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Prospects for Cooperation in Industrial Technology Between Thailand and the European Community*

Chatri Sripaipan
Joe Anderson

INTRODUCTION

This paper was commissioned to suggest possible areas of cooperation in science and technology between Thailand and the European Community (EC). While many potential areas can be identified, we consider cooperation in the field of industrial technology to be of the most immediate need and to have the highest potential for promoting industry, investment and trade for mutual benefit. In what follows, we start by defining a conceptual framework for technology activities in industry. Next, we describe the status of industrial technology in Thailand. Finally, we identify areas for possible cooperation between Thailand and the EC.

CONCEPTUAL FRAMEWORK FOR TECHNOLOGY ACTIVITIES IN INDUSTRY

Technology activities in industry may be divided into three levels.

Level 1: Utilization of Existing Technology

This is the most straightforward kind of technological activity that can be undertaken by a company. It involves the deployment or utilization of technology that is available "off-the-shelf" in international markets. This is usually purchased by companies to improve production processes and is often introduced with a minimum of modification to imported machinery or other equipment. Typically, the new technology is operated by the staff in the recipient company, but vendors can have roles in purchasing, delivery, setting-up, staff training and equipment maintenance. Technology activities may involve productivity improvement, quality control, and testing in order to utilize existing equipment to its fullest extent.

Level 2: Development of Technology

In more technologically sophisticated industries, individual companies frequently have to develop and adapt their existing products and processes to meet market demands. Here, because companies are often unable to purchase the necessary technology in a "ready-made" form, they have to undertake a certain amount of applied research to adapt and improve existing technology, thereby producing differentiated products required by the market. These development activities may be conducted in-house by the company through an informal management structure (usually the case with small companies) or in more formal R&D facilities, running along a continuum up to free-standing laboratories. Level 2 activities may also be conducted in collaboration with public- sector institutions or by paying for the services of private design, engineering, or research organizations.

Level 3: Basic and Strategic Scientific Research

Level 3 activities include the kind of scientific research typically conducted in the dedicated R&D laboratories of large companies. Such research may be fundamental in nature, and designed to advance scientific knowledge generally, but it is usually in a field relevant to the company's technology interests. Such work is often referred to as "strategic research" which can bring about new products, processes or

materials. Also related to level 3 is more fundamental "curiosity oriented" scientific research conducted in universities and public research institutes. Here research is not necessarily related to industrial needs but is oriented by criteria of scientific merit and is usually known as "basic research."

Level 3 activities (basic and strategic research) thus supply the knowledge from which new technology may be developed. In the case of company-sponsored strategic research, the impact on technology development may be direct and obvious. But, with publicly supported basic research, scientific developments diffuse broadly through scientific publications, teaching, academic seminars and conferences, and the movement of personnel between academia and industry. The impact of academic research on technology development is therefore often much more obscure.

To further illustrate what we mean by each of the three levels of technology activity, two hypothetical examples for the electronics and biotechnology industries are outlined below.

Hypothetical Examples of Technology Activity Levels in Two Industries

Electronics Industry: Television Assembly in Thailand Television assembly started in Thailand thirty years ago. However, the majority of companies still assemble televisions from "completely knocked down kits" (CKD) with imported components comprising up to 90 percent of the cost of raw materials. Televisions produced by the larger companies often have a higher "local content," but they are manufactured to specifications from abroad. There is no design work. Technology activities in the production line involve quality control, testing, and maintenance. There is periodic review of the process to improve productivity (increase yield and reduce errors) and reduce costs by "value engineering." These are strictly level 1 activities.

Level 2 activities include, for example, development work to enable television receivers to operate in remote areas. This may require changes to the original design to increase the sensitivity of the front-end circuits. Level 2 activities do not include simple design changes—for example, changing the appearance of the television to fit local tastes. The company should thoroughly understand the technology of television receivers and be able to change the circuitry to achieve the specification required.

Level 3 would include radical changes to the television technology. Examples are the use of digital signal processing (DSP) techniques to process the signal (instead of the current analog systems) to make multiple-window viewing possible. Equally, the change of display device from the present cathode ray tube to flat screen liquid-crystal display (LCD) would constitute a Level 3 activity.

