TECHNOLOGICAL CAPABILITY OF THE THAI INDUSTRY: STATUS, KEY ISSUES AND RECOMMENDATIONS

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ABSTRACT
A methodology for assessing technological capability of the Thai industries has been devised. Three important subsectors were covered in the study: biotechnology-based, materials-based and electronics-based. A total of 119 producing firms were surveyed and their various categories of technological capabilities assessed. Operative capability was, in general, found to be the highest among the four types of capabilities but did vary according to the characteristics of the firms. Innovative capability was the poorest regardless of the firms’ types. Important problems and issues which include manpower shortage and deficiencies in technological infrastructure were identified and discussed. A set of policy recommendations are proposed based upon the results of the firms’ surveys, macroeconomic and technological trends as well as the surveys of existing policy and technological infrastructures.

INTRODUCTION
That technology is one of the most prominent factors in the industrial and economic development of a country is well recognized. Technological capability is perhaps the most crucial determinant for long-term and sustainable competitiveness and growth of a firm, or of a nation for that matter. There is overwhelming supportive evidence for such belief both at home and abroad. Most countries, particularly less developed ones, including Thailand, are therefore doing their best to raise their respective technological capabilities. Recent successes of some newly industrialized countries and failures of others have taught us that accelerated technological capability development is indeed possible but it must be well-planned and properly

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implemented. Straight 'copying' of development models from other countries, due to various differences, just would not work and may lead to undesirable consequences or even disasters. Careful assessments of a country's specifics regarding the present status and needs, readily available and potentially available resources, constraints and opportunities as well as relevant socio-economic conditions are necessary. Well-conceived plans and appropriate strategies can then be developed.

This paper is based on an 18-month project attempting to assess the above-mentioned specifics pertinent to technological capability development in Thailand. Three groups of industries: biotechnology-based (BBI)\(^1\), materials-based (MBI)\(^2\) and electronics-based (EBI)\(^3\), are covered. Policy recommendations are then proposed based on such assessments together with other considerations.\(^4,5\)

METHODOLOGY AND THE SURVEYS

Technological capabilities of producing firms are categorized into four types: acquisitive, operative, adaptive and innovative. Acquisitive capability includes the firms' abilities to search, assess, negotiate and procure relevant technologies. The transfer of operation know-how as well as installation and start-up of production facilities are also included in the acquisitive category. Operative capability includes the abilities to efficiently operate and control machinery and other equipment as well as the abilities for maintenance, skill development (training), general management, production planning and quality control. Adaptive capability comprises knowledge acquisition, technology digestion and minor product and process modifications. The components of innovative capability include the abilities to carry out in-house research and development, radical product and process modifications, radical or major changes and new products and/or process inventions.\(^4\)

A total of 119 producing firms: 32 BBI, 55 MBI and 32 EBI; were selected for the survey. The selection was based on a number of criteria including export earnings, import values, domestic value-added, resource utilization, technology and industrial linkages, technology content, growth potentials and employment generation. Surveyed firms and their characteristics are shown in Table 1.\(^6\)

Field interviews and visits of production facilities were conducted by senior research fellows (scientists, engineers and economists) and research assistants. A set of questionnaires was left with each firm to be collected at later dates for additional detailed information. The subjects of the interviews include those directly related to the various categories of technological capabilities mentioned above as well as other relevant matters such as market niches, history of the firms, problems and obstacles being faced, etc. After each survey, the capability of the firm was initially assessed by individual team members. The results were then rigorously
### TABLE 1
SURVEYED FIRMS AND THEIR CHARACTERISTICS

<table>
<thead>
<tr>
<th>Technological areas and industries</th>
<th>IND</th>
<th>No. of Firms</th>
<th>Age</th>
<th>SIZ-</th>
<th>OWN-</th>
<th>MKT-</th>
<th>PRO-</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Old New</td>
<td>L</td>
<td>M</td>
<td>S</td>
<td>NT NF</td>
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<tr>
<td>Biotechnology</td>
<td>BIO</td>
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<td>67</td>
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<td>27</td>
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<td>-</td>
<td>14</td>
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<td>45</td>
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<td>27</td>
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<td>0</td>
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<td>5</td>
<td>7</td>
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<td>RUB</td>
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<td>3</td>
<td>2</td>
<td>22</td>
<td>4</td>
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<td>-</td>
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<td>1</td>
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<td>2</td>
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<td>2</td>
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<td>3</td>
<td>0</td>
<td>13</td>
<td>3</td>
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<td>Electronic components</td>
<td>CMP</td>
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<td>16</td>
<td>3</td>
<td>7</td>
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<td>1</td>
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<tr>
<td>Computer software</td>
<td>CSF</td>
<td>3</td>
<td>28</td>
<td>3</td>
<td>1</td>
<td>11</td>
<td>3</td>
</tr>
</tbody>
</table>

Sources: Data sets made available by area research teams.

