.3. Department of Science Services (DSS)

The DSS was established several decades ago to provide testing and analysis services to the public and private sectors. Before the creation of MOSTE, DSS was part of the Department of Industry and was subsequently transferred to MOSTE. The main functions of DSS are:

- To act as the government's scientific and technological laboratories.
- To provide chemical, physical and biological analysis services to government and private sector organizations.
- To carry out research on the utilization of the nation's natural resources and industrial and agricultural wastes for economic benefit.
- To provide analysis and testing services in order to control and certify the quality of industrial products, food and beverages.
- To provide training for students of analytical chemistry of the various governmental and industrial laboratories.
- To provide scientific and technological information services.

DSS provides considerable support to the Thailand Industrial Standards Institute (TISI) in testing products for which standards have been set by TISI. DSS also provides testing and analysis of quality for the private sector mainly in the food processing sector. It also carries out testing and certifies exports of certain items for which certificates are demanded by the importing source abroad. For instance, exporters of tapioca to the EC require such certification from the DSS.

DSS, in the recent past, has also commenced applied research activities to help small scale industries such as those in the ceramics and silk industry. DSS has also set up water and air pollution control laboratories and hopes to expand its activities in this area.

Many private sector companies in the food and pharmaceutical industries also send their products to DSS for testing to ensure that they are in conformity with the Thai Food and Drugs Regulations. Such certification is necessary for both local distribution as well as exports.

DSS also trains middle level chemists for laboratories through its Analytical Chemistry Training Division which is now affiliated with the Faculty of Science of Chulalongkorn University. However shortages of such chemists continue because many of the trainees continue higher education in Thai universities.

The Scientific and Technological Information Division (STID) at DSS has the largest library on S&T in Thailand. A proposal to link all information agencies within MOSTE by computer has not been implemented due to budgetary constraints. This project once completed will enable users to access all S&T information within MOSTE by going to the nearest MOSTE agency terminal.

DSS holds the view that its staff require considerable training and continuing education to cope up with the changes taking place in S&T - especially in emerging fields and in this area it sees tremendous scope for international cooperation.

At present DSS does not set standards but will do so in the future for reference material - material to compare products supplied with. For testing, at present, standards are supplied by clients such as TISI. DSS is a major partner with Thailand Institute of Scientific and Technological Research (TISTR) in the National Metrology and Laboratory Accredition Program for the development of primary standards. While DSS has accepted responsibility for mass and mechanical measurements, reference materials, accoustic measurements and laboratory accredition, TISTR works on electricity and frequency measurements and temperature photometry. A Metrology Committee oversees and coordinates metrology work of TISTR, DSS and TISI. DSS has still not commenced full scale accredition/certification of private sector laboratories because the necessary legal measures have not been implemented. Establishment of private sector laboratories has become necessary because of increased demand for testing and certification facilities and the inability of government institutes to cope up with this demand.

II.3.2.4. Thailand Institute of Scientific and Technological Research (TISTR)

The TISTR is a non-profit making state enterprise under MOSTE. It was originally set up by the Applied Scientific Research Corporation of Thailand Act of 1963 which was repealed and replaced by the Thailand Institute of Scientific and Technological Research Act of 1979 following the establishment of MOSTE.

The main functions of TISTR are as follows:

- To initiate and conduct research and to provide scientific and technological services to state agencies and private enterprises for economic and social development of the country;

- To conduct scientific and technological research in order to promote the utilization of natural resources appropriate to the economic conditions, environment, health and welfare of the people;

- To improve productivity in accordance with Government policies by propagating the results of scientific and technological research to benefit the country in agriculture, industry and commerce;

- To train scientific and technological researchers;

- To provide testing and measuring services and other scientific and technological services.

- To expedite the policies of the Ministry of Science, Technology and Energy dedicated to promoting the country's scientific and technological efficiency with the aim of self-reliance. This will be done by giving encouragement, incentive, assistance and support for the use of the results of research and development to tackle economic and social problems on all fronts.

- To mobilize the country's human resources to work for the development of scientific and technological research in order to effect practical operational results. This includes measures for screening, controlling and distributing technology systematically, and also for encouraging local inventions and high technology production in future.

- To operate as a "center of excellence" responsible for the provision of scientific and technological services, such as in testing and standards, supply of relevant information and consultation to the government and private sectors, both locally and regionally.

- To work in close cooperation with the private sector and with research and development units in order to build up an atmosphere in which science and technology are seen as means by which national problems may be solved.

TISTR attempts to achieve its objectives through the activities of its three major groups namely the R&D Group, the Specific Technology Group and the Services Group. The various departments and centres in these groups are listed below.

R&D Group

- Food industry department
- Pharmaceutical and natural products department
- Chemical industry department
- Biotechnology department
- Electronic industry department
- Metal and material technology department
- Agro technology department
- Energy technology department
- Environmental and resources management department
- Ecological research department

Specific Technology Group

- Thai Packing Centre
- Special Programme Centre
- Automotive Technology Centre

Services Group

- Testing and standards centre
- Thai national documentation centre

- Engineering consultancy service centre
- Industrial cooperation and promotion centre
- Research service centre

TISTR is at present carrying out several granted research projects with funding coming from international sources such as ASEAN, EEC, Japan, the UN agencies and local sources such as NRCT, STDB and the special agencies of MOSTE. Almost all the projects funded by ASEAN and EEC are either in the field of agriculture or food processing while the Japanese funded projects are in the area of manufacturing and electronics.

The Testing and Standards Centre (TSC) of TISTR works closely with DSS and TISI in testing and standardization activities. A certain amount of overlap in their activities seems to exist and coordination of their activities becomes difficult since these agencies come under the purview of different ministries.

II.3.2.5. The National Center for Genetic Engineering and Biotechnology (NCGEB)

The National Center for Genetic Engineering and Biotechnology (NCGEB) was established in September 1983 under the Ministry of Science, Technology and Energy to be the focal point for strengthening Thailand's capabilities in genetic engineering and biotechnology, and for applying these to national economic and social development. In performing these functions, the NCGEB promotes research in wide-ranging areas, from gene and cell manipulation through biomaterial processing and improvement to areas of biochemical engineering and technology with good potential for development in Thailand. The NCGEB also promotes industry-university links in relevant projects and activates selected programs by coordinating with the government, international sources and institutions active in the field of genetic engineering and biotechnology.

The NCGEB plans and promotes research and development from laboratory stages up to pilot scale, with emphasis on transfer and utilization of genetic engineering and biotechnology for industrial applications, agricultural applications, public health, energy and environmental applications and strengthening of infrastructure in genetic engineering and biotechnology. NCGEB has selected twelve priority fields: production of selected enzymes; biotransformation of starch; production of selected nutritional biochemicals; improvement of small and medium scale bioindustry; development, design and construction of pilot plants; plant and animal tissue culture for development of agriculture and agroindustry; production of improved rhizobium; organic fertilizer and mycorrhiza; development of natural rubber, production of improved bacterial larvicides; improvement of efficiency of biofuel production; utilization of industrial wastes; building up of infrastructure in genetic engineering and biotechnology.

At present the NCGEB cooperates closely with institutes in many countries including the USA, UK, the Netherlands, Australia, Japan, West Germany and ASEAN. Recent studies have indicated that there is a great potential for the production of biotechnologically derived speciality chemicals in Thailand (i.e. chemicals whose price exceeds US$2 per kilogram as defined by the Office of Technology Assessment of the USA) [40]. In this context the NCGEB has a major role to play in the speciality chemical industry in Thailand.

II.3.2.6. The National Electronics and Computer Technology Center (NECTEC)

The NECTEC was established in September 1986 in accordance with the importance given to electronics and information technology as a "sunrise technology" by the Fifth and Sixth Social and Economic Development Plans. The NECTEC is expected to strengthen the technological capability of Thailand in the field of electronics and information technology and provide policy guidelines to the Government through MOSTE in assisting the electronics and computer industry to achieve both import substitution and export capability.

The major functions of NECTEC are as follows:

- To develop technological capabilities in electronics and computer areas to support the electronics and computer industry of the country;
- To accelerate computer applications in order to improve efficiency and productivity, and
- To promote research and development supporting industrial promotion and international competitiveness of Thai products.

NECTEC provides funds for R&D work and industrial product development for researchers in universities and companies. A tripartite arrangement, consisting of technical personnel from universities and state enterprises, entrepreneurs and industry and representatives of MOSTE, is usually encouraged in NECTEC sponsored projects.

Eleven major program areas have been identified by NECTEC. These are:

- Development of sub-fractional motors for electrical and electronic appliances.
- Computer networks.
- VLSI design and fabrication.
- Biomedical electronics and instrumentation.
- Development of materials and devices technology.
- Industrial electronics and instrumentation.
- Computer system technology.
- Computer software development.
- Telecommunication equipment development.
- Technology transfer and human resources development.

An initial framework for the eleven program areas have been developed. Designated and competitive R&D projects in these areas are awarded after evaluation based on the framework. The framework will be continuously updated based on inputs from industry, the National Economic and Social Development Board (NESDB), researchers, and industrial and technology status reports commissioned on a regular basis by NECTEC.

NECTEC is presently carrying out two projects under its international cooperation program. The first is an ASEAN-Australia joint project to undertake VLSI design and MPC fabrication. The second is a machine translation system for Japan and its neighbouring countries (China, Indonesia, Malaysia and Thailand) which aims at achieving machine independent software for translation of languages in the countries mentioned. This project is being coordinated by the Japanese Centre of International Cooperation for Computerization.

II.3.2.7. The National Center for Metal and Material Technology (NCMMT)

The NCMMT has been established for strengthening metal and material technology capabilities and for applying these to national social and economic development. NCMMT promotes research in metallurgy and materials science as well as in product design and processing for developing metal and material industries. Metal industries as defined by NCMMT include transformation of minerals to metals, production of iron sheets, iron pipes and other iron shapes, production of non-ferrous metal, production of machinery parts, machineries and machine tools. Material industries include ceramics, polymers, fiber and textiles, rubber and composite materials industries.

The main objectives of NCMMT are as follows:

- To supply useful data and know-how in metallurgy and materials science as well as in production engineering and mechanical engineering to local industries in order to strengthen their capabilities and to improve product quality to compete with those of other countries in the international market.

- To encourage and assist local industries to use local abundant minerals and resources, or to transform these minerals and resources to other more valuable forms.

- To provide and fund research and development projects done by institutions within the network with extensive collaboration with the private sector, to meet the technological needs of both local and export-oriented industries.

- To be a service center that would link approved and well equipped laboratories with the private sector in the provision of services such as testing, property analysis and quality control in accordance with international standards.

- To be an information center that would provide useful information in metallurgy and materials science for commercial utilization.

- To analyze the impact of using local minerals and resources, on the industrial structure and status of metal and material industries in Thailand and provide the government with guidelines to facilitate the growth of these industries.

The major activities of NCMMT in coordinating and supporting various R&D projects in key areas are as follows:

Metallic Materials

- Experiments on machinery steel production
- Development of fine castings by the lost foam technique
- Structures and properties of metallic glasses
- Electroplating and electrogalvanizing of steel sheets
- Surface treatment by ion implantation
- Titanium nitride coating by sputtering techniques
- Fire-retardant inorganic tin compounds

Ceramics

- Biomaterial ceramics
- Resin-bonded grinding wheels production
- Preparation of bone china body compound
- Alumina ceramics
- Silicon carbide ceramics

Rubber

- Product development from gamma radiation vulcanized natural latex
- Latex tubes for medical use
- Production technology for expanded EVA and expand rubbers
- Thermoplastic elastomers

II.3.2.8. The Science and Technology Development Board (STDB)

The Science and Technology for Development Project is a cooperative project between the United States of America and Thailand, administered by the Science and Technology Development Board (established in 1985) which has an autonomous status, although it is formally under the Thailand Institute of Scientific and Technological Research. This seven year project (1985-1992) with a budget of US$ 45.4 million (US$ 26.5 million long-term soft loan and a US$ 8.9 million grant from USAID, US$ 9.5 million from the Thai Government and US$ 4.5 million from the Thai private sector) aims at increasing the efficiency and expanding the scope of science and technology application both in the public and private sectors for national development. The emphasis of this project is on solving problems related to three technological fields of high priority to Thailand namely bioscience and biotechnology, materials technology, and applied electronics technology. STDB is expected to strengthen the capability of related institutes; assist science and technology policy formulation; promote research, development and engineering; and extend appropriate support for industrial development. In this regard the mandate that has been set out in the five-year plan of STDB is as follows:

- To conduct and promote studies and research that support the formulation of policies, programs and approaches which facilitate the nation's scientific and technological development; and to promote policy dialogues concerning technology development and acquisition which will lead to an information and data base supportive of needed policy decisions.

- To promote the development of Thailand's infrastructure for science and technology.

- To support increases in the capacities for research, development and engineering in the private sector and in public science and technology (S&T) organizations including educational institutions.

- To support research, development and engineering activities aimed at meeting the requirements of the private sector; and to coordinate research in the private and public sectors that is directed toward achieving technological and commercial benefits in concerned industrial, agricultural and service sectors.

- To support increased S&T services, e.g. commodity quality analysis and testing, standards and calibration services, technological information services, and technical consulting services.

- To support increased capacities for selecting and acquiring imported technologies; including the ability to negotiate for the technologies and manage their acquisition such that the technologies can be efficiently used and absorbed, thus enhancing and strengthening the nation's technological capacity.

- To promote a strengthened S&T capacity to facilitate the application of technologies of increasing sophistication and in widening areas of application in the public and private sectors.

- To promote cooperation between the public and private sectors and between Thai and foreign organizations for enhancing the development of science and technology.

- To carry out other activities that are necessary for achieving the Board's objective, including raising funds to support the activities of the Board.

To achieve these objectives the STDB carries out three major programs of work which complement one another. These are administered by the:

- Planning, Program Development and Policy Review Office;
- Research, Development and Engineering Support Office; and
- Industrial Development Support Office.

The Planning, Program Development and Policy Review Office, also evaluates programs and administers a technology transfer aid program called Support for Technology Assessment and Mastery Program (STAMP).

The Research, Development and Engineering Support Office is by far the largest of STDB activities. It administers:

- The Graduate Fellowship Program for M.S. and Ph.D. studies in Thai universities. Eligibility extends to applicants from the private sector.

- The RD&E grants to support projects with industrial relevance in Biotechnology, Materials Technology, and Applied Electronics and Computer Technologies.

- The Company-Directed Loan Program from which a private firm may improve its S&T capability by borrowing up to 5 million baht and paying approximately half the commercial interest rate.

- The Company-Directed Grant Program which reimburses up to 50% of the costs the private firm spends in technical improvements.

The Industrial Development Support (IDS) Office administers the following programs:

- The Diagnostic/Research and Design Services (D/RDS) which aims to promote the technical consultant industry and the small and medium sized private industrial firms' use of consultants to improve their technical capabilities. The D/RDS is now administered through Chulalongkorn University's UNISEARCH organization.

- The Technical Information Access Center (TIAC) which promotes Thailand's various databases' growth and technical capabilities, provides access to practically all databases in Thailand and abroad, and in certain cases subsidizes the costs.

- The Standards, Testing and Quality Control (STQC) Program which aims to provide measurement calibration standards, improve measurement capabilities in government and private laboratories, provide training and equipment to effect quality assurance and quality control.

Discussions with officials at STDB brought out the following major points which reflect the thinking that goes on at STDB in the implementation of its programs.

- While STDB will extend RD&E grants in the three major areas, a key consideration in awarding such grants is commercial relevance and the extent to which the project has been initiated by "demand-pull" forces.

- While encouraging RD&E activities it is imperative to ensure that the fruits of these activities are enjoyed by the researchers and/or companies engaged in these efforts. The patents taken out based on the research results will thus belong to the researchers or the companies involved and the STDB is also training a patent writer who would eventually provide services to the Thai researcher or company to register the patent worldwide.

- STDB would like to work closely with counterpart organizations in the ASEAN and the EEC in developing common standards to facilitate trade. In this regard STDB is of the view that close links must be forged with national standards institutions in both Taiwan and Singapore who are already working towards "standards setting for EEC-1992". STDB expects to work closely with TISTR, DSS and TISI in formulating and implementing programs in this area especially in the area of human resources development.