Biotechnology Industry: Production of Industrial Enzymes The example chosen here is in the field of enzyme technology. Consider an established chemicals company wishing to start production of industrial enzymes using modern fermentation technologies. The equipment for this—such as bioreactors, fermenters, and downstream technology—can be readily purchased in international markets. The identification, acquisition, and implementation of such equipment would constitute a level 1 activity.

Once the process is running smoothly producing, say, a starch degrading enzyme, the company may wish to examine how its fermenters could be adapted to produce other enzymes such as proteases or peroxidases. This may involve experimentation with other microorganisms, or the substrate used. This would represent level 2 activities. In contrast to the television example given above, this kind of level 2 innovation would be to develop the production technology, not the product.

At a more sophisticated level, the company may wish to understand how it can improve the substrate-specificity of the enzymes produced. This would involve level 3 activities such as basic research on protein engineering and recombinant DNA. The outcome of such research might be an improved understanding of structure/function relationships in enzymes generally and could be published in scientific papers as an advance in human knowledge. At the same time, however, a company involved in this kind of work will gain valuable proprietary information on future product design. This type of "strategic research" is of course limited to companies with high levels of intellectual and financial capital and may be conducted in

the company's own research laboratory, or in collaboration with an academic center. This kind of level 3 activity is presently rare or even non-existent in Thai companies.

CURRENT TECHNOLOGY ACTIVITY LEVELS OF THAI INDUSTRY

Figure 1 shows our view of the balance of technology activities in the Thai manufacturing industry and likely future trends, based on data from a series of studies at the Thailand Development Research Institute. As depicted, the majority of companies in Thailand operate at level 1, having the most basic kind of technology activity in our analytical framework. This does not necessarily mean that level 1 companies run outdated or primitive operations. In contrast, some have acquired state-of-the-art technology and operate ultra-modern plants. The point here is that level 1 companies are not necessarily technologically unsophisticated but rather that they have experienced little pressure to undertake development work or are blocked from doing so by other factors.

Companies operating at level 2 are less common— few undertake their own adaptation and development of existing technology. Companies which do undertake such work are usually driven to do so either by the nature of the local operating environment or by direct market needs.

Even rarer are level 3 activities, and these are only conducted in a few large Thai companies or foreign-owned multinationals based in Thailand. The latter usually conduct level 3 R&D abroad, arguing that the manpower or skills do not exist in Thailand.

Our prediction is that as the Thai economy continues to develop away from an agricultural base into manufacturing, there will be an overall increase in technological activity in the country at all three levels, as shown in Figure 1. Although, it is probable that there will also be a relative increase in level 3 and level 2 activities, it is clear that in the next five years, level 1 activities (the deployment of utilization of technology that is available "off-the-shelf" in international markets) will continue to dominate the Thai manufacturing industry. Nevertheless, we would argue that any initiatives in international cooperation should address development issues at all three levels of industrial technology in parallel.

FACTORS LIMITING TECHNOLOGY DEVELOPMENT IN THAILAND

The most important factor limiting technology development in Thailand is the current economic and policy environment. The economy is growing at an unprecedented rate, fueled by direct foreign investment and an export boom. Under these conditions, most manufacturers are preoccupied with rapidly scaling up output to meet excess demand, and there is little pressure for companies to differentiate products or to innovate. This is reinforced by protective trade policies that impose high import tariffs on foreign technology-intensive goods and regulate the number of companies in any given sector. Such protection lowers competitive pressures, causing a laissez-faire attitude toward product or process innovation in the local manufacturing industry. These economic and policy factors therefore create an unhealthy environment for the development of technology activities in industry. Various arguments can be made as to why it is important to promote a better environment for industrial technology and how to bring this about, but these are outside the scope of this paper.

Besides economic and policy factors, there are other more direct constraints on technology development in Thailand which may be overcome through international cooperation. These include constraints due to an inadequate business infrastructure for S&T, inadequate provision of S&T institutes, and inadequate human resources. These will now be considered in turn.

Constraints Due to an Inadequate Business Infrastructure

Any shift from level 1 to level 2 technology activities in Thai industry will require an adequate supply of the components for technology development and an associated need for raw materials and higher value-added services. Technology components here may be as simple as plastic cases to supply a manufacturer of photographic film, or more complicated equipment, such as technical machinery for a new production

process. Services may include technology consultancy or information brokerage. Regardless of the type of product or service, it is widely argued that the network of vendors that can supply such technology components and services is currently very poor.

