

THE SCIENCE AND TECHNOLOGY SYSTEM OF THE KINGDOM OF THAILAND

Introduction

In Asia, unlike other countries, Thailand was not under colonial rule. With origins in Chinese culture, Thailand adopted Brahmanic system of justice and Theravada Buddhism as its state religion. The country was ruled by several Kings and Kingdoms. The history of modern science in Thailand can be traced to the ascendance to throne of King Mongkut of Chakri dynasty in 1851; and his successor King Chulalongkorn. The latter was the first King to travel to European countries and the first to send royal family members and others to study and draw western educational experiences from Europe. He founded the first Thai university, Chulalongkorn University in 1916. However, the first modern science related institutions were established in the late 19th Century beginning with Paetyakorn Medical School in 1889; Law School in 1897; Royal Pages School for administrators in 1902 on the lines of the French Gandes Ecoles (Davis et al 1997). The European influence continued into the 20th Century, mainly from 1940s when the country embarked on building modern higher educational and S&T institutions.

1. Development of S&T Policy Institutions

One of the first institutions to be set up related to S&T was the National Research Council, which was established in 1956. This organization had the responsibility to fund university research and coordinate public and private research programmes, and tendering advice to the government on S&T priorities. The second important event was the establishment of a Ministry of Science and Technology and Environment (MOSTE) in 1979. The third important event was the creation of the National Science and Technology Agency (NSTDA) in 1991 with the objective to give a boost to S&T for development.

Science and Technology institution building as part of the S&T policies in Thailand is closely associated with the national development plans of four years duration. This process began in 1961. S&T did not receive much attention in the national development plans until about the Fourth Plan. It was only in Fifth Plan (1982-86) that the government had a chapter on S&T for development. This exercise was continued in the subsequent national development plans. Among these S&T chapters in national development plans, the Seventh Plan (1992-97) is



somewhat significant for three reasons: a) For the first time the government declared to raise the GERD/GDP ratio to 0.75%; b) The beginning of a sectoral approach to technology development was advocated; and c) A range of innovation policy instruments and incentives were initiated. As noted earlier, NSTDA was also established during this planning period. This is the leading agency for S&T policy in Thailand. As early as 1990, three important departments of NSTDA, namely, a) Science, Technology and Energy Policy and Planning; b) Technology Transfer Centre; c) and Science and Technology Development Board (STDB) – were created to promote S&T generation, dissemination, and commercialization of technology.

However, the S&T developments since the 1990s up to the present government of Prime Minister Thaksin Shinawatra (starting January 2001), are viewed as rather narrow by some scholars (see Intarakumnerd, et al., 2002). The policies are said to have covered only four conventional functions, namely, research and development, human resource development, technology transfer, and S&T infrastructure development. Even though innovation policy mechanisms were initiated as early as 1990s, they did not have any practical or functional relevance. Unlike Japan, Korea, and Taiwan, S&T elements were seen as not being part of broader economic policies namely, industrial policy, investment policy and trade policy and, to the lesser extent, education policies.

Thai economic structure has also changed from an agriculture-based economy to an economy in which the industrial (manufacturing in particular) sector has gained distinctive significance. The share of the agriculture sector in GDP has reduced remarkably from almost 40% in the 1960s to approximately 10% in the late 1990s, while that of the industrial sector experienced exactly the reverse situation. Interestingly, there was a change in the composition of Thai exports along the line of other countries in the ASEAN region. The share of once-dominated resource based and labour-intensive exports has gone down while that of high technology-based and differentiated exports has gone up especially in the 1990s. Nonetheless, one cannot argue that Thai exports have turned to be more technological intensive, as the dividing categories do not reflect the sophistication of technological activities requiring to produce goods, for example, those categorised as high technology-based exports might be only assembled locally, while their technologically sophisticated and high-value-added components are imported. However, this trend suggests a general change in the structure of the Thai economy.

The major shift in policy regime came recently under the present Thaksin government. Media and academics in Thailand and the Southeast Asia labelled this government distinctive policy as “Thaksinomics” or Thaksin’s Economics (TIME Asia Magazine, Oct. 27, 2003). Thaksinomics is a concept of examining an economy holistically. From Thaksinomics’s perspective, an economy like Thailand is seen from two perspectives. The upper part is a well-developed capitalistic economy and should be able to compete internationally. This part should be developed along the line of ‘capitalism’. The lower part of a developing economy is much weaker. It is the part of grass-root and rural economy. It is the part that has many people living under poverty and government should apply a certain degree of ‘socialism’ to take care of them (Pornawilai, 2004: 32). Dual track policy is, therefore, the main thrust of Thaksinomics.