Notes: IND gives the industry acronym. With respect to Age, which is in years: entries in the Old column give the age of the oldest establishment in the sample; NEW, the youngest establishment. Under the OWN attribute: NT and NF apply to biotechnology and materials; J and F, to electronics. In the SIZ, OWN, MKT, and PRO columns, cell entries indicate the number of firms having the stated characteristic.
discussed before the final ratings were given.\(^1,3\)

The rating system involves the scoring of each component of the technological capabilities between 0 (zero) and 5. Although each number represents certain specific activities and abilities performed and possessed by the firms, they may be roughly interpreted as follows:

5: excellent capability, comparable to leading firms in the world  
4: very good capability, industrialized countries' average  
3: good capability, leading Thai firms  
2: fair capability, local average  
1: poor capability, below local average  
0: no capability

In addition to producing firms, other relevant policy and technological infrastructures were also surveyed. These include, among many others, the Board of Investment, Ministry of Industry, Ministry of Science, Technology and Energy, Ministry of University Affairs, various universities and research organizations, consulting firms, output users, input suppliers, etc.\(^4\)

**TECHNOLOGICAL CAPABILITIES OF THE BBIs**

The biotechnology-based industries under study include aquaculture, feed industry, seed industry, dairy industry, flower industry, organic acid industry, alcohol industry and health-related industries. The products range from fish and shrimps, animal feeds, seedlings and seeds, milk and its derivatives, orchids, citric acid, lysine, monosodium glutamate, to alcoholic beverages and antibiotics and vaccines. Relevant technologies include genetic engineering, fermentation technology, tissue culture, hybridoma fusion, chemical and biochemical analyses, microbial technology, enzyme technology as well as mechanical, chemical and electrical engineering and measurements and controls. Relative importance of these technologies depends upon the type of industry being considered.\(^1\)

**Overall Capability** : The pictorial representation of the overall technological capability of the BBIs is shown in Figure 1a.\(^1\)

In general there are many technologies, particularly relatively new biotechnologies, which are not employed by producing firms. Technological activities are few and far between although most firms realized the existence of the technologies and their potentials. Technologies normally take the second place to short-term economic considerations in most cases. Business strategy is based mainly on temporary comparative advantages such as low labour cost and availability of
cheap raw materials.

The technological capabilities of the BBIs, however, do vary among the various subgroups as can be clearly seen from Figure 1a. Aquaculture and feed industries have relatively high capabilities whereas those of alcohol and health-related industries are relatively low. The level of technological sophistication and the very nature of each subgroup do play a significant role with regard to the capabilities.

It can also be seen that innovative capability is the lowest among the various categories regardless of the type of industries or firms.

**Acquisitive Capability** : Acquisitive capability of the BBIs varies according to the nature of individual subindustries (i.e., the level of sophistication of the technologies employed) and the firms' characteristics. Aquaculture industry has high acquisitive capability due to the simple nature of the technologies while the high capability of the feed industry is due to its capital-intensive nature. The seed industry has good relationship with foreign firms, therefore, foreign technology can be easily acquired. Most dairy firms are joint-venture with or subsidiaries of foreign companies through which new technologies could be acquired. The technology in the flower industry is, on the main, handed over from older generations and therefore mostly local. Organic acid and alcohol industries employed, in general, turnkey-type technologies which have been developed overseas for some time. Their acquisitive capability is therefore relatively low. Health-related industry is generally spoon-fed, in a controlled fashion, with the technologies by foreign collaborators.

In general it has been observed that acquisitive capability of the BBI firm is inversely related to the degree of technological sophistication; the more sophisticated the technologies, the less the acquisitive capability. It has also been found that firms which have R & D activities have higher acquisitive capability.