- STDB envisages its Technical Information Access Center (TIAC) emerging as a hub of a consortium of databases. STDB plans to provide hardware and training for the establishment of such databases which would form part of the TIAC network.

- STDB views its major role as the mobilisation of the S&T community in Thailand and couple them with the economic development process. It feels that its current achievements are likely to lead to further US funding after 1992 but perhaps on a lesser scale. Legislation to incorporate STDB as a legal body is also expected to be passed soon which could facilitate the securing of funds from diverse sources.

- Even though the STDB Company-Directed Loan and Grant Programs may appear to be a duplication of the TTC Revolving Fund Program, STDB is of the view that considering their autonomous status and the access that they have to S&T expertise they can dispense such funds faster and more effectively.

II.3.3. THAILAND DEVELOPMENT RESEARCH INSTITUTE (TDRI)

In Part II.3.2. an attempt has been made to describe some of important agencies linked either formally or informally with MOSTE. However, the TDRI is also an important agency outside this group which plays a major role in S&T development in Thailand.

The Thailand Development Research Institute (TDRI), founded in 1984, is a non-profit research foundation which fosters independent policy research on national development issues. TDRI strives to contribute to the search for solutions to long-term problems facing Thailand and to influence policy formulation for sustainable social and economic development.

TDRI has four main objectives:

- the conduct and promotion of policy research
- the establishment of an information center
- the creation of a research network linking institutions and individuals engaged in policy research issues
- the dissemination of the results of policy research

TDRI is committed to develop its own research agenda to ensure the coverage of all key policy issues and has initially defined seven research programs:

- Agriculture and rural development
- Industry, trade and international economic relations
- Macroeconomic policy
- Natural resources and environment
- Human resources and social development
- Urban development, infrastructure and energy
- Science and technology development

The Development Information Center of the TDRI collects documents and compiles information utilizing current technology for storing and retrieving information. It networks with local and international data bases and provides a central access point to researchers and to government planners seeking up-to-date information on a variety of policy issues. The Center focuses its efforts on areas which have been designated as frontiers for policy research in Thailand.

TDRI is creating a policy research network to bring together scientists and researchers from within and outside the country in order to facilitate contacts among researchers and public and private sector decision-makers. In this way TDRI intends to play the role of a catalyst in facilitating and encouraging informed public concern.

TDRI plays a leading role in promoting the use of research results in national policy decision-making and also in informing the public on national policy issues. Research results of TDRI are published using a variety of formats suited specifically to relevant target audiences.

II.3.4. THE THAILAND INDUSTRIAL STANDARDS INSTITUTE (TISI)

Another major institute of relevance to S&T development not within purview of MOSTE is TISI. TISI comes under the Ministry of Industries. It was established in 1968.

TISI is the national standards organization for Thailand. According to the Industrial Product Standards Act under which it was set up, TISI has as its governing body the Industrial Product Standards Council which controls its policy, sets the priority of standards to be prepared, recommends qualified persons to be appointed to TISI technical committees, arbitrates and awards licenses under the certification scheme.

The primary functions of TISI are as follows:

- To prepare and publish national standards;
- To grant licenses to use TISI standards mark;
- To promote the implementation of standards;
- To represent Thailand in the International Standardization Organization; and
- To assume responsibilities for food standards activities in Thailand and collaborate with the Joint FAO/WHO Food Standards Program.

TISI participates in international standardization work and this serves as an important mechanism for transferring technology to Thailand in the field of international standards activities. TISI represents Thailand in the International Standardization Organization and in the Codex Alimentarius Commission of the Joint FAO/WHO Food Standard Programme. Some of the other international activities in which TISI participates are as follows:

- Technical expert group on jute products.
- ASEAN power utility/authority on standardization
- Regional Network for Agricultural Machinery (RNAM)
- Expert Groups on ASEAN Industrial Standardization (EGIS)
- Pacific Area Standards Congress (PASC)
- International Laboratory Accreditation Conference (ILAC)

In October 1989 an ASEAN Project on Industrial Standards and Quality Assurance has been initiated with EEC support. This project aims to facilitate standards harmonization in the field of electrical and electronics appliances, iron and steel and agricultural machinery.

A project funded by the Government of Japan has also been initiated to establish two centres namely the Industrial Standardization, Testing and Training Centre and the Industrial Metrology Testing Service Center. These will be executed by TISI and TISTR respectively. The establishment of these centres is expected to eliminate some of the weaknesses that Thailand has in calibration services, standard setting and certification. The first phase of this program which is expected to be completed in 1990 is being funded by a Japanese grant of 2,648 million yen. A second phase worth 1,595 million yen has also been planned.

II.4. AN EVALUATION OF S&T CAPABILITIES OF THAILAND

While there is tremendous potential for the application of science and technology in the overall development of Thailand, it is perhaps not incorrect to say that the scientific and technological capability necessary to utilize this potential is not adequate and has several weaknesses. This may already be evident from the discussions in Parts II.1, 2 and 3. This does not mean that there is no technological capability. In a relative sense Thailand's technological capability is certainly higher than many of the countries in the Asia Pacific region. However, it is not adequate at present to help achieve Thailand's aspiration of quickly catching up with some of the technologically advanced NICs.

In general, it appears that in Thailand there exists a good technological infrastructure which could serve as a foundation to build on but there is inadequate technological capability to carry out research and development, technology transfer and effective industrial production required by the changing structure of the economy. In this section it is proposed to present a brief evaluation of Thailand's technological capability under the following headings:

(a) R&D capability;
(b) Technology transfer capability;
(c) Technological capability of Thai industry; and
(d) S&T human resources development.

II.4.1. R&D CAPABILITY

A country like Thailand which is just developing its S&T capabilities cannot be expected to contribute technology which is intrinsically new and has to spend substantial amounts of money on purchasing technology. Still it is necessary for Thailand to invest in R&D to strengthen its capacity to assimilate, adapt and improve the technologies imported. Furthermore, as experience has shown, building up a sizable and productive R&D system and tradition in a country takes a considerable amount of time and unless Thailand strengthens its R&D capability gradually it will be difficult for it to eventually adopt a self-reliant strategy for technology-based development.

Tables 29-32 present some important statistics on R&D expenditure patterns in Thailand for the year 1985. An examination of R&D expenditure reveals that while the production sector spends most of its funds on development (current expenditure) and applied research (capital expenditure), the higher education and general services sector appear to be spending more on basic research. These two sectors also appear to be utilizing 80% of total R&D current expenditure and 95% of R&D capital expenditure. On the whole it appears that R&D activities appear to be more biased towards basic research in Thailand.

When the capital and current expenditures on R&D by field of specialization are examined it appears that Thailand is emphasizing heavily on the medical and agricultural sciences with emphasis on the engineering sciences being very low (Table 30).

An examination of sources of funds for R&D (Table 31) shows that foreign sources account for the largest percentage for basic and applied research with government sources contributing almost 80% of the funds for development. A striking feature is that productive enterprises contribute very little towards R&D.

When the distribution of R&D expenditure by major socioeconomic aims is examined (Table 32) it appears that while Thailand places considerable emphasis on development of agriculture, energy conservation, development of transport/communication, health service and social development it seems to give less importance to industrial development. This lack of emphasis on industrial R&D may prove to be an obstacle in Thailand's quest for NIC status.

While R&D expenditure patterns provide useful information on inputs into the R&D system, output and impact measures are often difficult to develop. Some common output measures that are used are outputs of scientific research in the form of publications and the number of patents taken out. It is felt by many S&T officials, who were interviewed during this study, that developing such measures would be difficult in Thailand unless concerted steps are taken to carefully record, abstract, index and rate scientific publications and technological innovations.

According to a 1986 TDRI study [51], the US-based Institute for Scientific Information (ISI) has recorded that Thailand has about 200-300 scientific authors who in a given year publish at least one scientific article. Thus, Thailand has 5 authors per million population compared to the figure of 140 and 700 for Japan and the USA respectively. However, since the ISI index does not include "report" literature, local journal articles and output of scientific services, it could be said to underestimate Thailand's R&D output. However the fact remains that this figure gives a partial measure of the low R&D capability of the country.

An output indicator of R&D activities is the number of patents applied for and awarded. Table 33 shows the number of patent applicants - both Thais and foreigners - during the period 1982 - 1986. In Thailand the patent act was promulgated in 1979. Table 34 shows the number of patents awarded. These tables reveal the following:

- Only 22% of the patent applications during this period came from Thais. The rest were foreign applicants.

- When the patents awarded are considered the pattern is more balanced with about 47% being awarded to Thais.

- The proportion of applications in the three areas are:

  - Chemistry 40%
  - Engineering 27%
  - Industrial designs 33%

- The proportion of patents awarded in the three areas are:

  - Chemistry 16%
  - Engineering 12%
  - Industrial designs 72%

- The proportion of patents awarded to patents applied for in the three areas are:

  - Chemistry 4%
  - Engineering 5%
  - Industrial designs 22%

- The proportion of Thai patent applications in the three areas are:

  - Chemistry: 3%
  - Engineering 17%
  - Industrial designs 49%

- The proportion of patents awarded to Thais in the three areas are:

  - Chemistry 6%
  - Engineering 47%
  - Industrial designs 56%

While it is difficult to draw firm conclusions from these figures they do indicate that in absolute terms foreigners dominate both patent applications and patents awarded. The reasons for this pattern could be many out of which one is the low level of innovative activity in Thailand. Also no obvious reason exists to explain the high rate of patents awarded to Thais in the field of engineering when Thai patenting activity in this area is relatively low. However, one feature is that during the period 1982-1986, the level of patenting activity among Thais has certainly increased.

Some of the conclusions that can be drawn about the R&D capability of Thailand are as follows [see also 17, 18, 19,10].

- There is some local R&D capability and it appears that the potential exists for rapid growth. However there appears to be an urgent need to mobilize the R&D capability both in the public and private sectors. The need to strengthen the linkages between the two has already been stressed.

- There is an urgent need in the productive sectors, be they private or state-owned, to increase their R&D activity. It is reported by MOSTE [46] that the private sector spends less than 3% of the total national R&D expenditure. It implies therefore that the productive sector relies heavily on imports of technology from abroad.

- The heavy emphasis on basic research appears to have led to a low level of capability development in engineering R&D. This is a key area where a greater thrust is needed on a priority basis if Thailand is to enhance its industrial capabilities. The causes for this lack of emphasis may be due to several factors involving education, organization of R&D, financial and promotional incentives, social traditions and legal aspects.

II.4.2. TECHNOLOGY TRANSFER CAPABILITY

The amount of technology imported into Thailand has increased steadily over the years. In 1978 the payment for royalties, trademarks, technical services, experts, training and management services is reported by MOSTE [46] to have been about 500 million baht which increased four-fold to 2045 million baht in 1985. Table 35 gives some statistics on payments for technology imports for the period 1982-1985 and Table 36 gives a more detailed breakdown for 1985.

In general, technology has been imported into Thailand through a wide range of mechanisms ranging from imports of machinery, plant and equipment, direct foreign investment, technical collaboration, "turnkey" projects, subcontracting, etc., to employ-

ment of foreign experts and training. For instance, in 1985, in addition to the 2045 million baht paid in the form of royalties, trademark fees, technical fees, expert fees, training fees and management fees, Thailand imported approximately 65,000 million baht worth of capital goods.

The statistics in Table 35 and 36 indicate that the automobile and auto parts industry is the single largest payer of technology fees with the food and beverage industry coming a close second. It can also be seen that most of the payments are for technology needed in the consumer goods sector and not for the capital goods sector. This again highlights the low level of technological capabilities of Thailand in the production of capital goods.

Discussions with key officials in some of the major S&T institutions of Thailand revealed the following important aspects related to technology transfer [see also 17, 18, 19, 20].

- Very little effort is made by Thai firms to assimilate, adapt and improve the technology transferred from abroad. Lack of adequate indigenous R&D capability could be one reason.

- Lack of local skills leads to poor utilization of imported know-how especially in Thai-owned firms.

- Thai-owned firms mainly depend on imports of machinery as a mechanism for importing technology while subsidiaries of foreign companies and Thai joint-ventures with foreign companies tend to rely on a wider range of mechanisms such as licensing, hiring of experts, overseas training etc.

- Foreign-owned companies prefer "packaged" technology transfer which makes it difficult to assimilate the imported technology due to lack of adequate information on the basis upon which the package was formulated.

In addition to these general observations, there exists some literature which have attempted to examine some of the technology transfer issues with special relevance to the technology transfer practices of Japanese and US firms [28, 32, 42, 43, 55].

The literature reviewed on Japanese technology transfer practices in Thailand revealed the following important points.

- In general, in Thai-Japanese joint ventures, the local partners acquire very little technical know-how over the years and the production technology is known only to the Japanese expatriates.

- Firms in which Japanese have invested (henceforth referred to as Japanese firms) usually place great emphasis on training of production workers, technicians and professionals. However the training is usually in narrow specialized areas which makes it difficult to transfer these skills to other industries

- Japanese firms usually have a high level of local participation on the production side where lower level skills are required. However local participation in managerial/executive levels or in highly technical positions is limited. The Japanese tend to use a relatively large number of expatriates in these positions

- Compared to Thai firms, the Japanese firms have a higher import content of intermediate inputs and do not have many linkages with local supplier or subcon-

tractors. Whenever such linkages are established they display a marked preference for other Japanese firms.

- The only Thai companies that are able to deal with the Japanese on equal terms are either big conglomerates like Siam Cement or Saha Union or Thai-Japanese joint ventures such as Thai Teijin where politically powerful Thai businessmen are the local partners.

- In Thai-Japanese joint-ventures even if some technology is developed locally for marketing only in Thailand, the Japanese partner will agree to the use of the company brand only if royalties are paid to the Japanese parent.

However, the Japanese tend to react to the above mentioned criticism by making the following observations:

- The Thais are impatient but they should learn to work many years with a firm, like Japanese workers, before they can be given senior management responsibility or understand the technology. The job-hopping tendency of the Thais aggravates this problem.

- Thai firms are usually family-dominated with decision-making powers concentrated in one or two people at the top. When such companies enter into joint ventures with the Japanese a basic clash of management styles occurs because they are not used to the group-oriented decision-making of the Japanese.

- Lack of adequate local skills and the tendency of Thais to take things too easily does not facilitate the assimilation of the transferred technology.

- Due to the lack of quality-consciousness that prevails in many local Thai firms it is not possible to enter into linkages with these firms to supply intermediate inputs. This is one reason why Thai-Japanese joint ventures are preferred as subcontractors.

The literature on the technology transfer practices of USA firms in Thailand revealed the following important points.

- American firms use relatively few expatriates when starting operations in Thailand and reduce the expatriate management role over time.

- Training receives great emphasis in American firms as well. Both general and firm specific training is given with managerial and technical staff receiving general training and skilled and unskilled workers receiving firm and task specific training.

- The acute shortage of qualified technical and management personnel coupled with pirating of skilled staff by other firms has made it difficult to develop Thai employees fully.

- American firms have a tendency to rely heavily on imported intermediate inputs with not much effort being made to develop local subcontractors. It has been found that higher the level of technology and smaller the American firm, the more difficult it is to develop local suppliers. Most potential Thai suppliers are family-run businesses which are risk averse, have little experience in subcontracting and are short-term profit oriented.

- American firms exert substantial control over sensitive and critical technology but gives the local managers the latitude to determine appropriate manufacturing/process technology. Local R&D is hardly undertaken.

- In some American firms, Thai employees have absorbed and utilized the imported technology so well and have developed expertise to the point where they have been sent by these American firms to help establish new operations overseas.

- In general the most important method by which technology is transferred from American firms to Thai nationals is through the opportunity given to them to participate in the management and operations of the firm. Thus, there appears to be technology transfer in operations through "learning-by-doing".

The discussion above on Japanese and American technology transfer practices could lead to the conclusion that the American practices are more favorable to the development of Thai technological capability in the long run. However, it must be remembered that in Thailand, as in other parts of the world, the Japanese companies appear to be more successful than their western counterparts! Discussions with key Thai officials revealed that there also seems to exist a difference in recruitment of local personnel between Japanese and US firms. Japanese firms predominantly recruit university graduates who are trained subsequently whereas US firms tend to recruit experienced engineers and other personnel.