Most manufacturing companies with level 2 activities repeatedly argue that they need assistance with identifying quality vendors either in Thailand or abroad and that they wish to see an upgrading of the capabilities of existing vendors.

Constraints Due to Inadequate S&T Institutions

S&T institutions are either organizations that conduct S&T activities (education, research, development), such as universities, government departments and private companies, or institutions that support these activities through providing services. Service institutions include S&T information centers, testing and calibration centers, technical consultancy services, etc. The main institutional deficiency in Thailand is in this service sector.

For example, if a Thai company has purchased technology from a foreign vendor, there is very limited after-sales service, and few local consultancy organizations to which companies can turn to for technical advice in the event of problems. Another limitation concerns the inadequacy of technical testing and calibration facilities which are necessary for ensuring that locally manufactured products meet international specifications and standards. Public-sector institutions providing services in this area have been described as inefficient and unreliable.

Consultancy and testing services mainly address the needs of companies with level 1 technology activities. Improving the institutional basis for services at level 2 is more troublesome and may not be achieved easily by improving networks of consultants. It has been argued that free-standing technology research institutes are needed to service the needs of industry. Examples of this kind of institute abroad can be found in the Hong Kong Productivity Council and the Industrial Technology Research Institute in Taiwan. These conduct industry-related applied research and develop technologies up to the pilot production stage. We would argue that similar institutes are required in Thailand to enhance level 2 activities in industry.

Finally, it is clear that existing S&T information centers cannot adequately describe either the R&D being conducted in this country or the technical and consultancy resources that are available in universities. It is ironic that present initiatives to promote S&T information are focused on foreign technical services and R&D conducted abroad, while such details are not yet available for Thailand. There is strong evidence showing that companies would not only welcome the provision of better information on R&D conducted in the Thai public sector and the S&T services available, but that they would also appreciate increased opportunities to utilize domestic S&T facilities.

Constraints Due to Inadequate Human Resources

The shortage of S&T manpower poses the most serious bottleneck for the further industrial and economic development of Thailand. Companies continually report difficulties in recruiting suitable staff, a demand for high salaries, and rapid turnover of staff. At the same time, government agencies and universities are losing S&T staff, with little prospect of filling the vacant positions.

As technology activities in most Thai companies do not yet extend beyond level 1, the immediate need is therefore for increased numbers of engineering graduates. A production increase of 15-20 percent annually is thought to be necessary. However, as technology activities shift from level 1 to level 2, there will also be a need for a different kind of training to produce engineers and scientists better equipped to undertake industrial R&D.

POSSIBLE AREAS FOR COOPERATION BETWEEN THAILAND AND THE EC

In conclusion, we would argue that there are two main constraints to strengthening R&D in Thailand. On

the one hand, there are prevailing economic conditions and a policy environment which mitigate against industrial innovation; on the other hand, there is an inadequate national infrastructure for S&T. The economic constraints can only be properly addressed by policy initiatives from a Thai government that is committed to taking a strategic, long-term view of industrial development. There is therefore not much scope for collaboration between the EC and Thailand in this domain. By contrast, there are many initiatives that can be undertaken collaboratively which would make a direct impact on improving Thailand's S&T infrastructure in ways that would also benefit the EC. Our suggestions here fall under three categories: a) improving the business infrastructure for technology development, b) strengthening S&T institutions, and c) improving the manpower supply.

COOPERATION TO IMPROVE THE BUSINESS INFRASTRUCTURE FOR TECHNOLOGY DEVELOPMENT

With the expansion of Thai industry, it is becoming apparent that manufacturing companies do not have enough suppliers of the raw materials, value-added services, or intermediate goods (molds, dies, precision plastic/metal parts) to support even their most basic (level 1) technology activities.

One way of overcoming this would be to first establish an EC- sponsored organization that identifies existing and potential vendors of technical supplies. Assistance for these vendors to upgrade technically could then be provided by organizations in the EC. And, where it is not possible to elevate the capabilities of existing vendors or where vendors of certain equipment/services do not exist in Thailand, European companies could be identified and assume the role of suppliers in Thailand. These could provide the necessary equipment/services through joint venture partners or by establishing Thai-based subsidiaries.