Graphical representation of the acquisitive capabilities of certain selected subgroups of the BBI illustrating capabilities of various components is as shown in Figure 1b.¹

**Operative Capability** : Operative capability is the highest among the four types of capabilities. Among the subindustries, the operative capabilities of the feed industry and aquaculture are the highest while those of the alcohol industry are the lowest. The main reason for this is the level of sophistication and the maturity of technologies being employed. The technologies for aquaculture industry
are relatively new and comparatively less sophisticated. The technologies for alcohol industry, on the other hand, is well-developed and mostly purchased on a turnkey basis. The fact that the alcohol industry is more or less monopolized also contributes to the low operative capability of the industry.

Joint-venture firms, in general, possess higher operative capabilities than Thai firms. These (i.e., joint-venture) firms place great emphasis on manpower training which is rather scarce in Thai firms. Foreign experts from sister companies assist these firms in training, operating as well as in general management, particularly at the initial stages.

The operative capabilities of selected subindustries are shown graphically in Figure 1c.¹

Adaptive and Innovative Capabilities. Adaptive capability of the BBIs depends, to a large extent, on the nature of individual subindustries. Aquaculture industry has comparatively high capability due mainly to the simple nature of the technologies employed. Recent rapid growth in the demand of aquaculture products also contributes to the high adaptive capability of the subindustry. There are some adaptation and innovation activities in the feed and seed industries. The activities are mainly directed towards minor modification and improvement of the products. Organic acid, alcohol and health industries have very low adaptive and innovative capabilities. Most of the adaptation and innovation are performed overseas. The technologies, and any modifications thereof, are purchased on a turnkey basis.

Graphical representation of generally adaptive and innovative capabilities of selected subindustries are shown in Figures 1d and 1e.¹

More detailed amount about the assessment and the capabilities of the BBIs are in reference 1.

Apart from the nature of the subindustries (i.e. the technologies), the capabilities of the BBIs also depend on the characteristics of the firms. This is summarized in Table 2.¹

TECHNOLOGICAL CAPABILITIES OF THE MBIs

The materials-based industries under study are foundry, machining, fabrication and assembly, forging, die making and sheet metal forming, plastic resin and plastic products industries, and rubber and classical ceramic industries. The products are correspondingly wide-ranging from simple castings, moulds and
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Fig. 1 Technological Capability of Selected BBIs
Technological Capability of the Thai Industry: Status, Key Issues and Recommendations

Fig. 1 (cont.) Technological Capability of Selected BBIs
dies, plastic resins, consumer products to sanitaryware, tiles and complex fabricated products and machinery. The technologies involved are also wide-ranging from production technologies such as foundry and forging to mechanical engineering design and quality control. The level of sophistication of the technologies therefore varies considerably from industry to industry. It should be noted also that the surveyed firms are mostly leading firms in the country. Only a few ‘small’ firms were surveyed as they (i.e., small firms) possess more or less identical capabilities.  

**Overall Capability** : The technological capabilities of the MBIs follow a similar pattern to those of the BBIs : operative capability is the highest and innovative capability the lowest. Graphical representation of the overall capability is shown in Figure 2a. The type of industries and relevant technologies as well as the firms’ characteristics are important parameters determining the technological capabilities of producing firms. Large Thai firms with their plentiful financial
and human resources have very high acquisitive and operative capabilities but their adaptive and innovative capabilities are low. Joint-venture firms possess high operative capability but not so good at others as technology acquisition, adaptation and innovation are performed elsewhere. Medium Thai firms need to adapt the technologies in order to be competitive and make the most of limited financial resources available. They therefore possess relatively high adaptive capability as compared with large Thai or joint-venture firms. Small firms are poor in all types of capabilities. Industries which employ relatively simple technologies generally have higher capabilities than those which employ more complex technologies. By international standard, the technologies employed in the MBIs are relatively simple and well-established.

**Acquisitive Capability**: The methods by which relevant technologies are acquired differ from firm to firm. Large Thai firms search the technologies systematically by sending teams of technical personnel to various technology sources. Negotiation and procurement are carried out in a proper manner. Installation and start-up of production facilities are normally done with considerable assistance from the technology owners, however. Joint-venture firms acquire technologies via parent or sister companies overseas with little effort of their own. Medium Thai firms employ various means for acquiring technologies, e.g., visiting trade exhibitions, via educational institutions. Personal contact is the most popular means for small Thai firms. In many instances, second-hand rather than new production facilities are purchased. Large Thai firms therefore have high acquisitive capability due to the availability of sufficient financial and manpower resources. Acquisitive capability of small Thai firms is the lowest.