The issues on technology transfer that have been highlighted raise many questions that S&T policy research has to address with regard to the upgradation of Thai technological capabilities. These include:

- What mechanisms of technology transfer can prove to be beneficial to Thailand in the long run?

- How can technology transfer be channelled in directions that can support overall development strategies?

- How can it be ensured that the technology transferred is assimilated, adapted and even improved?

- Can foreign companies be encouraged to undertake R&D in Thailand with a view towards facilitating the assimilation of imported technology and perhaps even the development of new technology.

II.4.3. TECHNOLOGY CAPABILITY OF THAI INDUSTRY

Three industries which are considered to be very important to Thailand's industrial development, as already mentioned, are the biotechnology-based industry, material technology-based industry and electronics and information technology-based industry.

The Thailand Development Research Institute (TDRI) has carried out considerable work in assessing the technological capabilities of these industries and these studies have come out with several important conclusions. In this section it is proposed to outline the major findings of these studies.

II.4.3.1. The TDRI definition of technological capability

For the evaluation of the technological capabilities of the three priority areas, technological capabilities of the firms in these industries have been divided into four main categories as follows [48]:

- Acquisitive Capability
- Operative Capability
- Adaptive Capability
- Innovative Capability

Each type of capability has been further subdivided into several components as follows.

Acquisitive Capability

- Search which is the capability to search or look for the sources of relevant technologies.

- Assess which is the capability to assess or evaluate the appropriateness of technologies from various sources so as to select the most suitable ones.

- Negotiate which is the capability to negotiate with the owners of the technologies with regards to benefits and restrictions prior to actual procurement.

- Procure which represents the manner in which producing firms procure the technologies, e.g. buying the whole plant on a turnkey basis, buying only certain portions, and so on.

- Transfer which represents the way by which the technologies and operation know-how are transferred to the firms, e.g. by extensive training prior to installation, the use of foreign experts in the transfer of technologies, etc.

- Installation and Start-Up which represent the way by which production machineries and facilities are installed and put into operation, e.g. the need for foreign engineers and the difficulties and problems associated with installation and start-up.

Operative Capability

- Operation and Control which is the capability to efficiently and effectively utilize and control manufacturing machinery and facilities including production planning, facility design, and inventory and quality control.

- Maintenance which represents the quality with which firms maintain production facilities, e.g. planned maintenance, breakdown maintenance, etc.

- Training which represents the way in which producing firms upgrade the technical competency of their personnel, e.g. by having systematic and organized training programs within the firm, by providing overseas training, etc.

- Skill which represents the overall level of operational ability of producing firms which would be reflected in the quality of the products, the ability to meet standard specifications, and so on.

- Management which represents the way in which the firm is managed, e.g. family-style management, management based on formal organization with clearly defined functional departments, etc.

Adaptive Capability

- Knowledge Acquisition which is the capability to acquire new or additional knowledge for products and processes improvement, e.g. via technical journals, trade exhibitions etc.

- Technology Digestion which represents the ability to digest and understand in detail various components of relevant technologies in order to adapt the technologies to suit local environments.

- Minor Product Modification which is the ability to alter some minor features of products to suit the needs of the markets, e.g. whether or not foreign or outside assistance is required to make such changes, whether or not any alteration to product features has been made, etc.

- Minor Process Modification which is similar to minor product modification above but concerns processes rather than products.

Innovative Capability

- Research and Development represents the actual ability and the capability to carry out R&D activities, e.g. having a separate R&D unit equipped with capable personnel and adequate facilities, having no R&D activity at all, etc.

- Radical Product Modification which is the ability to modify products in a radical way, e.g. the introduction of new functional features to products.

- Radical Process Modification similar to radical product modification but concerning processes, e.g. the introduction of new product lines by radically modifying existing processes.

- Major Changes which have been achieved by producing firms, e.g. the introduction of new products and processes which are completely different from existing ones.

- New Inventions which involve the introduction of either products or processes which are completely new.

While the definitions of some of the components mentioned above had to be modified for the different industries, in general, the principles were applicable throughout. The rating of each component of the technological capabilities was carried out using a scoring range of 0-5 where 0 indicated no capability and 5 indicated excellent capabilities comparable to those of the best in the world. Scores of 1,2,3,4 indicate poor capabilities below local average, fair capabilities corresponding to an average Thai firm, good capabilities better than average Thai firms and very good capabilities comparable to the average of firms in industrialized countries or those of leading Thai firms.

II.4.3.2. Evaluation of technological capability

In the field of biotechnology-based industries eight sub-industrial groups have been studied to assess the technological capabilities of this sector. These are:

- aquaculture
- animal feeds
- seed and seedling
- dairy and dairy products
- ornamental plants
- organic acids
- alcohol
- health-related industry

A total of 32 firms in these eight sub-industrial groups have been surveyed.

In the case of the material technology industries the following were studied.

- basic metal industry
- metal working industry
- machinery parts and machinery industry
- classical ceramics industry
- fine or advanced ceramics industry
- rubber products industry
- plastic resins industry
- plastic products industry

In these eight categories a total of 55 producing companies, had been surveyed.

In the electronics and information technology-based industries, the following categories have been studied.

- consumer electronics
- communication equipment
- computer hardware
- industrial electronics
- electronic components
- computer software

In these categories a total of 32 firms have been surveyed.

While external factors such as market factors, technological change, protection and legal/regulatory measures can affect technological capability development, the survey points out that these cannot explain why firms in the same industry possess different levels of technological capability. The answers to this question could perhaps be internal to the firm. The survey thus has attempted to examine the technological capabilities of these industries in terms of four attributes of the firm namely:

- firm size;
- investment promotion status;

- market orientation; and
- ownership.

The summary of technological capabilities with respect to these attributes are shown in Tables 37-40. A brief discussion on these findings is presented below.

Firm Size

(a) Acquisitive Capability

Table 37 shows that large firms in the biotechnology-based industries (BTBI) have higher levels of acquisitive capability than small and medium scale firms. This difference is not evident in the materials technology-based industries (MTBI) and the electronics and information technology-based industries (EIBI).

The TDRI study also points out that it is only the large Thai firms which have developed a high level of acquisitive capabilities especially in the machinery fabrication/assembly and foundry industries and electronics firms. These firms usually use teams of capable personnel to systematically search, evaluate, negotiate, bargain and purchase technologies. On the contrary large firms which are joint-ventures or foreign-owned have not developed these capabilities due to their reliance on the parent firm for technology acquisition.

(b) Operative Capability

Table 37 shows that large firms have higher levels of operative capability than small firms with the difference being more marked in MTBI and EIBI. This may be due to the fact that larger firms are in a better position to use their technology more effectively due to the greater emphasis that they place on manpower development, internal organization, maintenance, quality assurance etc. Furthermore large firms are better able to afford pre-installation and operation training programs for their engineers and technicians than smaller firms.

The TDRI study points out that small firms have low levels of operative capability because they tend to use second-hand machines from abroad with little understanding of the technology as a result of which they face frequent maintenance and quality problems.

(c) Adaptive Capability

Table 37 shows that, in general, large BTBI and MTBI firms have higher levels of adaptive capability than smaller firms. This is not the case in EIBI firms where smaller firms appear to have a slightly better rating than the larger ones. This is attributed by the TDRI study to the limited scope available for absorbing, imitating and adapting technology in the EIBI field when compared to technology in the BTBI and MTBI. Also the adaptive capability in EIBI firms is limited. It is also reasonable to expect the larger firms in BTBI and MTBI to be better prepared in terms of personnel and information to adapt technology.

(d) Innovative Capability

Table 37 shows a dismally low level of technological capability in the EIBI firms and only a little higher level in BTBI and MTBI firms. The TDRI study attributes this to the fact that these firms do not carry out any formal R&D. Even large firms carry out only testing of raw materials and products in-house while smaller firms lack even these facilities.

Investment Promotion Status

Table 38 presents the results of technological capability evaluation in relation to promotional status. The values indicate that there does not appear to be a major difference between the technological capability between promoted and non-promoted firms except in the case of operative capabilities. This is attributed by the TDRI to the fact that promoted firms tend to be larger. It has already been pointed out that larger firms have certain advantages which facilitate the development of operative capabilities. The tax-exemptions given to larger firms also release more funds for personnel development, machinery etc. which enhances operative capability. It is interesting to note that promoted MTBI firms consistently score higher than non-promoted firms in all four categories of capabilities. The TDRI study points out that investment promotion policies appear to be biased in favor of large firms which enable them to develop higher levels of operative capability than smaller firms.

Export Orientation

It is generally hypothesized that export oriented firms should have higher levels of technological capability than domestic market oriented ones. However, the results of the TDRI study do not fully support this hypothesis as Table 39 indicates that export and non-export firms show no apparent differences in technological capability levels. This is especially true in BTBI and MTBI firms. The sampled firms included some export oriented ones which, while using relatively stagnant technology and possessing rather low levels of technological capability, were able to export by taking advantage of the cheap labour resources in the country. However, the above hypothesis is confirmed by the firms in electronics industries where it can be seen that the average operative capability score of export oriented firms was 3.86 while that of domestic market oriented firms was only 2.61. As for adaptive capability and innovative capability, the average scores of both export and non-export firms indicate uniformly low capability levels.

Ownership Structure

Table 40 shows that there appears to be very little differences in the levels of technological capability between Thai or joint-venture firms especially for acquisitive, adaptive and innovative capabilities. In the case of small and medium Thai firms the necessary skills for searching, adapting and innovating are not there while the joint-ventures or foreign-owned firms rely on the foreign partner for such activities.

However, foreign firms appear to possess much higher operative capabilities due to the fact that most of the production management skills can be transferred from the parent company. Furthermore they continue to receive regular information on overseas trends in production, marketing etc. which facilitate the upgradation of operative capabilities.

As for adaptive and innovative capability, foreign firms in biotechnology and materials technology-based industries, especially those managed by Thais, tend to have higher levels of capability than Thai firms. This is because foreign firms can search for information and learn about technology changes and advances in other countries. Such information allows foreign firms to modify or carry out innovative activities more easily than Thai firms. Joint-venture firms which are managed by Thais, implying that a certain level of learning and technology transfer has been achieved, also have higher levels of adaptive and innovative capability than those which continue to rely on foreigners, implying lower levels of learning and technology transfer.

II.4.3.3. Reasons for the low level of technological capabilities

While this aspect has been discussed in earlier sections as well it may be useful to highlight once again, perhaps explicitly, the reasons for the low level of technological capability in Thailand. Some of the major reasons are summarized below.

- Shortage of Skills

  - Lack of technicians, engineers and specialists
  - At present there is an acute shortage of mould and die makers, precision machinists, materials engineers, metallurgists and chemical, mechanical, electrical, computer, production and process engineers.
  - There are very few scientists and engineers who can actually carry out high calibre R&D.
  - Poor teaching facilities, brain-drain among the university teaching staff etc., tends to produce poor quality graduates.

- Inadequate Information Services

  - Inadequate funding for purchase of recent technical information.
  - Difficulty in access to technical information due to geographic scattering of information centers
  - Language barriers
  - Inadequate efforts for translation of important material into the Thai language

- Inadequate Technical Services

  - Inadequacy of testing and analytical facilities which leads to considerable delays in obtaining technical services
  - Poor quality of currently provided services
  - Lack of suitably qualified personnel
  - Lack of consultancy facilities for product/process improvements

- Lack of Raw Material Supplies and Supportive Industries

  - Lack of adequate upstream and downstream industries to stimulate the development of BTBI, MTBI and EIBI firms
  - Non existence of supporting industries such as powder metallurgy, ceramic coating, high precision electronic parts etc.

- Lack of Specialized Technology Centers

  - Lack of specialized centers in the fields of technology transfer, information and technical services, human resources development and technology development

- Lack of R&D and Innovation Activities

  - Short-term profit motives render R&D activities unattractive
  - Lack of infrastructural facilities and qualified personnel make the establishment of R&D activities difficult
  - Fiscal and financial measures to encourage R&D are not available

- Inadequate S&T Policy and Legal Support

  - No clear definition of S&T policies
  - Unnecessary duplication and poor coordination of activities of S&T agencies
  - No clear industrial policy
  - Absence of a mechanism to coordinate and plan S&T policy at the national level
  - Ineffective enforcement of laws governing intellectual property rights
  - Inadequate steps by the Board of Investment (BOI) to encourage R&D in promoted firms
  - Lack of fiscal and financial measures to enhance local technology capability development

II.4.4. S&T HUMAN RESOURCES DEVELOPMENT

Thailand has a well established system of 16 state-owned universities and 25 private universities with an enrolment of about a million students. Table 41 provides some relevant statistics on student enrolment. While the above mentioned universities come under the Ministry of University Affairs, two more institutes -one a teacher training college and the other a technology institute come under the Ministry of Education.

This is one of the most critical problems constraining the technological capability development of Thai industry in general and in the three groups of industries in particular. Suitably qualified personnel at all levels: skilled labour in certain fields, technicians, engineers and specialists, are in short supply. The problem in materials technology-based industries is particularly severe because of the nature of the industries which require experience and skills as well as technical knowledge, in addition to the ability to use modern manufacturing facilities. As this group of industries is relatively new to Thailand, experience and skills are lacking and knowledgeable personnel are rare. Mould and die makers, precision machinists, materials engineers and metallurgists, for example, are in great demand at present. One of the results of the manpower shortage is frequent job-hopping. Small and medium size firms are reluctant to invest in the training of personnel as it is likely that they will eventually lose these trained people. Frequent job changes are also an impediment to specialization which is of crucial importance in materials-based industries.

The shortage of graduate scientists and engineers is pervasive in both the private and public sectors. This is particularly true in the materials and electronics-based industries which need engineers of various disciplines, including mechanical, electrical, production, computer, metallurgical and materials. In biotechnology-based industries the problem, in general, is less severe but shortages of certain types of personnel such as chemical and process engineers and modern biotechnologists do exist. Technological capability development in whatever area needs these types of people. One cannot really do very much without an adequate supply of suitable qualified personnel.

Tables 42-44 present some statistics on the stock of S&T personnel in Thailand. It can be seen from Table 42 that heavily funded fields of specialization such as the agricultural sciences also have the largest number of R&D personnel. Table 43 also shows that the productive sector is the largest employer of S&T personnel. Table 44 presents some statistics on the qualification profile of Thai engineers and scientists.

However, as already pointed out in this report, Thailand's technological capability development appears to be suffering due to a shortage of S&T manpower. In this context two recent TDRI reports [49, 50] dealing with the analysis of supply and demand of S&T manpower in Thailand provide useful information. The model is based on assumptions about GDP growth rates, retirement rates of S&T personnel and the coefficient between the output of different sectors of interest and S&T manpower. While the study points out that the analysis has limitations due to the fact that it ignores increase in the productivity of S&T manpower and possible substitution between S&T and non-S&T manpower, and between labour and capital, it nevertheless can provide useful insights into the areas in which corrective action will be needed to overcome the skill shortages. The supply trends for the study are based on an aggregate target output basis from the Sixth Plan and its revisions, which have then been split up into the various fields.

The TDRI study classifies the S&T area of specialization, in accordance with the three major industrial priority groups (BTBI,MTBI,EIBI) and associated fields of technology, as follows:

B. Biotechnology	B1 -	Agricultural fields, such as general agriculture, botany, zoology, animal science and forestry.
	B2 -	Food science
	B3 -	Bioscience, including biology, biochemistry,bacteriology, biotechnology, and biophysics.
	B4 -	Pharmacy
	B5 -	All other health related areas.
E. Electronics Technology	E1 -	Computer science. including computer engineering.
	E2 -	Electrical engineering, including electrical, electronic and communications engineering.
M. Material Technology	M1 -	Mechanical engineering.
	M2 -	Metallurgy, including material science and mining engineering.
T. Related Technology	T1 -	Other engineering, including civil engineering, sanitary engineering, survey engineering, agriculture and irrigation engineering, and other engineering disciplines not covered under E,M,T2 or T3.
	T2 -	Chemical engineering
	T3 -	Industrial engineering.
S. Physical Science	S -	Basic science disciplines, such as physics, chemistry, geology, marine science, general science, and other sciences.