The new ten-year Science and Technology Action Plan (2004-2013) places the concept of national innovation systems and industrial clusters at its heart. The main objectives of the plan are to enhance Thailand’s capabilities in response to rapid changes in the age of globalization and to strengthen the country’s long-term competitiveness under the vision that “the Thai economy will be strong, the Thai knowledge-based society will be able to compete internationally, the Thai nation will be secure, and Thai people will have a good quality of life.”

In driving toward the goals of the vision, four fundamental factors for development are emphasized:

- (1) the strength of the national innovation system
- (2) the strength of human resources
- (3) the encouraging environment for development, and
- (4) the capacities of four core technologies for the future, i.e., information and communications technology, biotechnology, material technology and nanotechnology.

The scope of the plan is said to be much broader than the aforementioned four functional areas. As (Intarakumnerd (2005) noted, measures to stimulate innovations and to strengthen national innovation system and industrial clusters are explicitly highlighted. Targeted clusters, more or less identical to those identified by the government, in the plan are food, automotive, textiles, software, microelectronics, tourism, life science, and community (grass-root) products. A responsible authority, which will act as a cluster development agent, has been assigned to facilitate cooperation among actors in each cluster. Although it is too early to evaluate the effects of the plan on the enhancement of Thailand's technological and innovative capability, this is considered as a major change in the scope and main thrust of science and technology policy in Thailand currently. Thailand's national innovation system is in transition. It is gradually evolving from a "weak and fragmented" system toward a "stronger and more synergistic" one. The transformation is slow and difficult. While signs of change in the government and significant numbers of private firms are noticeable, other key players, especially the universities, appear to be reacting more slowly. Overall, more time is required to judge whether these changes are adequate to have a significant impact on Thailand's innovation capabilities and competitiveness, both within the country and in comparison with her major competitors.

1.1 *Information Technology Policy*

In February 1996, the first National IT Policy, called **IT2000**, was announced by the Thai government. IT2000 put forward the vision for the country to exploit IT to achieve economic prosperity and social equity. To this end, the policy emphasized three common development agendas, namely:

- (i) to build an equitable national information infrastructure;
- (ii) to invest in people to accelerate the supply of IT manpower and to develop an IT-literate workforce; and
- (iii) to achieve good governance through the use of IT in delivering public services and in government administration.

In bringing such policy to implementation, each government agency developed its own master plan to correspond with the direction set forth in IT2000.

In 2002, the IT2000 was revised and *IT2010: Towards the Knowledge-Based Economy*, policy was issued by the government. The government issued a call to improve the quality of life of its population through knowledge and promote self-reliance and to reduce social differences to a minimum. To this end, IT2010 identifies three cross-cutting principles to support the "ICT for KBE/KBS":

- a) Building human capital;
- b) Promote innovation; and
- c) Invest in information infrastructure and promote the information industry.
(www.nectec.or.th/users/htk/publish/20020302-National-ICT-Policy-v16.doc)

2. Organization of S&T Institutions

The organization structure of S&T institutions and S&T policy structure is shown in Figure 1. Within the overall system, the different policy-related functions are distinguished as follows: Level 1: Policy formulation at a national level, cutting across the policy responsibilities of different line-ministries and other government agencies. Level 2: Policy formulation and development at the ministerial level – concerned with developing and articulating policy designed to meet ministry missions and mandates. Level 3: Policy implementation – concerned with managing and funding the delivery of programmes and activities intended to achieve the policy aims of ministries and departments. Functions at this level are sometimes further sub-divided – for instance between those concerned with (a) research and new knowledge production, (b) technology development, and (c) the support of business enterprises in developing innovation capabilities and in acquiring, using and applying knowledge and skills.

Moving on to “Horizontal” issues, it is quite evident that vertical ministerial entities typically operate independently, although some crosscutting policy and planning bodies already exist (such as NESDB, NSTC, MOST, NRCT and NSTDA). In particular, a number of the research funding bodies already have crosscutting roles (such as NRCT, TRF and NSTDA), although their influence on the core activities of the major ministries carrying out ST&I functions remained limited.