Graphical representations of acquisitive capabilities of selected groups of the industries are shown in Figures 2b-2f.²

**Operative Capability**: The operative capability of most of the surveyed firms are relatively high due in part to the nature of the sample of the firms under study. Most are ‘leading’ firms in Thailand and the technologies employed are mostly relatively simple. The operation and control of production facilities and quality control are carried out efficiently particularly in large and medium-sized firms. Large and joint-venture firms place strong emphases on manpower training while medium and small Thai firms pay less attention to the matter. Maintenance of machinery and other facilities seems to be the weakest point. Overall, the operative capability of the MBIs is good as is evidenced from the quality and the competitiveness of the products. A number of manufactured items are being exported worldwide, e.g., ceramic products, industrial and agricultural machinery, plastic products, etc. Small Thai firms still have very low operative capability, however.
Figures 2b-2f show some details of the operative capability of certain subindustries.²

Adaptive and Innovative Capabilities: Adaptation of technologies, mainly product modifications, is widespread within certain subindustries of the MBI, notably agricultural and industrial machinery, ceramic and plastic product industries. The nature of these industries is such that product modification is a necessity in order to meet the continually changing requirements of the customers. The adaptation activities are carried out mostly by Thai technical personnel. It should be noted, however, that, due to the nature of products being manufactured, the modifications are relatively simple to do. In many a time outside assistance, particularly from customers, is also required. Innovative capability of the MBIs is generally low. There is virtually no real R&D activities in any of the firms under study although some large firms have initiated the activities recently. Some development work (e.g., in machinery industries) is carried out mainly on a trial-and-error basis. Major product and process modifications and innovations are few and far between. There is one ceramic firm which has developed a fast firing furnace which is claimed to be the first of its kind in the world.

Graphical representations of adaptive and innovative capabilities of certain groups of MBIs are shown in Figures 2b-2f.

More detailed and descriptive assessments of the types of the technological capabilities of the MBIs could be found in reference 2.

The influences of firms’ characteristics on the various types of technological capabilities are shown in Table 3.²

TECHNOLOGICAL CAPABILITIES OF THE EBIs
This group of industries includes electronic consumer product industries, computer hardware and software, communication equipment, industrial electronics and electronic component industries. The products are wide-ranging, from audio and video equipment, telephone systems to computer keyboards and disc drives, printer, computer software, transformers, meters as well as various parts and components for electronic systems. The technologies are also wide-ranging which can be divided into several levels: materials, boards, components, equipment, systems and software. Relevant technologies include those for material processing, boards and components fabrications, computer technologies. Mechanical, industrial and production engineering technologies such as precision machining, quality control, plant layout, etc., are also relevant.³
Fig. 2 Technological Capability of Selected MBIs
Fig. 2 (cont.) Technological Capability of Selected EBIs
TABLE 3
TECHNOLOGICAL CAPABILITY SCORES FOR MBIs

<table>
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<tr>
<th>Characteristics (no. of firms)</th>
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<tr>
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<tr>
<td>Without (27)</td>
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</table>

Overall Capability: Graphical representation of the technological capabilities of the EBIIs is as shown in Figure 3a.3

It can be seen that the capability profile follows a similar pattern to those of the BBIs and the MBIs, i.e., operative capability is the highest and innovative capability the lowest. There exist, however, differences in technological capability among the various types of firms. Foreign-owned firms, for instance, have much higher operative capability than small and medium Thai firms. Export-oriented firms possess higher operative capability than those firms which sell their products primarily in domestic market.

Acquisitive Capability: On average, the acquisitive capability of the EBIIs can be considered rather low with the installation and start-up component being the weakest. Large Thai firms, however, exhibit distinctly strong acquisitive capability. Technological progresses are closely watched and followed by technical personnel via various means, e.g., technical journals, trade exhibitions, attending
conferences and seminars, etc. Outside assistance is normally needed for installation and start-up of production facilities, however. Small/medium Thai firms, joint-venture and foreign-owned firms have similar acquisitive capability. Market orientation and promotion status do not have significant influence on the acquisitive capability of producing firms.