Table 45 gives the projected demand for S&T manpower by fields while Table 46 gives the expected supply trends. The expected excess supply trends are shown in Table 47. The figures in parentheses refer to expected shortages. The following major observations can be made.

At the postgraduate level there are shortages in all fields except in agriculture. This type of shortage has two consequences. Firstly it leads to a shortage of high calibre R&D personnel. Secondly such shortages can affect the quality of the S&T graduate output at lower levels.

A similar pattern exists at the bachelor degree level. This can affect the expansion of the productive sector. However, there are indications that the situation will improve in the EIBI. However the MTBI will be still facing shortages.

While there is likely to be a significant improvement in the supply of civil engineers by 1990, the shortage of chemical and industrial engineers is likely to continue.

At the vocational level there will be excess supply. However this does not mean that there will be no shortages in specialized areas. Past experience has shown that firstly there is a relatively low stock of vocational workers in S&T occupations when compared to past production and secondly the employment rates among vocational school graduates is very high. These suggest that the quality of output at the vocational level may not be sufficiently high.

Urgent steps are needed to meet the shortage of the required skills without which Thailand's plans to use the BTBI, MTBI and EIBI as thrust areas for development may not be implementable.

II.5. SCOPE FOR COOPERATION BETWEEN THAILAND AND THE EC IN THE FIELD OF SCIENCE AND TECHNOLOGY

Part II.1. in this report outlined briefly the evolution of the Thai economy. Parts II.2. and 3 attempted to present an overview of Thailand's S&T policies and plans, and the institutional framework for S&T respectively. Part II.4. presents a review of Thailand's technological capabilities with emphasis on R&D, technology transfer, the three priority industrial sectors (BTBI, MTBI and EIBI) and S&T human resources. The objective of this part is to examine the scope for cooperation between Thailand and the European Community (EC). This examination will be based firstly on the important observations made in Part II.1. through 4 and secondly on a review of Thailands needs in the area of S&T.

II.5.1. ASSESSMENT OF TECHNOLOGICAL NEEDS OF THAILAND

A useful starting point for determining the scope for Thailand-EC cooperation in the field of S&T would be to identify the needs of Thailand in the field of S&T. Based on discussions that were held with officials in the Thai government and S&T support organizations, and a review of relevant literature it appears that technological needs exist in the following areas:

- Agriculture and agro-based industry.
- Manufacturing industry
- Natural resource conservation and utilization
- Industrial support services
- The priority areas of BTBI, MTBI and EIBI.

Each of these will be briefly discussed below.

Agriculture and Agro-Based Industry

In Thailand, agricultural growth during the decades of the 60s and 70s took place mainly due to the expansion of area under cultivation. The sector is now facing problems due to the following reasons.

- Limited scope for further expansion due to geographical factors and cost consideration.
- Soil erosion and uncontrolled water flow due to excessive expansion of cultivation into watershed areas and marginal lands.
- Depressed commodity prices and uncertain future in the world markets of crops such as rice, maize, sugar, cassava and rubber.

Thus future growth in this area has to necessarily come through productivity increases and crop diversifications. In this context the following technological needs arise:

- Development of flood and drought-tolerant seed varieties which can be used productively in areas other than the conventional irrigated and rainfed lands.
- Development of new crops to diversify away from traditional crops facing unfavourable prices in world markets. Such crops will require genetic improvement and pest-resistance appropriate to the Thai environment.

- Technologies for quality control and certification of improved seed.
- Water control technologies and water distribution technologies that facilitate irrigation management, maintenance and cost recovery.
- Post-harvest technologies that can increase the value-added of crops, reduce post-harvest losses, improve quality and transform products into forms that will meet market needs.
- Development of animal feed formulas that combine locally available low cost ingredients with crops such as maize and cassava that are currently facing an uncertain future in traditional markets such as the EEC.

Manufacturing Industry

Thailand's industrial growth in the 1960s and 1970s could be attributed to import substitution facilitated by tariffs and other protectionist measures. Due to the limited scope for future expansion in this direction the government has during the 1980s promoted industrial production for export. It has also attempted to promote the production of intermediate and capital goods. While some categories of Thai products are competitive in the world markets, these are now facing increasing protectionism in developed-country markets. On the other hand, the products that do not face such protectionism are not competitive due to high production costs, inadequate quality and lack of standardization. The attempt by the government to produce intermediate and capital goods for the local market is also being hampered by Thailand's low technological capability which restricts the country's access to critical technologies in the area possessed by developed countries.

Thus, in the area of manufacturing industry, the following technological needs appear to be relevant:

- Technologies for improved quality control.
- Product standardization.
- New product development capabilities.
- Capabilities for designing and producing industrial equipment.

Natural Resource Conservation and Utilization

Another important source of growth during the 1960s and 1970s has been the exploitation and export of natural resources such as forests, minerals and fisheries. These resources have been depleted and/or degraded to a stage where they can no longer serve as future sources of growth. Thus, to manage the natural resources of Thailand more effectively technologies are needed for the following:

- Rehabilitation and protection of critical watersheds.
- Increasing supply of fuelwood and industrial wood without environmental degradation.
- Reduction of soil erosion and improvement of soil properties.
- Reduction of overfishing and conflicts between coastal and offshore fisheries.
- Improvement of domestic processing of tin.
- Reduction and control of environmental pollution.

Industrial Support Services

Three types of support services that enhance quality improvement and international competitiveness of local products are standardization, instrumentation and information services. The technological needs in these areas appear to be as follows:

- Upgrading capabilities in standardization and the associated functions of testing, certification and calibration.
- Improvement of technical information services and enhancing the internal and external information links of Thai S&T.
- Improvement of capabilities for acquiring, repairing and maintenance of instruments needs for S&T activities.

The Priority Areas of Biotechnology-Based Industries (BTBI), Material Technology-Based Industries (MTBI) and Electronics and Information Technology-Based Industries (EIBI)

Thailand, as already mentioned, has identified BTBI, MTBI and EIBI as particular relevant to its economy in the light of current needs and future prospects. The technological needs in these three areas are listed below:

(a) BTBI

- development of improved crop varieties, fertilizers and pesticides
- development of new post-harvest technologies and processing techniques for agricultural products
- development of human and animal vaccines, diagnostic agents, drug from plants and microorganisms
- development of treatment and recycling techniques of organic waste from industrial and household activities
- development of renewable biomass sources

(b) MTBI

- development of capabilities in steel making
- development of capabilities in metal based chemicals and rare earth preparation and application
- development of downstream industries of tin, lead, zinc and antimony
- development of a ductile iron casting industry
- development of capabilities in specialised casting and die making processes
- development of a precision machine tool industry
- development of advanced capabilities in metal working especially forging
- development of a high quality classical ceramics industry
- development of feldspar extraction and purification industry
- development of capabilities for fine ceramics production
- development of a specialised engineering rubber products industry
- development of capabilities for specialised rubber processing
- development of capabilities in petrochemical processes
- development of capabilities in specialised plastic processing techniques
- development of industries for mould making and machinery for producing plastic products

(c) EIBI

- development of higher capabilities in data processing, including both hardware and software
- development of capabilities in telecommunications, including signal conversions, signal processing and transmission
- digital technology
- development of advanced capabilities in software engineering

- semiconductor or integrated circuit (IC) technology
- development of capabilities for the production of electronic materials.

II.5.2. AREAS FOR POTENTIAL COOPERATION

While there is theoretically scope for potential cooperation in all the areas of technological needs highlighted above it must be remembered that the extent of cooperation required in the various areas would differ. For instance it is felt that in EIBI, there exists in Thailand substantial capability in a field like PABX in the telecommunication area. Thus while theoretically there exists scope for cooperation it may not receive high priority. In this section it is therefore proposed to highlight a few key areas where it is felt that there is considerable scope for cooperation. These are highlighted below:

- Considering the fact that Thailand has placed great emphasis on BTBI there could be scope for cooperation in using biotechnology for producing specialty chemicals in Thailand both for local use and exports. Such specialty chemicals could be pharmaceuticals, vaccines, enzymes, diagnostic reagents, dyes, colouring agents and pigments, perfumes and aromas, flavours, amino acids etc. In 1987 Thailand imported 3,287.7 million baht worth of specialty chemicals and exported an amount worth 829.4 million baht [40]. However, lack of adequate S&T manpower in this field and R&D facilities may be a barrier.

- There is a great deal of interest in Thailand in producing high quality machine tools and other capital goods locally with a view towards promoting the growth of Thai industry. At present the parts industries are not sufficiently geared to support the machine tool industries. Thus there appears to be scope for cooperation in developing both the machine tool industries as well as the parts industries.

- The parts and components industries and the plastic industries need computer-aided design, manufacturing and engineering (CAD/CAM/CAE) capabilities. For instance CAD/CAM can be used for designing and design modification and for machining complex three dimensional surfaces. These come in very useful for example in mould making and in producing precision items. The main barriers in using CAD/CAM/CAE is lack of skills, software and hardware [26]. This is an area where there appears to be considerable scope for cooperation.

- In the field of standardization, testing, certification and calibration there appears to be considerable scope for cooperation with regard to harmonization of standards between Thailand and Europe in view of Europe 1992, and in the training of Thai personnel in this field. The lack of adequate trained personnel is a major barrier to the establishment of certified private sector laboratories.

- Another area for potential cooperation is in the establishment of science and technology parks in Thailand. At present a feasibility study for the establishment of such parks is being carried out by MOSTE [29, 30]. It is envisaged that five science and technology parks will eventually be set up if the feasibility study supports it. Expertise from the EC in the designing, planning and implementation of these parks would be valuable and could eventually benefit EC-Thai joint venture firms as well.

- Thailand, as already pointed out, is gravely concerned about the degradation of its environment. This is a promising area for cooperation between Thailand and the EC not

only in terms of providing consultancy but also in designing and implementing schemes for conserving and protecting the environment.

- Another area which perhaps holds considerable scope for cooperation is in the area of human resources development. By officials in Thailand it was pointed out that the EC could help upgrade S&T skills in Thailand by:

  - providing scholarships to Thais for technical and higher studies in the EC;

  - establishing high quality technical training centres in critical fields in Thailand;

  - requesting EC companies based in Thailand to explore the possibilities of providing on-the-job training to fresh vocational and technical institute graduates;

  - providing experts to meet critical technological needs in the short term and for training Thais who could eventually take over;

  - sending EC university faculty to spend their sabbaticals in Thai universities, especially those in areas where Thai skills are scarce; and

  - initiating exchange programs for Thai university faculty to spend their sabbaticals in the EC.

- With the expansion of Thai industry, it is becoming evident that manufacturing companies do not have enough information on potential suppliers of materials, plant and equipments. One initiative that the EC could take is to establish an information center in Thailand which provide information on potential vendors in the EC and the services that they can offer. The information center can go one step further and identify also potential transferrors of technology in the priority areas of BTBI, MTBI and EIBI. This can also facilitate the setting up of EC-Thai joint ventures.

- Many important agencies in Thailand such as the Ministry of Science, Technology and Energy (MOSTE) and the Science and Technology Development Board (STDB) are setting up S&T information centers. Further expansion of these centers are also envisaged. EC involvement in such projects would be mutually beneficial since it offers the scope for sharing information.

- Many manufacturing companies in Thailand are simply not aware of the benefits that appropriate technology can bring in improving production efficiency and diversifying products. And, where these benefits are perceived, there are few places for companies to turn to for assistance in selecting, purchasing and implementing new technology. There is a clear need, therefore, to create an institutional basis for stimulating demand and utilization of technology in Thai industry. One option might be to establish a pro-active industrial extension service which would identify existing companies that are ready for technological intensification. The service would help these companies improve production efficiency and effectiveness, demonstrating where new technology can help solve problems or enhance production. The focus of this service should be in enhancing the acquisition and implementation of existing technology, rather than in helping companies to develop new technology. The target groups needing such assistance are small and medium industries. In some cases, the problems facing the client companies may not be solely technical, but could be related to ineffective technology management. The industrial extension service should therefore also provide advice and guidance on management and finance. In essence, this organization would be a brokerage for

consultants who are able to provide packaged services in engineering diagnosis, market analysis, human resource assessment, and guidance in obtaining modernization loans and equipment. The EC might consider financing the establishment of such an institution which could make available the technological expertise available in the EC. The exact modalities of setting up this institute would have to be worked out with the Thai Government.

- The scope for joint EC-Thai R&D on a commercial basis exists but the implementation of such programs may be made difficult due to manpower shortages and inadequate protection of intellectual property rights in Thailand. However, as already pointed out, there is scope for R&D in industry - especially in EC-Thai joint ventures - for carrying out incremental improvements. However, as highlighted earlier, Thailand has a fairly high level of R&D capabilities in the fields of agriculture and health and may thus offer good scope for EC-Thai cooperation in biotechnology.

II.5.3. SCOPE FOR EC INVESTMENT IN THAILAND

The direct investment patterns in Thailand have been discussed in Part II.1. and it has been pointed out that the EC does not have a major presence in the Thai investment scene which is now dominated by the Japanese. In Part II.4. it was also pointed out that Japanese technology transfer practices are considered to be unsatisfactory in terms of upgrading Thai technological capability. One question that is frequently asked by many foreigners in Thailand is what makes the Japanese "click" in Thailand. During the study this question was posed to the members of the S&T community and government officials who were interviewed. Their reasons as to why Japanese investment in Thailand is growing substantially are summarized below:

- Japan views Thailand as its first point of contact in ASEAN, a region which straddles the sea lanes on which Japan relies for its supplies of oil and other commodities.

- Japan needed an offshore base for its export-oriented industries to escape high labour costs at home and an uncompetitively high yen (endaka). Thailand provides an attractive low-cost location.

- Both Thailand and Japan share the same religion - Buddhism, and there are cultural similarities.

- Both Thailand and Japan have monarchies who are highly revered and respected by the people.

- The two countries have never been at war with each other.

- Thai people are gentle and passive. Selling ideas to them requires time and patience. The average western investor is too impatient and the potential Thai partner finds this behavior aggressive. On the contrary the Japanese handle this aspect with great patience.

- Since most of the consumer products sold in Thailand during the last two decades came from Japan, the Thais view Japan as a country which can best understand their needs.

- The Japanese Government has played a supportive role by helping Thailand to develop its S&T infrastructure by providing vocational training centres, training equipment, fellowships etc. This made the life of the Japanese investor easier because he could draw upon skilled trained labour who were already influenced by the Japanese way of doing things. It may be useful to note that Japanese Government support along these lines dates back to almost 20 years ago and is not something recent in origin. The Japanese Government appears to have considered this investment as one that would yield rich dividends in the long term and this approach seems to have worked. The Technological Promotion Association (Thai-Japan) receives an annual grant of almost 15 million baht from Japan with "no strings attached" (as mentioned by its General Manager), to be spent on providing technical services and training to Thais. The TPA plans to set up colleges and perhaps even universities of technology with Japanese support.

- The Japanese are prepared to accept shortcomings in the Thai system - red tape, infrastructural problems, inadequate patent protection etc. - as constraints within which they have to work. They therefore adapt their strategy to cope up with these problems. On the other hand the investor from the developed west is reluctant to make changes in his way of doing things and expects the Thai environment to adapt itself to suit his way of doing things.

- The Japanese investors, supported by their Government, do a very careful study of the Thai environment and the industry of interest before moving in. Thus, the Thai environment holds very few surprises for them.

While no empirical studies exist to confirm or disprove the above views, they nevertheless provide useful insights into some possible reasons for the success of the Japanese in Thailand. Annex 2 gives a case study of how a group of British investors succeeded in establishing a joint-venture firm to manufacture atomised powders. This is a priority area in the field of MTBI. This illustrates many of the difficulties that a small/medium EC investor is likely to face when trying to invest in Thailand. However, the case clearly brings out the fact that these problems are not insurmountable and can be handled with patience and a judicious selection of the right Thai partner.