Figure 1: Organisational Structure of S&T in Thailand

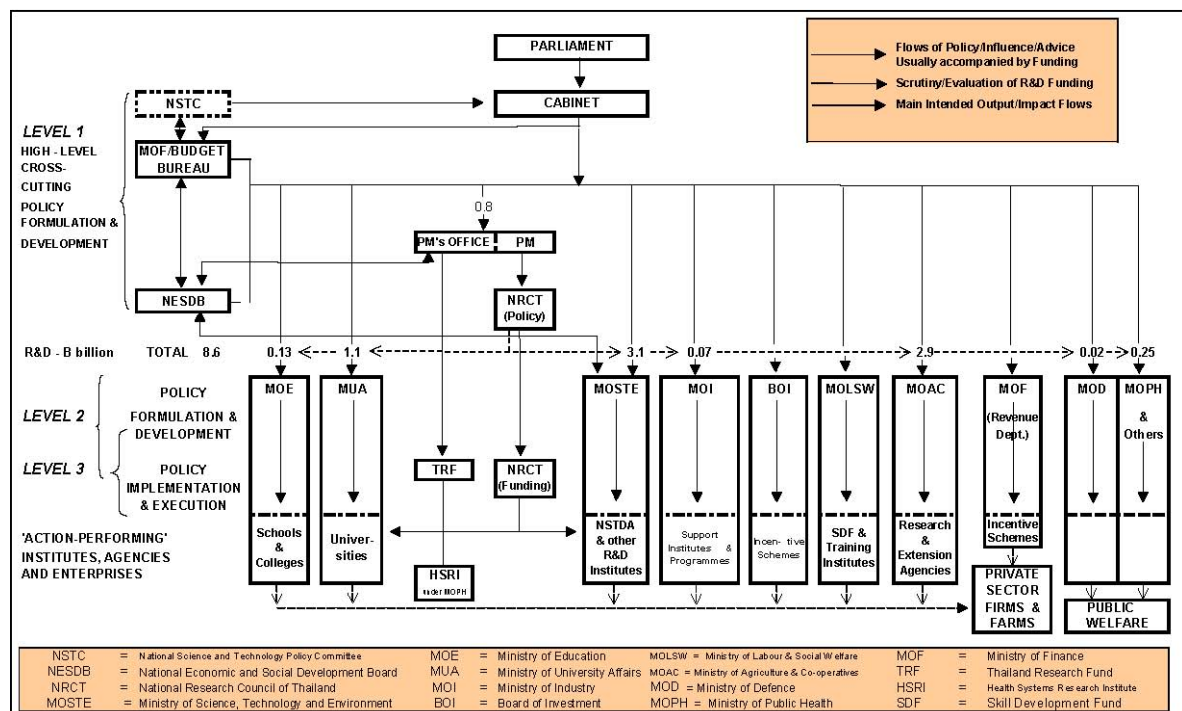


Table1: R&D Expenditure Trends 1999-2002 in Thailand (million Baht)

	1999	2000	2001	2002
GERD	11896	12406	13485	13302
Public	6342	8087	8202	8138
Private	5554	4319	5283	5164
GERD/GDP	0.26%	0.25%	0.26%	0.24%

2.1 R&D Budget Trends

Gross expenditure on R&D (GERD) as proportion of GDP increased from 0.21% in 1987 to about 0.26% in 2002 (see Table 1) which is quite low compared to neighbouring dynamic economies of Asia, namely, South Korea, Taiwan, Singapore and even Malaysia. While the government spends about 60%, the private sector accounts for 40%.

2.2 Higher Educational Sector and Human Resources in S&T Universities

The higher education system in Thailand began with the creation of a law school in 1887, soon followed by a medical school, the Royal Pages' School for training in government administration and an engineering school. These schools were combined to form a university in 1916, which represented Thailand's first university, the Chulalongkorn University. The main objective in the creation of the university was the importation of knowledge from western countries for the modernization of Thailand. Chulalongkorn University remained the only university until 1934 when Thammasart University was established. Thammasart was founded in 1932 with the aim of educating a large number of people in the moral and political sciences. In the 1960s and 1970s, there was quantitative expansion to serve the National Economic and Social Development Plan with the creation of universities in the provinces, as well as vocational, agricultural and teacher training colleges.

Later on, more universities were founded, each specializing in a specific field. Silpakorn University in Fine Arts, Kasetsart University in agriculture, and the University of Medical Sciences (now Mahidol University). This has been the case until the 1960s, when new comprehensive universities were founded: Chiangmai University, Khonkhaen University, and Prince of Songkhla University. During the same period, the traditional one-field universities began to expand to offer degrees in other fields. Also in that same decade, three technical colleges at Thonburi, North Bangkok and Ladkrabang were merged into one, and upgraded to a higher educational institute, the King Mongkut's Institute of Technology (<http://www.transworldeducation.com/articles/thailand2.htm>). The Private College Act of 1969 enabled the elevation of private institutions to degree-granting level. After a number of student uprisings and increased demand for higher education, two open universities were established in 1979 and 1981.

Then in the 1980s, the shortage of engineers was so acute that other universities began programs in engineering and technology, new public universities were set up, and several private colleges were upgraded to universities. In addition to institutions under the Ministry of University Affairs (MoUA), technical colleges were combined as Rajamangala Institute of Technology, and teacher-training colleges were combined as Rajabhat Institute, both of which offer baccalaureate programs. In the 1990s, there was a movement of establishing the so-called international programs, in which English is used as the medium of instruction. There was also a wave of establishing 'special programs' in engineering, providing classes outside the traditional hours to boost the number of engineering graduates. (<http://www.transworldeducation.com/articles/thailand2.htm>).