Graphical representation of the acquisitive capability of various subindustries is shown in Figure 3b.3

**Operative Capability**: Operative capability is the highest among the four types of capabilities but is still not sufficiently high for global competitiveness. The lowest components are maintenance and manpower training, particularly for medium/small Thai firms. Foreign-owned firms exhibit the highest operative capability. The production technologies employed are up-to-date and specific trainings for employees are normally accomplished both prior to starting and on-the-job. Great emphasis is placed upon quality control and manpower training. Computers are introduced wherever possible. Thai firms possess much lower operative capability. BOI-promoted and export-oriented firms have higher capabilities than, respectively, nonpromoted and domestic market-oriented firms.

Figure 3c represents some details of the operative capability of the EBIs.3

**Adaptive and Innovative Capabilities**: There are some technology adaptation activities in large Thai and joint-venture firms. These, however, are limited to reverse engineering and minor product modifications. Foreign-owned firms make little attempt to adapt or innovate as their main objective is for production only. Real R&D activities have just been initiated in certain Thai firms. New invention is virtually nil. Most EBI firms are busy trying to catch up with the fast-moving technology. They do not have much time or resources to spare for innovative activities.

Figures 3d and 3e show the adaptive and innovative capabilities of various subindustries.

More details about the assessment of technological capabilities of the EBIs could be found in reference 3.

A summary of technological capability scores of the EBIs is shown, according to the firms’ characteristics, in Table 4.3
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1. Acquisitive Capability
2. Operative Capability
3. Adaptive Capability
4. Innovative Capability

(a) Overall Capability

(b) Acquisitive Capability

(c) Operative Capability

Industry Area
1. Consumer Electronics
2. Communications Equipment
3. Computer Hardware
4. Industrial Electronics
5. Electronic Components
6. Computer Software

Fig. 3 Technological Capability of the EBIs
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(d) Adaptive Capability

(Adapted from Fig. 3 (cont.) Technological Capability of the EBIs)

(e) Innovative Capability

Industry Area
1 Consumer Electronics
2 Communications Equipment
3 Computer Hardware
4 Industrial Electronics
5 Electronic Components
6 Computer Software
### TABLE 4
TECHNOLOGICAL CAPABILITY SCORES FOR EBIs

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Capability</th>
<th>Acquisitive</th>
<th>Operative</th>
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<td>Export (14)</td>
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<td>Export &amp; Domestic (18)</td>
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<td>Without (13)</td>
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### CONCLUSIONS AND IMPLICATIONS
1. The technological capabilities of producing firms in the three subsectors follow a similar pattern: Operative capability is the highest and innovative capability the lowest. More detailed examinations reveal, however, that the high operative capability results from substantial contributions from foreign-owned and joint-venture firms which are, on the main, essentially production outposts of multinational companies. Most Thai firms, except large ones, still have low operative capabilities. In view of the fact that small and medium-sized firms are highly significant in the Thai economy in terms of number and employment generation, serious attention must be paid to the upgradation of the operative capability level of these firms. The increase in the severity of international competition and rapid technological advances demand that the operative capability of these firms must be much higher in order for them to survive and grow in the long run. Effective technology transfer and diffusion mechanisms need to be devised in order to promote the localization of technology.
2. In certain industries, notably electronics-based, export-oriented firms have higher operative capability than firms which primarily aim for domestic market. Exposure of firms to international competition seems to be one of the effective means to raise their operative capability. Protection measures therefore have to be carefully planned and implemented. BOI-promoted firms also have higher operative capability than those which are not being promoted. This suggests that up-to-date technology hardware (i.e., production facilities), affordable by promoted firms, does play a significant role in increasing operative capability of the industry. The capability to design, modify, build/construct modern production machinery and equipment will therefore be critical for long-term competitiveness.

3. Although there are some adaptation activities in all the three subsectors of the industry under study, these are mostly limited to minor product modifications which are relatively simple to accomplish. Technology digestion and process modifications are few and far between. As the technologies become increasingly more sophisticated (hence more difficult to adapt) and in view of the fact that technology adaptation is essential for any industry, it is imperative that the adaptive capability level of the Thai industry be raised. This applies to all types of firms including joint-venture and foreign-owned ones as the 'Thai environment' cannot be identical with those in any other countries. Effective adaptation could only be accomplished through organized efforts either in terms of R&D teams or equivalent groups of qualified personnel who thoroughly understand the technologies. Small and medium-sized firms will, due to limited financial and human resources, have considerable problems. Some sort of assistance needs to be provided.