ANNEXES

ANNEX 1 - STATISTICAL TABLES

ANNEX 2 - CASE STUDY OF A THAI-BRITISH JOINT VENTURE IN THE MATERIALS TECHNOLOGY-BASED INDUSTRY

ANNEX 3 - LIST OF OFFICIALS INTERVIEWED IN THAILAND

TABLE 1 : Key Economic Indicators

Description	Growth rate		Growth rate		Growth rate	
	1988	1988 (%)	1989	1989 (%)	1990	1990 (%)
Gross domestic product		11.0		10.4		8.8
- Agriculture		8.6		4.0		2.5
- Manufacturing		12.5		12.0		11.5
- Services		9.5		10.4		9.7
Exports	399,230	33.9	514,000	28.7	617,000	20.0
Imports	501,000	46.4	640,000	27.7	787,000	23.0
Trade Balance	(101,770)		(126,000)		(170,000)	
Current Account Balance	(44,500)		(60,000)		(95,000)	
Foreign Direct Investment	27,358	480.6	39,938	46.0	47,127	18.0
Inflation (%)		3.8		6.5		6.0

Note : 1990 values are estimated figures. All monetary values are in millions of baht
Source : NESDB, Thailand Development Research Institute

TABLE 2 : Sectoral Contribution to GDP

	Contribution to GDP (%)			
Sector	1980	1982	1984	1986
Agriculture, Forestry & Fisheries	25.37	22.31	19.34	16.66
Mining & Quarrying	2.11	1.75	2.15	2.13
Manufacturing	19.64	19.46	19.85	20.63
Construction	5.82	5.09	5.34	5.07
Electricity and Water Supply	0.92	1.71	1.91	2.57
Transportation and Communication	6.61	7.46	8.45	9.27
Wholesale and Retail Trade	18.79	18.89	18.40	18.58
Banking, Insurance and Real Estate	6.12	7.21	8.15	7.94
Ownership of Dwellings	1.08	1.17	1.25	1.36
Public Administration and Defence	4.13	4.41	4.37	4.47
Services	9.41	10.54	10.79	11.32
Total	100	100	100	100
GDP in million bahts	684,930	846,136	988,863	1,098,362

Source : National Statistical Office

TABLE 3 : Overall trade figures

Year	Exports (billion baht)	Imports (billion baht)	Balance of trade (billion baht)
1979	108.2	146.2	-38.0
1980	133.2	193.6	-60.4
1981	153.0	219.0	-66.0
1982	159.7	196.6	-36.9
1983	146.5	236.6	-90.1
1984	175.2	245.2	-70.0
1985	193.4	251.2	-57.8
1986	233.2	241.4	-8.2
1987	299.9	334.2	-34.3
1988	403.6	513.1	-109.5
1989*	520.0	666.0	-146.0

* estimated values

Source : Trade Information Division, Department of Export Promotion

TABLE 4 : Imports by Sections of SITC

SITC	Percentage Contribution				
	1982	1983	1984	1985	1986
0. Food and Live Animals	3.19	3.23	3.79	4.06	5.94
1. Beverages and Tobacco	1.19	0.54	0.69	0.90	0.83
2. Crude Materials, Inedible, Except Fuels	5.33	5.68	5.66	6.42	6.29
3. Mineral Fuels	31.02	24.21	23.48	22.66	13.48
4. Animal and Vegetable Oils, Fats	0.25	0.35	0.48	0.21	0.07
5. Chemicals	12.40	13.08	12.57	13.62	15.55
6. Manufactured Goods	15.27	16.25	15.63	16.36	17.79
7. Machinery and Transport Equipment	23.65	28.92	29.37	28.08	30.79
8. Miscellaneous Manufactured Goods	3.15	3.70	4.24	3.62	3.91
9. Goods NEC	4.55	4.04	4.09	4.07	5.35
Total (million of US$)	8,526.73	10,278.91	10,518.03	9,238.67	9,124.01

Source : United Nations, Foreign Trade Statistics of Asia and the Pacific (1982-1986)

TABLE 5 : Exports by sections of SITC

SITC	Percentage contribution				
	1982	1983	1984	1985	1986
0. Food and Live Animals	53.95	50.26	49.26	44.38	43.31
1. Beverages and Tobacco	1.62	1.27	0.97	0.85	0.67
2. Crude Materials, Inedible, Except Fuels	9.62	11.16	10.81	10.39	8.87
3. Mineral Fuels	0.40	0.42	0.67	1.39	0.79
4. Animal and Vegetable Oils, Fats	0.19	0.19	0.26	0.31	0.10
5. Chemicals	0.83	0.89	0.97	1.33	1.60
6. Manufactured Goods	16.29	17.00	15.94	17.42	16.29
7. Machinery and Transport Equipment	6.05	5.66	7.30	8.96	10.89
8. Miscellaneous Manufactured Goods	9.00	11.47	12.42	13.79	16.60
9. Goods NEC	2.05	1.68	1.40	1.18	0.88
Total (million of US$)	6,956.83	6,368.20	7,412.87	7,120.64	8,835.17

Source : United Nations, Foreign Trade Statistics of Asia and the Pacific (1982-1986)

TABLE 10 : Exports and imports of technology intensive products

SITC	Value of exports (E) and imports (I) in millions of US$									
	1982		1983		1984		1985		1986	
	I	E	I	E	I	E	I	E	I	E
High R&D intensive										
54	102.0	11.2	113.6	12.4	114.1	10.4	110.3	10.2	114.4	11.1
75	51.0	0.7	84.4	0.7	165.9	11.8	192.9	54.1	261.6	61.7
76	127.7	8.1	254.3	6.1	292.6	7.2	235.7	5.2	294.9	8.2
77	466.4	323.8	612.5	301.2	633.8	405.6	459.8	425.5	807.2	711.6
792	23.4	3.1	15.7	3.4	108.0	8.6	94.8	2.9	34.5	1.6
87	99.1	14.2	146.8	22.6	137.6	15.4	123.5	18.3	119.3	9.3
88	69.6	22.8	86.3	23.3	79.0	26.3	89.6	34.0	107.8	47.1
Medium R&D intensive										
334	560.6	27.0	592.5	26.1	812.8	34.3	610.5	24.7	369.0	13.3
51	248.7	14.1	317.0	9.8	347.8	9.5	322.1	18.0	382.8	28.3
52	78.4	0.7	90.5	3.3	89.3	4.2	76.2	4.1	90.3	8.3
56	145.9	0.1	216.2	0.2	194.6	0.2	187.4	0.0	185.6	0.1
58	182.4	10.8	237.6	10.5	215.1	26.5	218.0	28.1	267.3	46.8
59	150.5	4.4	191.5	6.5	194.9	8.3	176.5	19.3	180.4	23.6
62	33.2	24.5	40.2	26.2	40.0	36.9	35.6	45.0	35.0	60.2
69	142.1	47.3	188.0	47.5	179.6	47.5	192.8	43.7	168.0	65.2
Rest 7	1330.3	84.7	2003.5	48.6	1957.2	107.6	1583.4	149.7	1384.7	177.0
Total	3811.2	597.4	5190.5	548.2	5562.2	760.5	4707.8	882.8	4802.3	1273.3

TABLE 11 : Thailand's exports (billion baht) by country group

Year	Japan	EEC	USA	Asean	Middle East	Australia	Others
1980	20.10	34.31	16.83	21.60	9.61	1.43	29.32
1981	21.75	33.17	19.80	22.42	13.52	1.75	40.71
1982	21.95	37.38	20.26	25.05	11.40	1.72	41.97
1983	22.09	31.03	21.90	23.00	11.73	2.15	34.58
1984	22.78	36.31	30.10	24.88	13.11	2.87	45.19
1985	25.83	36.87	38.02	28.01	13.65	3.37	47.61
1986	32.48	49.55	41.41	33.29	13.91	4.18	58.37
1987	44.61	66.64	55.73	40.82	20.62	5.54	65.90
1988	64.41	83.84	80.87	47.12	23.78	7.52	96.04

Source : Trade Information Division, Department of Export Promotion

TABLE 12 : Thailand's imports (billion baht) by country group

Year	Japan	EEC	USA	Asean	Middle East	Australia	Others
1980	39.98	24.81	32.14	18.18	33.65	4.52	40.33
1981	52.07	27.73	29.29	22.23	40.52	7.94	38.27
1982	46.08	22.64	26.22	23.65	37.47	4.33	36.22
1983	64.75	30.15	29.70	31.26	30.51	4.28	45.95
1984	66.07	30.65	32.68	38.79	23.89	4.62	48.56
1985	66.58	37.19	28.43	45.82	20.18	4.16	48.82
1986	63.66	36.46	34.52	34.16	12.49	4.24	55.83
1987	86.86	52.26	41.61	51.14	16.39	5.85	80.09
1988	148.91	79.39	69.55	62.39	19.43	8.78	124.66

Source : Trade Information Division, Department of Export Promotion

TABLE 13 : Thailand's balance of trade (billion baht) by country group

Year	Japan	EEC	USA	Asean	Middle East	Australia	Others
1980	(19.88)	9.50	(15.31)	3.42	(24.04)	(3.09)	(11.01)
1981	(30.32)	5.44	(9.49)	0.19	(27.00)	(6.19)	2.44
1982	(24.13)	14.74	(5.96)	1.40	(26.07)	(2.61)	5.75
1983	(42.66)	0.88	(7.80)	(8.26)	(18.78)	(2.13)	(11.37)
1984	(43.29)	5.66	(2.58)	(13.91)	(10.78)	(1.75)	(3.37)
1985	(40.75)	(0.32)	9.59	(17.81)	(6.53)	(0.79)	(1.21)
1986	(31.18)	13.09	6.89	(0.87)	1.42	(0.06)	2.54
1987	(42.25)	14.28	14.12	(10.32)	4.23	(0.31)	(14.19)
1988	(84.50)	4.45	11.32	(15.27)	4.35	(1.26)	(28.62)

Source : Trade Information Division, Department of Export Promotion

TABLE 14 : Composition of imports from Japan

Item	Percentage of total imports from Japan				
	1984	1985	1986	1987	1988
Capital goods	43.02	44.40	41.70	43.60	48.36
Raw materials and intermediate goods	29.56	32.52	33.76	30.51	27.46
Consumer goods	10.18	9.77	9.72	8.99	6.94
Vehicles and transport equipment	15.20	11.17	11.57	14.37	15.02
Others	2.04	2.14	3.25	2.53	2.22
Total	100.00	100.00	100.00	100.00	100.00
Total imports from Japan (billion baht)	66.07	66.58	63.66	86.86	148.91

Source : Compiled from Prasartset, Suthy (1990)

TABLE 15 : Imports of important products from Japan

Item	Percentage of imports				
	1984	1985	1986	1987	1988
Non-elec. machinery & parts	26.84	25.88	25.02	28.30	30.96
Vehicles & trans. equip.	17.32	12.68	13.29	16.24	16.53
Iron & steel	15.15	17.50	17.45	15.82	14.31
Elec. machinery & parts	11.87	11.28	12.25	10.62	12.07
Chemicals	10.33	11.25	12.21	11.59	8.84
Metal products	2.61	2.91	2.89	3.02	3.51
Fish & prepared fish	1.05	0.83	1.64	1.05	2.67
Scientific equip. & photo goods	2.00	2.39	2.51	2.21	2.34
Pipes and fittings	1.70	1.85	1.18	1.05	1.63
Other metals & scraps	1.62	1.36	1.54	1.30	1.11
Clothes	2.53	2.69	2.43	1.77	1.07
Paper	1.07	1.31	1.31	1.14	0.86
Glass and ceramics	0.80	1.01	1.05	1.01	0.86
Locomotives & equipment	0.01	1.31	2.95	0.44	0.63
Fertilizer & pesticides	1.81	1.99	2.07	1.44	0.51
Animal & plants	0.45	0.55	0.64	0.57	0.48
Rubber products	0.41	0.47	0.47	0.49	0.39
Yarn	0.63	0.50	0.71	0.57	0.35
Airplanes, ships & equip.	0.88	1.23	0.44	0.66	0.31
Textile fiber	0.61	0.72	0.56	0.35	0.28
Precious stones & ornaments	0.11	0.07	0.17	0.21	0.19
Paper & pulp	0.01	0.00	0.04	0.02	0.01
Total percentage	100.00	100.00	100.00	100.00	100.00
Total imports (billion baht)	57.99	58.66	55.40	76.86	135.27

Source : Compiled from Prasartset, Suthy (1990)

TABLE 16 : Composition of Thailand's exports to Japan

Category	Percentage of total exports				
	1984	1985	1986	1987	1988
Agricultural products	63.11	63.35	66.16	57.88	51.00
Minerals	5.27	6.14	3.24	3.09	2.58
Manufactured goods	29.79	28.28	27.47	36.22	43.14
Others	1.82	2.23	3.13	2.81	3.27
Total	100.00	100.00	100.00	100.00	100.00
Value of exports (billion baht)	22.78	25.83	32.48	44.61	64.41

Source : Compiled from Prasartset Suthy (1990)

TABLE 18 : Major exports to USA and important trading partners in EEC

Country	Total imports		Total exports		Major exports to these markets (% share in this market)
	Value (bil.$)	% share	Value (bil.$)	% share	
USA	80.87	20.0	69.56	13.6	IC(11), Canned seafood(10), Garments(9), Jewellery(6), Footwear(4)
West Germany	18.64	4.6	27.57	5.4	Garments(24), Tapioca(11), Canned Seafood(5), Rubber(5), Fabrics(4)
United Kingdom	14.88	3.7	15.19	3.0	Canned seafood(18), Garments(15), Footwear(7), Gems(4), IC(4)
Netherlands	22.01	5.5	5.46	1.1	Tapioca(57), Computer Parts(6), Garments(6), Canned Seafood(3), Tin (2)
France	9.60	2.4	12.41	2.4	Garments(25), Canned Seafood(5), Rubber(6), Footwear(5), Furniture(5)

TABLE 19 : Private direct investment inflows, 1960-1989 (million baht)

Year	Equity investment	Direct investment loans a/	Total direct investment	Annual growth rate (%)	% share of equity in total
1960	n.a.	n.a.	72.00	n.a.	n.a.
1965	860.30	50.00	910.30	66.00	94.50
1970	685.30	328.80	1,014.10	2.20	67.60
1975	1,654.10	1,737.30	3,391.40	27.30	48.80
1980	3,703.80	5,555.20	9,259.00	22.30	40.00
1981	4,127.00	5,215.00	9,342.00	0.90	44.20
1982	3,884.00	5,712.00	9,596.00	2.70	40.50
1983	7,255.40	6,688.80	13,944.20	45.30	52.00
1984	7,612.50	9,357.70	16,944.20	21.70	44.90
1985	6,339.90	3,826.40	10,166.30	(40.10)	62.40
1986	6,304.50	4,221.10	10,525.60	3.50	59.90
1987	10,621.00	1,915.00	12,536.00	19.10	84.70
1988	23,068.10	9,892.40	32,960.50	162.90	70.00
1989 (p)(b)	15,293.90	5,004.30	20,298.20	34.40	75.50

Notes : (p) Preliminary
(a) Medium/and long-term loans from parent or related companies including capital funds of foreign commercial banks
(b) Data refer to January-June
Source : Bank of Thailand