COOPERATION TO STRENGTHEN THE INSTITUTIONAL INFRASTRUCTURE FOR S&T

As previously outlined, the institutional base for supporting technology development in Thailand is extremely poor. Technical consultancy services are badly organized and have no solid institutional base; industrial standards and testing services are scattered and ineffective, and organizations providing S&T information services are not sufficiently geared toward the needs of industry. These are all areas in which collaboration with the EC would be mutually beneficial, as suggested below.

Industrial Extension and Technical Consultancy

Many manufacturing companies in Thailand are simply not aware of the benefits that appropriate technology can bring in improving production efficiency and diversifying products. 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 the demand and utilization of technology in Thai industry.

One option might be to establish a pro-active industrial extension service that 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 level 1 activities—i.e., 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-sized 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. In certain cases, it would clearly be appropriate to involve European consultants, thus providing business opportunities for companies in the EC.

Thailand's Science and Technology Development Board (STDB) has recently established a "Technical Service Center for Industry" (TSCI), which will fulfill many of the functions of an industrial extension service. This is a move in the right direction, but TSCI is a temporary organization that will exist for only three years. The total number of consultancy contracts that TSCI is required to undertake during this time is only 175, which is unlikely to make a large impact on the overall technological capability of Thai industry (which has tens of thousands of small- and medium-sized companies).

Our suggestion is that a more permanent industrial extension service could be established and operated on a larger scale, arranging several hundred consultancy contracts a year. It could either be established as a private company, an autonomous organization under the Ministry of Science, Technology and Energy (MOSTE), or as a statutory body. Whatever the structure, it is likely that the income generated from client fees will have to be subsidized, at least in the early stages, by the Thai government or from overseas aid. The EC may consider such direct support. And, in addition to direct funding, the EC may also consider subsidizing European consultants in Thailand through the proposed industrial extension service.

Industrial Standards Testing and Calibration Services

As Thailand industrializes, the need for an effective industrial standards system cannot be overemphasized. The present system is judged by many manufacturers to be inadequate, due to excessive delays in product testing and insufficient coverage of products. Of special concern are the needs of export companies that have to test products according to specifications of client countries in Europe, the United States, and Japan.

The need for a reliable and efficient industrial testing and calibration service is now recognized in some areas of the Thai public sector, and foreign aid funds have been sought and obtained from the Japanese government, which is providing over US$50 million for an appropriate organization to be established in Thailand. This new testing and calibration facility will be operated by the Thailand Institute for Science and Technology Research (TISTR) and the Thai Industrial Standards Institute (TISI). However, in order for the center to be effective, it must obtain accreditation from the technical standards authorities of major client countries. The EC could take a lead here in ensuring that the facility will receive accreditation according to standards laid down by member countries. This will provide a valuable service to Thai industrial development and ease channels of trade with Europe.

S&T Information

At present, there is no comprehensive directory of current scientific and technological research being undertaken in Thai public-sector institutions. Some universities produce indexes of researchers and publications, but these lists are often incomplete and out-of-date. This makes it very difficult for companies to identify local expertise or technical resources to support their level 2 activities. And as level 3 activities develop in Thailand, there are signs that local and foreign companies will increasingly wish to engage in collaborative research with universities to develop academic concepts through to new products. Again, information on the achievements and research outputs of universities is required, but at present this is relatively inaccessible and uncomprehensive.

The EC could provide assistance here by supporting the development of databases on Thai S&T. These would consist of details of all Thai scientists and technologists working in public sector research institutions (including the universities and TISTR), focusing on their expertise and the services they could provide to industry. Added to this could be information describing the outputs of Thai S&T, to include all published material (papers in journals, technical reports, conference papers, etc.) and non-published items (such as engineering designs, technical specifications, patents, software, etc.).

Together, such systematized information would permit analysis of areas of weakness and strength in Thai S&T and trends in S&T activity within individual institutes and the technology sector. As well as providing the basis for a national management information system in Thai government S&T agencies, the development of databases on S&T inputs and outputs would also provide European companies with useful

intelligence on Thai R&D capabilities.