4. Innovative capability of producing firms in all three subsectors is very low. This is perhaps understandable considering the stage of industrial development of the country which practically has just started. Technological innovation is, however, an essential element if the Thai industry is going to compete successfully in international market in the long run. Thailand cannot possibly rely on cheap labour and the availability of natural resources as the major competitive advantages for too long. Appropriate means must be devised and measures taken to improve the level of innovative capability of the Thai industry. As research and development is the main, if not the only, source of technological innovation, it must be encouraged, promoted and even coerced in certain circumstances, both in the public and private sectors.

5. The acquisitive capability of the Thai industry is also low and needs to be upgraded. Technology acquisition is very important for any enterprise, particularly at the initial stage. Improper selection of technology could lead to prolonged headaches or even a disaster. Proper evaluation and selection of technology require a wealth of information and the availability of competent technical personnel. Adequate
technological information system and a pool of technical personnel should be provided to assist producing firms, particularly small and medium-sized ones.

MAJOR PROBLEMS AND OBSTACLES

1. Manpower Shortage This is a very serious problem at present particularly the shortage of engineers. It is estimated that the annual demand of engineers is around 7,000 whereas the present supply is about 2,800. Scientists in the fields of materials, biotechnology and computer science are also in short supply. The technical manpower-shortage problem is pervasive in industrial sectors as well as in public organizations including universities. Without an adequate number of properly trained technical personnel, it is difficult, if not impossible, to raise technological capability of any kind.

2. Inadequate Technical Information Services These include the inadequacy in the amount of the information available and accessibility problems of available information. The fact that most of the technical information is in English and is scattered in various places makes it rather difficult to access. The explosive growth of technological information in recent times demands that a proper system for collection and dissemination of the information is necessary. Technological development in modern times cannot be effectively accomplished without the supply of up-to-date information.

3. Inadequate Technical Services These include testing, analyses, and, product certification as well as calibration and consulting services. As most of the firms in Thailand are medium to small scale by international standard, outside technical services are normally required. At present the services available are inadequate in terms of quality and quantity. This leads to delays and sometimes inaccurate results.

4. Lack of Specialized Technology Centres Most of the existing organizations (e.g., research organizations, universities) attempt to do too many things at a time with limited resources. This lack-of-focus effort leads to the resources being spread too thinly over too many areas to be effective. The creation of specialized centres (or centres of excellence) would enable such organizations to focus their efforts in certain specific areas which could be of real commercial uses.

5. Other Problems These include lack of supportive industries (particularly high quality and precision part industries), inappropriate tax system (the VAT system will be introduced in early 1990, however), the attitudes towards technology of entrepreneurs (which seek short-term profit rather than long-term growth), lack of definite and explicit technology and industrial policies and the reinforcement of the intellectual property right law. These are being recognized and some measures
have been taken to ameliorate the problems.

RECOMMENDATIONS

1. It must be appreciated that technological capability development is a long drawn and difficult process requiring fertile environment, political commitments and considerable efforts from various quarters, public and private alike, to flourish. Proper timing is one of the most critical factors for the success of such endeavour. It is perhaps the most appropriate time now for Thailand to seriously embark upon this monumental task of technological capability development. The government and the industry must be prepared to invest more resources on such undertaking. This must start right away before it is too late.

2. Undoubtedly one of the most essential, if not the most essential, ingredients for capability building is human resource. The development of properly qualified technical personnel at all levels, which are in severe shortage at present, must be done rather urgently. This could be accomplished by various means:

- Expansion of formal educational system in selective high priority areas such as engineering, physical and bioscience, materials, computers and electronics. The number of graduate scientists and engineers must be doubled to meet the present and future demand.

- Graduate programmes in high priority areas should be expanded to develop high-level research scientists and engineers.

- A number of Thai students (about 800) should be sent abroad for further education and training is selected in high priority areas.

- Curricula in universities and colleges should be continually modified and should lean more towards practical and professional training. More collaboration with local industries should be strongly encouraged.