TABLE 20 : Foreign direct investment patterns (a) by country of origin

Country	Percentage Share (b)						Annual Growth Rate (b)				
	1980	1985	1986	1987	1988	1989 (p)(c)	1980-85	1985-86	1986-87	1987-88	1990 (p)(c)
United States	18.9	54.2	18.7	20.1	11.3	14.2	26.7	(65.5)	1.2	(44.0)	77.9
Japan	23.3	34.8	44.1	36.1	51.7	50.2	11.2	26.7	(18.1)	42.9	42.1
EEC	20.0	9.7	7.4	10.4	8.0	9.3	(7.7)	(23.8)	41.1	(23.4)	112.4
U.K.	2.1	2.8	3.6	3.6	3.1	3.6	8.1	31.9	0.0	(14.0)	390.8
W.Germany	6.8	3.8	2.3	5.0	2.2	1.5	(6.4)	(38.6)	113.8	(55.6)	0.1
France	0.3	3.3	1.3	1.5	1.0	3.0	61.7	(59.4)	11.4	(32.0)	140.2
Netherlands	0.6	(1.0)	(0.8)	0.8	1.0	0.3	(23.8)	(14.6)	(200.0)	24.4	(2.5)
Italy	4.0	0.3	1.1	0.1	0.1	0.4	(14.0)	360.0	(93.0)	25.0	335.4
Australia	1.0	(1.8)	2.1	0.3	0.1	0.4	(24.7)	(217.8)	(86.8)	(46.4)	169.1
Canada	(1.1)	0.8	0.5	0.1	0.2	0.1	13.1	(38.1)	(76.9)	75.0	(15.8)
Switzerland	1.9	1.8	4.0	8.7	2.0	3.5	1.3	121.7	117.9	(77.1)	(177.0)
Asian NIEs	36.2	(6.9)	21.7	22.6	28.4	20.2	(12.3)	(412.1)	4.2	26.1	(0.1)
Hong Kong	28.7	14.7	13.8	8.8	10.4	10.1	(7.2)	(6.2)	(36.4)	22.8	23.4
Korea	0.3	(0.1)	0.1	0.2	1.1	0.5	(10.5)	(187.5)	257.1	324.0	(23.6)
Singapore	7.2	(25.5)	5.8	5.9	5.4	(0.9)	(38.2)	(122.9)	1.4	(9.1)	(116.7)
Taiwan	0.0	3.9	1.9	7.6	11.2	10.5	145.1	(50.5)	295.8	47.2	45.4
Asean-4	4.0	0.9	(0.6)	(0.0)	0.3	0.0	(11.7)	(165.9)	(100.0)	0.0	(39.3)
Brunei	0.0	0.1	0.1	0.0	0.0	0.0	999.9	(37.5)	60.0	(100.0)	(28.6)
Indonesia	0.1	0.2	0.1	0.1	0.1	-	11.8	(37.5)	(30.0)	14.3	225.0
Malaysia	3.9	0.4	0.1	(0.1)	0.2	0.0	(13.4)	(74.4)	(190.9)	(270.0)	(296.2)
Philippines	(0.0)	0.2	(0.9)	0.0	0.0	(0.1)	(52.8)	(473.9)	(100.0)	0.0	26.1
Other	2.1	6.5	2.1	1.7	1.9	2.2	28.5	(67.8)	(17.3)	(213.4)	(20.0)
Total	100.0	100.0	100.0	100.0	100.0	100.0					
Tot.Amount (mill. baht)	3,878.2	4,402.2	6,908.1	9,043.7	28,243.8	17,132.8	2.6	56.9	30.9	212.3	36.5

Notes: (a) Equity and loans from parent or related companies including capital funds of foreign commercial banks; (b) The calculations are based on the net inflow of foreign direct investment and do not include net capital outflow of Thai investors (equity investment); (c) Data refer to January-June; (p) Preliminary

Source: Background paper no. 6, The 1989 TDRI year-end conference, December 16-17, 1989

TABLE 21 : Applications approved

	1987		1988		1989	
	Number	Amount	Number	Amount	Number	Amount
Total	625	67,290	1,454	200,894	1,086	260,615
Foreign	385	50,064	888	156,419	700	190,889
- Japan (%)	35	49	30	49	30	45
- Taiwan (%)	26	15	35	14	29	11
- Hongkong (%)	8	6	10	7	8	5
- US (%)	9	9	12	11	9	7
- EC (%)	13	14	12	17	18	21
Total foreign (%)	62	74	61	78	64	7

Source : Bangkok Post, February 28, 1990

TABLE 22 : Projects started

	1987		1988		1989 (1)	
	Number	Amount	Number	Amount	Number	Amount
Total	172	18,577	224	17,930	272	26,174
Foreign	86	12,160	136	14,013	191	20,675
- Japan (%)	35	46	34	54	47	67
- Taiwan (%)	9	3	17	5	28	11
- Hongkong (%)	13	20	13	14	8	5
- US (%)	12	14	11	15	7	8
- EC (%)	17	9	23	21	12	17
Total foreign (%)	50	65	61	78	70	79

(1) January-November; all amounts are in million baht
Source : Bangkok Post, February 28, 1990

TABLE 23 : FDI distribution of selected countries by sectors - 1987-1988 (percentage)

Sectors	Japan		USA		AsianNIEs		Europe	
	1987	1988	1987	1988	1987	1988	1987	1988
Financial sector	13.7	4.7	(6.4)	4.8	(147.5)	11.8	13.0	24.0
Trade	(11.3)	8.0	25.4	27.5	11.28	15.4	9.0	17.6
Construction	27.1	9.1	7.5	2.8	6.1	4.7	1.0	1.0
Mining & quarrying	0.0	0.1	11.4	8.2	0.3	1.6	(0.2)	2.2
Agriculture	3.9	1.2	4.0	2.0	1.1	0.6	1.8	0.1
Industry	57.3	72.1	44.2	33.4	22.2	56.9	59.4	43.1
Services	9.4	5.0	14.0	21.4	6.6	9.0	15.9	11.6

Source : Background Paper No.6, The 1989 TDRI year-end conference, December 16-17, 1989

TABLE 24 : Sectoral importance of FDI 1980-1988 (percentage)

Sector	1980	1985	1986	1987	1988	1989
Financial	(5)	(29)	7	5	10	12
Trade	19	25	26	9	14	18
Construction	20	36	18	15	7	9
Mining	15	12	4	2	2	2
Agriculture	5	2	3	3	1	(0)
Industry	26	31	31	53	58	47
Services	18	24	12	13	9	13

Source : Bangkok Post, February 28, 1990

TABLE 26 : FDI distribution of selected countries in industry, 1987-1988 (percentage)

Industry sector	Japan		USA		AsianNIEs		Europe	
	1987	1988	1987	1988	1987	1988	1987	1988
Food	(0.4)	2.2	5.4	6.5	2.3	4.9	13.3	10.6
Textile	0.5	2.2	18.7	1.6	3.9	7.5	26.5	5.2
Metalbased and non-metallic	6.9	11.2	1.6	1.3	0.3	3.0	6.5	0.6
Electrical appliances	25.3	32.1	6.3	9.9	4.1	15.8	0.5	1.5
Machinery and transport equipment	4.8	4.6	0.2	1.1	(0.1)	0.3	0.1	0.3
Chemicals	9.1	2.4	4.8	1.1	6.4	10.5	9.9	22.2
Petroleum products	0.0	13.9	0.1	0.0	0.2	0.0	0.0	0.0
Others	11.3	3.5	6.6	11.3	5.0	14.9	2.6	2.8
Total industry	57.3	72.1	44.2	33.4	22.2	56.9	59.4	43.1

Source : Background Paper No.6, The 1989 TDRI year-end conference, December 16-17, 1989

TABLE 27 : Summary of number of research projects and research budgets of government agencies

Government agency	Projects (1990)		Research budget (1990)	
	Number	Percentage of total	Value (Baht)	Percentage of total
Office of the Prime Minister	35	0.96	6,350,408	1.36
Ministry of Defence	1	0.03	260,000	0.06
Ministry of Finance	6	0.17	148,960	0.03
Ministry of Agriculture and Cooperatives	2001	55.22	228,172,920	48.73
Ministry of Communication	12	0.33	638,890	0.14
Ministry of Commerce	5	0.14	1,755,850	0.37
Ministry of Interior	45	1.24	15,656,795	3.34
Ministry of Science Technology and Energy	86	2.37	71,064,435	15.18
Ministry of Education	303	8.36	16,392,540	3.50
Ministry of Public Health	89	2.46	5,826,347	1.24
Ministry of Industry	44	1.21	6,102,315	1.30
Ministry of University Affairs	997	27.51	115,887,227	24.75
Total	3624	100.00	468,256,687	100.00

TABLE 28 : Annual budgets of some important S&T agencies in Thailand (million baht)

	1989	1990	1991
MOSTE	162.8	385.7	513.8
- Tech. Transfer Center *	1.97	2.0	3.0
- NCGEB *	30.0	35.2	35.7
- NECTEC *	46.88	65.7	76.1
- NCMMT *	33.54	68.8	88.5
NRCT	141.3	149.8	221.0
STDB			
- Govt.	N.A.	57.9	45.4
- US.	N.A.	267.8	138.1
TDRI	71.09 (1)	N.A.	N.A.
TISI	53.04	58.9	73.5
DSS	99.97	105.1	137.6
TISTR	N.A.	233.8	178.8

* These centers are under the MOSTE and their budgets are included in the MOSTE budget. The figures indicate only the budget for special projects handled by the centers.

(1)Of this amount 48.4 million baht is from sposorship and 20.05 million baht from a grant from the Canadian International Development Agency.

Source : NESDB and TDRI, 1989 Annual Report

TABLE 29 : R&D expenditure in Thailand by sector of performance (1985)

Description	R&D Expenditure (US $)			
	Current Expenditure		Capital Expenditure	
	Manpower Costs	Other Costs	Plant and Equipment Costs	Other Costs
Production Sector				
Total current Expenditure (US$)	15,343,930	806,779	1,037,351	874,570
On Basic Research (% of Total)	06.70	2.67	34.00	34.00
On Applied Research (% of total)	08.94	1.88	56.00	56.00
On Development (% of Total)	84.36	95.45	10.00	10.00
Higher Education Sector				
Total current Expenditure (US$)	20,759,471	323,043	7,952,516	6,701,318
On Basic Research (% of Total)	54.88	39.75	60.00	60.00
On Applied Research (% of total)	30.43	38.20	28.00	28.00
On Development (% of Total)	14.69	22.05	12.00	12.00
General Services Sector				
Total current Expenditure (US$)	42,083,048	1,127,042	12,512,939	10,186,268
On Basic Research (% of Total)	44.30	35.53	51.00	51.00
On Applied Research (% of total)	26.48	22.17	30.00	30.00
On Development (% of Total)	29.22	42.30	19.00	19.00
All Sectors				
Total current Expenditure (US$)	78,186,449	2,256,864	21,078,506	17,762,156
On Basic Research (% of Total)	39.73	24.39	54.00	54.00
On Applied Research (% of total)	24.09	17.21	30.00	30.00
On Development (% of Total)	36.18	58.40	16.00	16.00

Source: Asian and Pacific Centre for Transfer of Technology of UN-ESCAP.

TABLE 30 : R&D expenditure in Thailand by field of specialisation (1985)

Field of specialisation	R&D expenditure					
	Current expenditure			Capital expenditure		
	Basic research	Applied research	Development	Basic research	Applied research	Development
Engineering sciences	0.26	0.44	0.97	0.34	0.54	2.74
Earth & space sciences	2.98	0.67	0.67	2.37	1.08	1.38
Physical sciences	10.42	11.36	3.67	11.45	14.52	9.58
Biological sciences	21.67	18.09	0.52	18.57	10.74	1.37
Mathematics & computers	2.87	8.56	1.51	3.03	2.69	4.11
Medical sciences	11.31	16.64	24.79	15.83	30.11	42.46
Social sciences	34.11	23.53	62.46	29.28	24.73	28.78
Aesthetic sciences	16.14	20.39	4.97	18.86	15.06	8.23
	0.24	0.32	0.44	0.33	0.53	1.35
Total percentage	100.00	100.00	100.00	100.00	100.00	100.00
Total expenditure (US$)	31,612,691	9,219,950	29,610,672	20,873,330	11,794,516	6,172,816

Source : Asian and Pacific Centre for Transfer of Technology of UN-ESCAP

TABLE 31 : Source of funds for R&D in Thailand (1985)

Source of Funds	Basic Research	Applied Research	Development
Government (% of Total)	36.00	34.00	78.75
Productive Enterprise Funds (% of Total)	7.00	0.84	0.05
Foreign Funds (% of Total)			
- Bilateral	45.00	47.20	18.89
- Multilateral	8.00	14.00	0.43
Special Funds (% of Total)	4.00	4.00	1.88
Total	100.00	100.00	100.00
R&D Expenditure (1000 US$)			
- Current Expenditure	31,613	19,220	29,611
- Capital Expenditure	20,873	11,795	6,173
- Total	52,486	31,015	35,748

Source: Asian and Pacific Centre for Transfer of Technology

TABLE 32 : Distribution of R&D expenditure by major socioeconomic aim (1985)

Major Socioeconomic Aims	Percentage of R&D Expenditure
Exploration and Assesment of Biosphere	3.08
Utilization of Civil Space for Social Welfare	0.35
Development of Agriculture, Forestry and Fisheries	11.83
Promotion of Industrial Development	8.33
Promotion, Conservation and Distribution of Energy	11.78
Development of Transport/Communication	10.46
Development of Education Services	8.69
Development of Health Services	13.32
Development of Urban/Rural Settlements	0.74
Protection of the Environment	11.44
General Advancement of Knowledge	3.73
Defence	7.41
Others	8.44
	0.40
Total	100.00

Source: Asian and Pacific Centre for Transfer of Technology of UN-ESCAP

TABLE 33 : Number of patent applicants during 1982-1986

Year	Types								Overall total
	Engineering		Chemistry		Industrial designs		Total		
	Thai	Foreigners	Thai	Foreigners	Thai	Foreigners	Thai	Foreigners	
1982	36	124	4	207	87	100	127	431	558
1983	35	191	12	322	141	131	188	644	832
1984	36	227	12	393	182	192	230	812	1,042
1985	46	237	9	415	129	153	184	805	989
1986	44	205	16	429	182	159	242	793	1,035
Total	197	984	53	1,766	721	735	971	3,485	4,456

Source : MOSTE

TABLE 34 : Number of patents awarded

Year	Types						Total
	Engineering		Chemistry		Industrial designs		
	Thai	Foreigners	Thai	Foreigners	Thai	Foreigners	
1982	1	1	-	1	6	46	55
1983	3	1	1	6	14	27	52
1984	6	7	1	9	19	19	61
1985	4	3	1	7	71	16	102
1986	12	17	1	44	68	32	174
Total	26	29	4	67	178	140	444

Source : MOSTE

TABLE 35 : Technology import payments by Thailand (1982-1985)

Industry	Year			
	1982	1983	1984	1985
Rubber products	72.306	37.758	82.163	74.915
Textiles	89.480	111.737	119.690	158.135
Food and beverages	150.164	222.209	247.913	257.410
Pharmaceuticals	133.111	100.990	108.557	109.198
Petroleum products	37.558	56.546	11.962	47.849
Cosmetics	157.188	143.097	154.224	138.006
Paints	9.060	16.063	12.009	26.886
Chemicals and chemical products	48.870	42.035	50.896	68.067
Batteries	6.911	10.359	10.466	7.481
Electrical appliances	132.414	124.276	194.597	178.143
Automobile and auto parts	167.810	170.862	280.008	259.999
Others	487.897	534.442	721.259	718.740
Total	1,493.135	1,570.407	1,993.830	2,044.835

Source : Technology transfer Center, MOSTE

TABLE 36 : Remittance of technology fees in 1985 classified by types of fees and industries (Unit : thousand baht)

Type of industries	Technology fees						
	Royalties	Trademark fees	Technical fees	Expert fees	Training fees	Management fees	Total
Rubber Products	39,003.02	-	33,264.74	-	-	3,646.76	74,915.42
Textiles	70,867.80	398.53	82,240.78	2,173.26	414.75	3,661.47	159,747.59
Food and Beverages	123,818.04	31,710.14	92,107.59	600.59	26.70	8,725.19	256,987.73
Pharmaceuticals	93,008.77	-	15,361.12	-	-	577.48	108,947.37
Petroleum Products	9,190.41	-	38.886.85	-	-	-	48,077.26
Cosmetics	73,076.05	-	54.664.69	-	-	7,789.14	135,529.88
Paints	22,281.67	-	4,810.16	54.17	-	-	27,116.00
Chemicals and Chemical Products	48,062.80	-	19,259.30	-	-	-	67,322.10
Batteries	6,888.57	592.94	-	-	-	-	7,481.31
Electrical Appliances	121,174.54	270.04	46,336.90	3,900.81	-	6,374.88	178,057.17
Automobile and Auto Parts	225,487.41	301.99	12,676.27	18,043.22	-	3,500.00	259,999.89
Others	370,547.55	2,180.51	280,800.90	17,506.76	750.23	48,837.70	720,623.63
Total	1,202,398.53	33,445.15	680,408.78	42,278.81	1,191.68	83,112.62	2,044,835.57

Source: Technology transfer Centre, MOSTE.