In addition, a flow of information in the reverse direction would also be mutually beneficial. Here, it would be valuable for Thai companies and universities to have better access to information on S&T training opportunities in European institutions.

COOPERATION TO IMPROVE HUMAN RESOURCES IN S&T

Thailand urgently needs an improved supply of S&T manpower at all three levels of technological activity in industry. At level 1, it is necessary to increase the numbers of engineers graduating each year to satisfy the demand from industry for manpower able to supervise the acquisition, implementation and operation of industrial technology. At level 2, there is a need for more advanced training in engineering to enhance domestic capabilities in industrial R&D. At level 3, it will be necessary in the longer term to strengthen the capability of the academic community to undertake fundamental research in S&T. Developments at levels 2 and 3 are particularly amenable to assistance through international cooperation. These will now be considered in turn.

Graduate Engineering Training—Level 2

One of the key deficiencies constraining industrial R&D in Thailand is the undersupply of engineers who have received the postgraduate training necessary for them to be capable of effectively initiating and undertaking research programs. One way of helping to correct this would be to establish one or more graduate engineering schools in Thailand. These could be established as joint-ventures between European universities and any Thai organization (university or otherwise) able to provide facilities and staff backup. The Sasin Graduate Institute of Business Administration, a joint program between Chulalongkorn University and two American management schools, is one example that could serve as a model.

The EC could act as a broker in establishing such schools by (a) identifying interested universities in Europe, (b) soliciting and screening applications for a joint venture from potential Thai partners, (c) sponsoring meetings and study tours of European and Thai academic institutions, and (d) providing the seed money to help establish the joint ventures. Like Sasin, the proposed graduate school could eventually be self-supporting.

The current and expected high growth of private industries should guarantee that the proposed engineering school would be economically viable in both the short- and long-terms. The school would undoubtedly make a long-lasting impact on the academic engineering community and private industry by increasing the number of highly trained engineers in the country. This would be achievable at present only through the involvement of foreign university teachers, as the number of qualified engineering lecturers in Thailand is presently inadequate to support a new graduate school.

Training in Advanced Technology - Level 2

There is currently a high demand for in-service (level 2) training in industrial technology, and the main source of supply here is through short courses provided by the Technological Promotion Association (TPA). Some universities also run a number of extension or continuing education courses.

Not included, however, are courses that provide training in the techniques of advanced engineering, such as computer-aided design (CAD) for new products and training facilities for R&D management. It would therefore be desirable to establish an advanced training organization, possibly supported by an endowment fund or membership charges to participant companies. This organization should aim to diagnose professional technology training needs at the levels of individuals and companies, act as a broker for training services using both local and European resources and, where necessary, prepare and deliver courses. The involvement of the EC here would provide valuable access to European teaching materials and resources and help to promote business opportunities for European-based training consultants.

Academic S&T Research - Level 3

In the longer term, improvement in the technological capabilities of Thailand will depend to an extent on the strength of the local science base. The kind of basic and strategic research undertaken in academic institutions anywhere is often driven by curiosity alone and has little direct relevance to the problems of industry. However, the benefits of such work are diffuse and profound. It supplies the knowledge base and intellectual capital necessary for participating in the international S&T community. In particular, academic science generates an endemic capability to evaluate and absorb ideas and innovations in high technology emerging from other countries. More directly, academic science can also give rise to knowledge that underpins local technological innovations and can provide high calibre training for original and innovative minds.

Despite strengths in certain areas of basic and strategic science—notably, some life sciences and biotechnology—Thailand's overall academic science base is still very weak. This could be strengthened through increased cooperation between academic institutions in Europe and Thailand. Besides conventional exchange programs for academic staff, the EC could consider funding a few key centers of excellence in Thai academic institutions to act as nucleating points for the development of research groups in areas of strategic scientific interest to both Thailand and EC member countries. These centers would require funds for senior staff (European or Thai scientists) to lead research programs and provide the structured opportunities for promotion that are necessary to attract junior scientists into a research career. Besides the obvious benefits for Thailand, such assistance from the EC could also provide a means for European scientists to tap into certain rich areas of Thai science, create new research opportunities, and strengthen cultural links between the two regions.