- The industries must also play their roles in the training and development of technical manpower. Specific process and product technologies and special skills can only be learned and gained through the training in the industries.

3. Equally important to the capability development in the Thai industry are technical and information services. This is due to the structure of the Thai industry which comprises mainly small and medium-sized firms. They do not have the capacity to maintain expensive analytical and testing facilities and to
gather all the relevant information. Central facilities need to be provided.

- Relevant organizations, e.g., the Ministry of Science, Technology and Energy (through the three centres), Ministry of Industry, various universities and research organizations, the Federation of the Thai Industries, etc., must set up or improve on the existing technological information service systems so as to make them readily accessible to the industry and the public at large. Serious attempt to translate technical information (e.g., books, handbooks, codes of practices) into Thai should be made.

- Presently available technical and consultancy services are far from adequate quantitatively and qualitatively. Existing organizations such as MIDI, the Department of Science Services, various university laboratories, etc., should be strengthened. Additional organizations are required to meet the increasing demand of such services from the industry. Such organizations should be run as a business unit or as nonprofit non-governmental organizations to be effective.

4. As research, development and engineering (RD&E) plays a highly significant role in technological capability building, it must be strongly promoted. In view of the lack of R&D activities, particularly in the industry which is virtually nonexistent, the promotion of R&D must be done rather urgently.

- National R&D spending should be rapidly increased to 0.75% of the GNP from the present value of about 0.2%. Although the figure is very low by international standard, which is between 2-3% for industrialized and newly industrialized countries, it must be gradually increased due to limited absorptive capacity of R&D organizations.

- It is often claimed, and rightly so, that the ineffectiveness of existing research organizations including universities is due at least in part to lack of focus in R&D activities which results in the resources being spread too thinly over too many areas. The creation of specialized R&D centres or centres of excellence would ameliorate the problem.

- Financial incentives in terms of tax exemption of R&D equipment, accelerated depreciation for R&D facilities would encourage producing firms to carry out R&D work.

- Cooperative R&D would enable small and medium-sized firms to perform R&D work as well as academic institutions to learn more about
industrial problems. This should therefore be strongly encouraged.

- More soft loans for R&D investment should be made available so as to encourage private firms to engage in R&D activities.

- Research and development personnel must be properly rewarded, materially wise and status wise, in order to attract and retain high calibre scientists and engineers. The quality of the research products can be, at best, as good as that of those who create them—the researchers.

5. Inducive policy, legal as well as competitive business environment are also very important in fostering technological capability development.

- Explicit political commitment towards science and technology development is essential.

- Promotion and protection measures must have time frames in order to expose the industry to competitive environment.

- BOI-promoted firms, particularly large scale ones, should be required to carry out extensive technology transfer and set up R&D facilities in Thailand.

- Intellectual property right law should be strictly enforced in order to encourage technological innovations.

- The introduction of value-added tax (VAT) system would promote subcontracting which, in turn, would lead to specialization. This is highly desirable from the technological capability development point of view.

ACKNOWLEDGEMENT

This paper reports on the results of a large technology policy research project conducted at the Thailand Development Research Institute during July 1987 - January 1989. Entitled “the Development of Thailand’s Technological Capability in Industry”, the 18-month project, funded by a grant given by the Canadian International Development Agency (CIDA) through the Ministry of Science, Technology and Energy of Thailand, was conducted in 5 subprojects. Subproject 1, on biotechnology-based industries, was headed by Dr. Yongyuth Yuthavong. Subproject 2, on material technology-based industries, was headed
by Dr. Harit Sutabutr. Subproject 3, on electronics and information technology-based industries, was headed by Dr. Kosol Petchsuwan. Subproject 4, consisting of a rigorous statistical analysis of the project data, was carried out by Dr. Larry E. Westphal. Subproject 5 was a synthesis and overview of the project findings as well as formulation of policy recommendations and was headed by Dr. Kopr Kritayakirana.

Full names of all researchers, research staff, surveyors, consultants and advisers for the entire project are shown in the appendix. The authors of the present paper simply abstracted key results and summaries from the full report to facilitate easier access to project findings by a wider audience. Fuller acknowledgements of the contributions of various people to the project are cited in the "Acknowledgement" pages in each of the 6-volume final report of the project.

REFERENCES


APPENDIX
TDRI Project on
The Development of Thailand's
Technological Capability in Industry

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