TABLE 37 : Technological capability classified by size

Industry/Firms size	Number of firms	Average score of technology capability			
		Acquisitive	Operative	Adaptative	Innovative
Biotechnology Based Industries					
- large	23	3.57	3.58	3.43	2.23
- medium/small	9	3.17	3.27	2.97	2.27
Materials Technology-based Industries					
- large	34	3.40	3.98	3.74	1.81
- medium/small	21	3.44	2.78	3.07	1.78
Electronics and information Technology-based Industries					
- large	15	2.80	3.84	2.42	0.72
- medium/small	17	2.74	2.55	2.51	0.94

Source : TDRI, The Development of Thailand's Technological Capability in Industry, Vol.6, TDRI, 1989

TABLE 38 : Technological capability classified by promotion status

Industry/promotion status	Number of firms	Average score of technology capability			
		Acquisitive	Operative	Adapta-tive	Innova-tive
Biotechnology Based Industries					
- promoted	17	3.46	3.65	3.22	2.29
- non-promoted	15	3.45	3.31	3.40	2.19
Materials Technology-based Industries					
- promoted	28	3.53	4.23	3.76	1.98
- non-promoted	27	3.29	2.79	3.03	1.61
Electronics and Information Technology-based Industries					
- promoted	19	2.81	3.56	2.33	0.59
- non-promoted	13	2.71	2.57	2.67	1.21

Source : TDRI, The Development of Thailand's Technological Capability in Industry, Vol.6, TDRI, 1989

TABLE 39 : Technological capability classified by market orientation

Industry/market orientation	Number of firms	Average score of technology capability			
		Acquisi-tive	Operative	Adapta-tive	Innova-tive
Biotechnology Based Industries					
- export	9	3.55	3.42	3.22	2.58
- domestic	14	3.39	3.36	3.04	1.95
- both	9	3.45	3.77	3.81	2.47
Materials Technology-based Industries					
- export	8	3.71	3.34	3.34	1.68
- domestic	8	3.15	3.84	3.94	2.18
- both	39	3.33	3.42	3.44	1.69
Electronics and Information Technology-based Industries					
- export	14	2.70	3.86	2.21	0.45
- export and domestic	18	2.82	2.61	2.67	1.14

Source : TDRI, The Development of Thailand's Technological Capability in Industry, Vol.6, TDRI, 1989

TABLE 40 : Technological capability classified by ownership

Industry/ownership	Number of firms	Average score of technology capability			
		Acquisi-tive	Opera-tive	Adapta-tive	Innova-tive
Biotechnology Based Industries					
- Thai	20	3.34	3.20	3.18	2.16
- Joint-Venture/Foreign owned	12	3.65	3.98	3.52	2.38
Materials Technology-based Industries					
- Thai	45	3.40	3.29	3.31	1.71
- Joint-Venture/Thai Managers	6	3.63	3.93	4.45	2.37
- Joint-Venture/Foreign managers	4	3.21	3.93	4.00	1.55
Electronics and Information Technology-based Industries					
- Thai	17	2.89	2.49	2.55	1.06
- Joint-Venture/Thai Managers	6	2.78	3.37	2.89	0.50
- Joint-Venture/Foreign managers	9	2.53	4.27	2.04	0.64

Source : TDRI, The Development of Thailand's Technological Capability in Industry, Vol.6, TDRI, 1989

TABLE 41 : Estimated number of student enrollments in public and private universities/institutes under the sixth higher education development plan (1987-1991)

Level of Education	Academic Year					Total
	1987	1988	1989	1990	1991	
Public Univ.						
Bachelors	775,645	892,838	1,060,806	987,378	1,047,226	4,763,893
Post-Grad. Diplomas	1,087	1,474	1,608	1,712	1,798	7,679
Masters	16,091	18,475	20,198	21,677	22,761	99,202
Doctoral	1,040	1,475	1,910	2,321	2,545	9,291
Total	793,863	914,262	1,084,522	1,013,088	1,074,330	4,880,065
Private Univ.						
Bachelors	59,018	66,011	71,376	76,550	76,550	347,235
Post-Grad. Diplomas	-	-	-	-	-	-
Masters	1,187	1,480	1,725	2,003	2,003	8,279
Doctoral	-	-	-	-	-	-
Total	60,025	67,491	73,101	76,164	78,553	355,514
Grand Total	854,068	981,753	1,157,623	1,089,252	1,152,883	5,235,579

Source : Division of Planning, Ministery of University Affairs, 1986.

TABLE 42 : Stock of S&T personnel in Thailand by field of specialization (1984)

S&T personnel by field of specialization	Total	In R&D (% of total)
Engineering sciences		
- engineers	20,689	2,338 (11.30)
- scientists	3,283	1,133 (34.51)
- technicians	176,538	13,769 (07.80)
Natural sciences		
- engineers	66,070	10,565 (16.00)
- scientists	34,123	6,618 (19.39)
- technicians	43,058	919 (02.13)
Agricultural sciences		
- engineers	11,345	2,269 (20.00)
- scientists	8,678	3,523 (40.60)
- technicians	38,752	25,847 (66.70)
Medical sciences		
- engineers	7,341	-
- scientists	10,085	4,091 (40.57)
- technicians	12,917	-
Social sciences		
- engineers	6,007	1,129 (18.70)
- scientists	9,851	-
- technicians	30,140	-
Overall totals		
- engineers	111,452	16,301 (14.63)
- scientists	66,020	15,365 (23.27)
- technicians	301,405	40,435 (13.42)

Source : Asian & Pacific Centre for Transfer of Technology of UN-ESCAP

TABLE 43 : Stock of personnel in Thailand by sector of performance (1984)

Description	Number
Engineers	
- Total stock	111,452
- Percentage in production sector	49.0
- Percentage in higher education sector	26.6
- Percentage in general sector	24.4
Scientist	
- Total stock	66,020
- Percentage in production sector	59.7
- Percentage in higher education sector	19.8
- Percentage in general sector	20.5
Technicians	
- Total stock	301,405
- Percentage in production sector	64.3
- Percentage in higher education sector	6.1
- Percentage in general sector	29.6

Source : Asian & Pacific Centre for Transfer of Technology of UN-ESCAP

TABLE 44 : Qualification profile of S&T personnel in Thailand (1984)

Description	Total	In R&D
Engineers		
- Percentage with only Bachelors degree or equivalent	84.3	47.7
- Percentage with post-graduate diploma and/or Masters degree	13.7	46.3
- Percentage with Doctoral degree	2.0	6.0
Scientists		
- Percentage with only Bachelors degree or equivalent	67.8	56.7
- Percentage with post-graduate diploma and/or Masters degree	26.9	38.7
- Percentage with Doctoral degree	5.3	4.9

Source : Asian & Pacific Centre for Transfer of Technology of UN-ESCAP

TABLE 45 : Projected demand of S&T personnel by fields

	1988	1989	1990	1991	1996	2001
Post-Graduate						
B1	133	208	220	233	219	142
B2	17	27	28	30	28	18
B3	69	96	100	105	120	119
Total B1-B3	220	331	349	368	367	279
E1	47	53	51	53	64	95
E2	81	97	98	102	118	157
Total E	128	150	149	155	182	252
M1	128	149	146	153	201	282
M2	4	6	6	6	7	6
Total M	132	154	152	159	208	288
T1	224	278	252	260	405	528
T2	23	30	31	34	41	48
T3	117	139	139	147	192	267
Total T	363	447	442	440	638	843
Total E+M+T	623	751	723	755	1,028	1,383
Total S	163	188	195	206	205	202

	1988	1989	1990	1991	1996	2001
Bachelor Degree						
B1	442	580	596	628	641	632
B2	74	96	110	124	156	267
B3	194	227	219	236	286	480
Total B1-B3	690	903	924	988	1,083	1,379
E1	172	192	190	198	285	432
E2	1,061	1,173	1,138	1,184	1,488	2,326
Total E	1,234	1,365	1,327	1,383	1,773	2,757
M1	1,610	1,766	1,688	1,776	2,364	3,487
M2	55	55	45	44	57	78
Total M	1,665	1,821	1,733	1,820	2,421	3,925
T1	1,047	1,171	1,021	1,041	1,798	2,689
T2	326	352	347	363	507	773
T3	458	542	531	566	766	1,109
Total T	1,831	2,064	1,898	1,970	3,071	4,571
Total E+M+T	4,730	5,250	4,958	5,173	7,265	11,253
Total S	635	731	739	782	1,081	1,576

TABLE 45 (continued)

	1988	1989	1990	1991	1996	2001
Vocational						
Total E	2,997	3,679	3,665	3,587	4,569	6,197
Total M	7,379	8,405	7,507	8,099	10,865	18,407
Total T	2,393	2,754	2,647	2,773	4,430	6,144
Total E+M+T	15,304	18,348	17,516	18,661	24,457	35,661
	1988	1989	1990	1991	1996	2001
Higher Vocational						
Total E	1,351	1,587	1,524	1,599	1,877	2,765
Total M	4,344	4,844	4,289	4,656	6,424	11,066
Total T	1,414	1,587	1,423	1,488	2,650	3,866
Total E+M+T	8,047	9,264	8,533	9,118	12,682	19,585

TABLE 46 : Projected supply of S&T personnel by fields

	1988	1989	1990	1991	1996
Post-Graduate					
B1	256	275	294	313	407
B2	12	13	13	13	16
B3	51	54	56	595	72
Total B1-B3	319	342	363	385	495
E1	36	37	39	40	46
E2	44	48	51	55	72
Total E	80	85	90	95	118
M1	13	13	14	14	17
M2	0	0	0	0	0
Total M	13	13	14	14	17
T1	98	104	109	115	143
T2	13	14	15	16	22
T3	13	14	15	16	21
Total T	124	132	139	147	186
Total E+M+T	217	230	243	256	321
Total S	48	47	46	45	39

	1988	1989	1990	1991	1996
Bachelor Degree					
B1	1,634	1,722	1,810	1,899	2,340
B2	103	109	115	121	152
B3	237	247	257	267	316
Total B1-B3	1,974	2,078	2,182	2,287	2,808
E1	94	111	128	159	376
E2	546	632	710	858	1,880
Total E	640	743	838	1,017	2,255
M1	325	366	411	497	1,087
M2	78	90	1,044	128	302
Total M	403	457	515	625	1,389
T1	959	1,015	1,153	1,406	3,184
T2	101	107	120	145	322
T3	112	112	119	137	240
Total T	1,172	1,233	1,391	1,688	3,746
Total E+M+T	2,215	2,433	2,744	3,330	7,390
Total S	576	593	608	624	704

TABLE 46 (continued)

	1988	1989	1990	1991	1996
Vocational					
Total E	6,207	6,814	6,290	6,449	6,659
Total M	10,003	11,395	10,895	11,550	13,412
Total T	4,715	5,334	5,067	5,339	6,080
Total E+M+T	20,925	23,543	22,251	23,338	26,152
	1988	1989	1990	1991	1996
Higher Vocational					
Total E	5,692	3,347	6,122	7,720	8,820
Total M	7,625	8,418	8,044	10,058	11,218
Total T	8,484	9,567	9,322	11,864	13,901
Total E+M+T	21,801	24,332	23,487	29,641	33,939

TABLE 47 : Projected excess supply of S&T manpower

	1988	1989	1990	1991	1996
Post-Graduate					
B1	123	67	74	80	188
B2	(5)	(14)	(15)	(17)	(12)
B3	(18)	(42)	(44)	(46)	(48)
Total B1-B3	99	11	14	17	128
E1	(10)	(16)	(13)	(14)	(18)
E2	(37)	(49)	(47)	(47)	(46)
Total E	(47)	(65)	(59)	(61)	(64)
M1	(115)	(136)	(132)	(139)	(184)
M2	(4)	(6)	(6)	(6)	(7)
Total M	(119)	(141)	(138)	(145)	(191)
T1	(126)	(174)	(143)	(145)	(262)
T2	(10)	(16)	(16)	(18)	(19)
T3	(104)	(125)	(124)	(131)	(171)
Total T	(239)	(315)	(283)	(293)	(452)
Total E+M+T	(405)	(521)	(480)	(499)	(707)
Total S	(88)	(141)	(149)	(161)	(166)

	1988	1989	1990	1991	1996
Bachelor Degree					
B1	1,212	1,214	1,214	1,271	1,699
B2	29	13	5	(3)	(4)
B3	43	20	38	31	30
Total B1-B3	1,284	1,175	1,258	1,299	1,725
E1	(78)	(80)	(61)	(39)	91
E2	(515)	(541)	(428)	(326)	391
Total E	(593)	(622)	(489)	(366)	482
M1	(1,285)	(1,400)	(1,277)	(1,279)	(1,277)
M2	23	36	59	84	245
Total M	(1,262)	(1,364)	(1,217)	(1,195)	(1,032)
T1	(88)	(156)	131	365	1,386
T2	(225)	(245)	(227)	(218)	(185)
T3	(346)	(430)	(411)	(429)	(526)
Total T	(659)	(831)	(489)	(282)	674
Total E+M+T	(2,514)	(2,817)	(2,213)	(1,843)	124
Total S	(59)	(139)	(131)	(158)	(377)

TABLE 47 : (continued)

	1988	1989	1990	1991	1996
Vocational					
Total E	3,210	3,135	2,625	2,592	2,090
Total M	2,624	2,991	3,387	3,451	2,547
Total T	2,321	2,580	2,419	2,566	1,651
Total E+M+T	8,156	8,705	8,431	8,609	6,287
	1988	1989	1990	1991	1996
Higher Vocational					
Total E	4,341	4,769	4,598	6,121	6,943
Total M	3,281	3,573	3,755	5,402	4,794
Total T	7,070	7,980	7,899	10,375	11,252
Total E+M+T	13,754	15,068	14,954	20,523	21,257

ANNEX 2 : CASE STUDY OF A THAI-BRITISH JOINT VENTURE IN THE MATERIALS TECHNOLOGY-BASED INDUSTRY - SOLAR BRONZE (THAILAND) Co Ltd

Based on a presentation by Mr. J. Peter Mills, Technical Director of Solar Bronze (Thailand) Co. Ltd., at the Seminar on New Technology-Based Companies in Thailand conducted by the AIT-School of Management (11 April 1990) and an interview with Mr. J. Peter Mills on 23 April 1990.

Solar Bronze is a manufacturer of metallic powders and whilst in the larger term that will cover a large range of metals and powder types, at the moment the company is concentrating upon a product known as bronze powder - the trade name for trans flake or laminar powder. Solar Bronze is a joint venture project being 51% Thai and 49% British owned. The three main shareholders are all actively involved in the operational running of the company although only two are based in Thailand. Mr. Kamjorn, the Thai shareholder, deals with the administration side of the company and the Thai marketing and selling. Mr. P. Mills deals with the technical and production side, and the third main shareholder deals with the export marketing and selling.

Bronze powder, the product Solar Bronze manufactures at present, is a trans powder that has a flake or laminar physical shape, that is it has a sheet-like form being very thin compared to its size. To make this shape one takes a basically round, trans particle and rolls it out to form the sheet-like shape. As bronze powder is mainly used in the pigment industries - as paint and ink to produce an imitation of real gold colour - visual quality is very important. The next time you look at gold on a cigarette packet or a chocolate wrapper or a gold painted object - and for those familiar with Thai beers - the gold on the labels of Kloster and Singha - it is almost certainly bronze powder you are looking at. Visual quality is totally related to the flake shape, anything other than this quickly reduce the gold-like appearance. But as the size of this product can be as small as 5/1000 of a mm and the thickness is 100 times less than this the difficulties of manufacturing it can be appreciated. To produce good quality, consistently requires, that the equipment used be operated under just the correct operating conditions. There can be no room for error without significant quality loss.

Considering all this it is hardly surprising that there are only nine significant manufacturers in the whole world. Of these five are European, two American, one Japanese, and one Indian. There are also about eight other small manufacturers one of which is Solar Bronze. However even more significant is the fact that the leading manufacturers in terms of quantity and technology are all European and these supply about 70% of the annual consumption of bronze powder.

Before we discuss the implementation of the project in Thailand we should clarify the background of three of the British shareholders - Mr. Mills, a second engineer, and the Export Sales Director. These three supplied the technical and marketing expertise for the project but they did not own or operate an existing bronze powder manufacturing business in Britain. They all had worked for a British manufacturer and they had done consultancy work for other manufacturers. Their cumulative experience within this industry was over 25 years and included extensive work in R&D, production control, modernization of existing

production facilities, the designing and building of two new bronze powder factories, and the marketing and selling of bronze powder in Asia.

They had each on various occasions suggested to the company they worked for to set up a manufacturing base in Asia but there had never been any response to the suggestion. Hence, they eventually decided to pool their individual knowledge and experience and as consultants offer their services to possible investors in the Asian area. They had considerable experience but needed the financial backing of a local partner.

Why did they chose Thailand ? In the end it really chose itself although there were strong business reasons why it would make an ideal location. However, they did not start with Thailand or any other Asian country as a favorite. They chose the Asian area to build in. The reasons were quite simple, an intrinsic liking for the color of gold and a lack of an indigenous manufacturer using modern production techniques. Put simply there was a large hole in the supplier market which the existing European manufacturers were not prepared to fill.

Of course there were more general reasons: the growing market potential of the Asian area; the lower labour costs (although we should add that Solar Bronze is not a large manpower user); and the lower investments costs of land, buildings and - if locally made - equipment and machinery.

Their market analysis also revealed a dissatisfaction with existing European suppliers due to inconsistent pricing policies and a general attitude to this part of the world market.

Everything about their analysis of the project indicated that Asia was the correct location and from a geographical point of view South East Asia offered the delivery advantage of being central for export west to the Indian subcontinent and the Middle East, east to Far Eastern markets and south to Australasia.

Now they needed to locate a financial backer, which is not an easy undertaking when all you have to offer is knowledge without an existing business to back-up your claims.

One of the first things they did was to contact and consult with various organizations and financial institutions in Britain that had business or industrial experience in this part of the world. They got some good, if at times daunting, advice which could be summarized as...it's going to take a long, long time, it's going to mean repeated, often fruitless trips to these countries and this means it's going to cost a lot of time and money.

From there they contacted various embassies and trade commissions, a few companies and just to leave no stone unturned - even voluntary overseas organizations...and strange how things go, it was one of the latter that advised him to contact UNESCO in Vienna, Austria. Much to their delight UNESCO sent a multipage computer printout of government and financial organizations in different Asian countries involved with industrial promotion.

One of these listed was the Department of Industrial Promotion in Thailand. They first approached them in 1986 and right from the beginning they were impressed by the quick efficient response and the obvious interest shown. So much so that within three months of first writing. Mr.Mills was in Bangkok as by this time they were concentrating entirely upon Thailand as general business opinion - and Mr. Mills' experience confirmed it - was that Thailand was the place to set-up.

But after nine months of repeated trips here they still did not have a financial backer although they had contacted and spoken to a large number of companies and individuals. So back Mr. Mills went to the Department of Industrial Promotion who suggested he contact the Industrial Finance Corporation of Thailand (IFCT) and the Small Industry Finance Office (SIFO). Both were instrumental in introducing them to further interested parties. However IFCT's clients tended to want projects of a much larger size than theirs whilst SIFO on the other hand was really for projects a little smaller. But it was through SIFO that they met their eventual partner Mr. Kamjorn.

During their discussions with interested parties they had come to the following conclusion. There was obviously a lot of interest to invest in new industries and just as obviously there was a lack of technical projects for these people to choose, at least with the investment money which to them seemed available. Mr. Mills came to Thailand to discuss a metal powder project but got asked his opinion on how to make many things from shoe polish to silicone rubber. He even recalls being asked about making coinage blanks for money.

But Mr. Mills found some strange contradictions. New technology was asked for but the people seemed frightened that it wasn't already being done in Thailand. An export based product was desired but then rejected especially by these companies whose existing business had a home market only...and investors seemed to like their project because they were not a large established company asking for a large stake in the project but then were unwilling to give anything at all. Of course they expected caution and sense from sensible business people but all too often they were left with the feeling that too many wanted something for nothing. The richer the prospective backer that more this seemed to apply.

Further down the financial scale they still found enormous interest in the project and often more willingness to go ahead with it but these smaller businesses found raising the capital needed difficult. The investment Mr. Mills required wasn't large but it fell outside the small size range. And concerning the costing of the project here they found a constant problem with possible backers...no matter what he said or asked these would not reassess their estimates of the investment needed using the knowledge of prices and facilities in Thailand. In particular Mr. Mills wanted them to look into the question of availability of equipment and what and how much could be manufactured here. This was very important as he could not see how to get BOI approval to alleviate the import tax on machinery...Their investment was too small for any of the groups the industry could be classified under to be eligible for such privileges.

Then they met their eventual partner, Mr. Kamjorn. This reassessing of the costs was the one thing he did that others hadn't and it convinced him that the investment could be a lot less than Mils c.s. had estimated. He had an existing small business and whilst not an engineer himself his business had engineering facilities and more importantly he had local knowledge of engineering facilities, contractors, and parts suppliers.

At this initial stage of the partnership Mills c.s. were still looking at just supplying the technical and production expertise. Mr. Kamjorn in the meantime was himself contacting other Thais with a view to coming into partnership with him to help finance the project. However, he found the same problems that Mills c.s. had experienced...interest but a lack of commitment to inject capital. Trying to find further partners wasted them a lot of time but it did have the advantage that with Mr. Kamjorn they were able to do a much better estimate of the likely costs. And it was through this new costing and the long deliberation of other parties that they at this time made a significant alteration to the concept of financing the project. They decided to stop looking and with Mr. Kamjorn raise the capital themselves.

Of course this meant looking carefully into the feasibility from a financial point of view - as to what size project they could build. The result was a plan to build a pilot factory which would introduce them into the market at minimal cost and then serve as a foundation from which they could expand their capacity and product range... and, of course, to act as collateral to get future financial loans for the expansion.

Financially it was very difficult and the key to making it work was being able to design and build so much of their equipment locally. To a limited degree they also had to accept a slower pace of building and implementing the project so that they could pay for it over a longer period. And in settling on the concept of a pilot factory they were aided by their industry being a specialized technology production technique using equipment of moderately simple technical design.

Very simply - and briefly - the Solar Bronze production process starts with the alloying of copper and zinc in a furnace to produce brass which whilst molten is sprayed using a high pressure jet. This produces a small sized sand-like brass powder which is the feed material which is then rolled out to form the flake particle. This material called atomized powder is also the second product range. The rolling out is done in a ball mill, a rotating ball mill filled with steel balls. Screening equipment to size the powder is included in the ball mill system so that the product can be removed continuously. A final processing stage polishes the product to make it even more gold like. Since each ball mill system is a complete production process it will be understood that production capacity is entirely related to the number of mills installed... and this explains how Solar Bronze has been able to build a pilot factory from which they could base future expansion programs.

They prepared detailed designs of all the equipment needed and also - through Mr. Kamjorn visited local factories using locally made - often home made - equipment of the type required.

Thus for the furnace they talked to various local brass and bronze foundries who very kindly showed them the furnaces they had made and gave them contacts where they could obtain foundry supplies and equipment.

For the screening equipment they visited rice mills who again helped them in the same way. In this way they were able to build up a knowledge of where to get parts and equipment. Finding supplies for some of the more unusual items wasn't easy but this system of...if you don't know ask a friend who knows a friend whose friend works at...seemed to be the way things are done in Thailand. But full credit to the Thai partner who spent the considerable time and effort to visit these places and people. And if all else failed he had this friend who has a friend...!

Hence Mills c.s. started to manufacture both at their partners facilities and at outside contractors...small engineering businesses since the larger specialized contractors would have increased the needed investment. And here they came accross an unexpected problem - which they had certainly not contemplated - many of the craftsmen could not understand engineering drawings. The machining shops weren't too bad but many engineering fabricators were completely unfamiliar in working with detailed drawings. In an English speaking country that would have created a problem, but in Thailand the language barrier just increased it. In the end they had to redraw most parts and layouts as perspective drawings or sketches often colored to make identification easier...make cardboard models...or if all else failed (and this applied especially with installation side) Mr. Mill stood on the workshop floor and took them through the work a part at a time.

Of course, using the larger contractors would have overcome this problem but then they would have lost most of the cost advantage of fabricating parts and equipment in Thailand. And it must be stres that once the Thais understood what was needed the standard of work done was good - often very good. It was just that if they could see it, they could copy it...if they couldn't you sometimes got unexpected results.

Mr. Mills did also have a delivery problem with contractors who often, almost inevitably, failed to deliver on time. To be fair, however, to these smaller businesses it must be remembered that Thailand's economy has been increasing very quickly and that many workshops are overloaded with work...and to aggravate matters these same workshops are losing their skilled workers to newer, bigger and often better paying companies. It all made project planning very difficult but Mills c.s. had to learn to live with it.

And from Mr. Mills'own personal point of view he had to learn to live with many things and to readjust his engineering demands to the local conditions...He found it was a brave man who assumed anything was so small and commonplace that it was bound to be in stock and available. He was in a metric country so he designed in metric...only to find locally made nuts and bolts are cheaper and easier to obtain in imperial sizes...He could buy drive belts anywhere but no pulleys to fit them...there were always surprises in store. As many who come from a country where time is money have found before, it was certainly difficult - it still is - to adjust to a philosophy where sometimes time seems not unduly important. And he has still to figure out what to do about the Thai "graeng jai" and people saying "yes" when they mean "no" or "I understand" when they haven't any idea what you have been talking about.

After the experiences of manufacturing and purchasing equipment, installation had no new surprises...builders who try to manufacture concrete without enough cement are present in Europe as well.

Commissioning of the factory went reasonably well and it is important to mention here that they have just completed this stage of the project and have been sampling perspective customers.

As mentioned at the start, Solar Bronze does not need to use a large work force. All their commissioning needed no more than two operators and even when in full production five will be a maximum and underutilized at that. The person they chose to train more intensively, whilst not a university graduate, was eager to learn and quick to do so, and there will be no long term problem in transferring the expertise needed to produce a quality product consistently. On the semiskilled labour side there are no major problems. One area where they do have to take care because Solar Bronze is a small company is petty theft - the metals used are easily resaleable, expensive and if inclined that way not over difficult to pick-up and walk away with. We wouldn't call it serious crime but the temptation sometimes gets stronger than the will to resist it.

However, a potentially more serious problem in terms of losses is the electricity supply. In the rainy season there are sometimes power failures but of more importance are voltage losses which particularly this year have become increasingly common. Their larger motors (and Solar Bronze is a heavy power user) will not run under these conditions and this sometimes gives very serious stoppages in the middle of production operations. They have also found problems with telecommunications. They need extra phone lines at the factory site but having waited for six months there still seems little chance of getting any.

There was also of course the legal side to set up...company registration, accounts, and visa and work permit for Mr. Mills himself. They had to leave much to their Thai partner. Something common to all was that it was time consuming and overloaded with photocopied documents and forms.

In particular obtaining a work permit and long term non-immigrant visa was very difficult and extremely wasteful of time. It took four months to get a work permit and at one point they had the silly situation of the Immigration Department refusing to give visa until Mr. Mills had a work permit and the Labour Department refusing to give him a work permit until he had a visa. Four 40 kilometer trips it took just to sort that one permit out.

And where will the company go from here? Of course, Solar Bronze needs to establish itself in the market as a reliable, consistent supplier and within a further three months period the staff will be fully production trained. Already customers are showing interest both here and in many other countries and so there is confidence that already they are starting to prepare plans for an expansion to double capacity expansion to double our capacity.

And even though Solar Bronze is still new and small it does not ignore the future - it included pilot plant test facilities along with the original pilot factory. Again credit to the Thai partner for listening to and understanding the need for R&D - something Mr. Mills finds most Thai businessmen - even successful ones - very reluctant to invest in. To prove the benefit of such farsightedness only two weeks ago a Korean company approached Solar Bronze to develop a special type of metal powder for them...as they already are prepared they could advise them that they could.

Diversification of the product range will depend partly upon them being able to raise further finances, partly to their own development efforts, and especially on the need for the products they make in Solar Bronze in Asia - powder metal technology is still in its infancy here. But by being established in Thailand Solar Bronze is prepared for it when it arrives...and in some ways they hope they may help it quickly develop by the fact that they are there to supply the needed material. The potential is very big because these intermediate raw materials they will manufacture are used in many applications. - automobile and engineering parts, electronics, welding techniques, explosives and fireworks, and building materials, to name just a few.

The main conclusions to be drawn from what Mills c.s. have done in Thailand was that in the end they have had to accept that implementing the project by necessity needed to take a long time. And more importantly that they could never have done it without the correct local partner who was prepared to blend the needs of new technology with demands and restrictions of local conditions.

There have been delays and often unexpected problems but the final question must be, was it worth it, did they succeed in implementing the concept of the project, and have they been successful? To all these the answer is definitely yes.

Had they been an existing company or financially stronger the project would have taken less time and in some ways been easier...but it would also have cost much, more. And the important point is that they do produce good quality and have done it not by-passing or ignoring local suppliers and conditions but by using them and so reducing their overall investment cost.

ANNEX 3 : LIST OF OFFICIALS INTERVIEWED IN THAILAND

Ministry of Science, Technology and Energy (MOSTE)

- Dr. Aphirat Arunin, Deputy Permanent Secretary
- Mr. Narong Rattana, Director/Technology Transfer Centre
- Mr. Chirapandh Arthachinta, Director/Office of Policy and Planning
- Prof. Dr. Sakarindr Bhumiratana, Deputy Director/NCGEB

National Research Council of Thailand (NRCT)

- Dr. Charoen Vashrangsi, Secretary General
- Ms. Wanasri Samanasena, Director/Translation and Foreign Relations Division

National Economic and Social Development Board (NESDB)

- Dr. Bunyaraks Ningsananda, Director/Overall Planning Division
- Mr. Phayap Phyormyont, Director/Human Resources Development Division
- Ms. Narumol Dharmaraksa, Deputy Director/Technology & Environmental Planning Division

Thailand Institute of Scientific and Technological Research (TISTR)

- Dr. Santhad Rojanasoonthon, Acting Governor
- Mr. Chalermchai Hornak, Director/Office of Policy and Planning
- Mr. Siri Nondhasri, Director/Testing and Standards Centre

Thailand Development Research Institute (TDRI)

- Dr. Chatri Sripaipan, Program Advisor/Science and Technology Department

Science and Technology Development Board (STDB)

- Dr. Thalerng Thamrong-Nawasawat, Director STDB
- Dr. Montri Chulawatanatol, Deputy Director
- Dr. Wirojana Tantraporn, Deputy Director and Technical Advisor
- Dr. Nit Chantramonklasri, Director
- Mr. Wit Satyarakwit

Ministry of Commerce (MOC)

- Mr. Kavee Rauyruin, Director/Export Services Division

Thailand Industrial Standards Institute (TISI)

- Mr. Samnao Chulakarat, Secretary General
- Ms. Kanya Sinsakul, Director/Standardization Division

Department of Science Services (DSS)

- Mr. Kasem Snidwongse, Director General
- Dr. Anamai Singhabhandu, Director/Physics and Engineering Division

Technological Promotion Association (TPA)

- Dr. Prayoon Shiowattana, General Manager

Industrial Finance Corporation of Thailand (IFCT)

- Dr. Poonsa-nga Somboonpanya, Vice President/R&D Department

Board of Investment

- Mr. Pairot Sompanti, Director/Planning Division
- Mr. Thamrong Mahajchariyawong, Head/Technology Registration Branch
- Mr. Philippe Lyssens, Thai-Belgian Investment Promotion Service

Solar Bronze (Thailand) Co.Ltd

- Mr. J. Peter Mills, Technical Director

Note: Officials Interviewed in Brussels

- Mr. Luc Vandebon, European Commission, DG XII
- Mr. Franz Jessen, European Commission, DG I
- Mr. Chobvit Lubpairee, S&T Counsellor, Royal Thai Embassy.

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