Students in the higher education system increased from merely 69,000 in 1970 to almost 800,000 students in 1984. As Table 2 shows, the number of students increased to 196000 in 1990 and 393000 in 2002. Provision of higher education by private sector and foreigners has been allowed since 1965 and at the beginning, colleges were established. The first 4 degree-granting private universities were operating in 1984. It has since been rapidly expanding. The National Education Act of 1999 outlined major structural changes including the amalgamation of the Ministry of Education and the Ministry of Higher Education. The higher education system is supervised by the new Higher Education Commission. More autonomy is given to the universities, institutes and colleges, which are assuming the legal entity governed by their own board.

Currently there are about 20 public universities and 33 private universities under the MoUA. Some public universities have set up self-supporting semi-autonomous units, such as Sirindhorn International Institute of Technology (SIIT) of Thammasat University, and Sasin of Chulalongkorn University. Due to the economic crisis of 1997-98, in order to improve the efficiency of the public sector, the government has set up a policy to move public universities out of the bureaucratic system. The majority of budget is still supported by the government, but in the form of block grant, not as line-item budget, as is currently the case. University employees will no longer be government officials (<http://www.transworldeducation.com/articles/thailand2.htm>).

Table 2: Number of Higher Education Institutions and student enrolment 2004

Type of Higher Education Institutions	1990	1998	2004
Public	17	24	-
Private	16	42	-
Total no Institutions	43	66	120
No of Students	196000	350000	393000*

For 2002 figure: Source: Charas Suwanwela, Chulalongkorn University, Bangkok, Thailand, 2004

Before 2003, the higher education system came under the responsibility of two ministries (Ministry of University Affairs, Ministry of Education) and one agency (Office of the National Education Commission). Since 2003, they are amalgamated into a single Ministry of Education. The Thai education system is composed of both public and private institutions. Some Thai public institutions have recently been transformed into autonomous universities. At present, provision of higher education in Thailand in 2003 is mainly under the responsibility of the Ministry of Education, with other ministries and agencies participating through provision of specialized education.

In 2002, a budgetary allocation of Baht 32,005 million was provided to public higher education institutions, representing 14.4% of the total national education budget. Besides, the state has allocated a research grant of approximately Baht 2,414 million to higher education institutions through the Office of Higher Education Commission, Ministry of Education in 2003. List of leading universities in Thailand and students and faculty in higher education is shown Tables 3 & 4. The number of faculty and students are given in these tables only for these selected institutions. However, the Table 5 shows the total number of graduates and postgraduates in different disciplines in the country in 2002. Further, the Table 6 indicates the break up of institutions and students in different types of higher educational sector consisting of private, state and public universities etc.

Table 3: A List of leading Universities and RTOs Specialised in S&T in Thailand

University	Year of establishment	Number of graduate students in S&T in 2001			Number of professors or researchers with a PhD in 2001
		Bachelors	Masters	PhD	
Chulalongkorn University	1899	4,396	2,687	66	211
Thammasat University	1934	3,938	1,361	3	34
Kasetsart University	1938	4,458	1,759	6	27
King Mongkut's Institute of Technology North Bangkok	1959	2,259	261	3	6
Mahidol University	1969	4,321	1,242	403	285
King Mongkut's Institute of Technology Ladkrabang	1971	3,018	587	1	6
Suranari University of Technology	1984	1,019	20	1	-
Mahanakorn University of Technology	1990	2,337	4	-	-
King Mongkut's University of Technology Thonburi	1996	1,711	532	7	6
National Science and Technology Development Agency	1991	-	-	-	212

Source: Ministry of Education

Table 4: Number of Faculty Members in the Main Universities of Thailand 2002

University	Year of Establishment	Natural Sciences	Engineering	Medical Science	Agriculture	Social Sciences
Chulalongkorn University	1899	383	356	824	0	922
Thammasat University	1934	147	85	184	0	576
Kasetsart University	1938	232	256	100	400	694
King Mongkut's Institute of Technology North Bangkok	1959	117	153	0	0	122
Mahidol University	1969	296	59	1836	0	122
King Mongkut's Institute of Technology Ladkrabang	1971	137	374	0	122	99
Suranari University of Technology	1984	na	na	na	na	na
Mahanakorn University of Technology	1990		-	-	-	-
King Mongkut's University of Technology Thonburi	1996	81	106	na	na	31

Table 5: Number of Graduates and Postgraduates across Disciplines, 2002

Disciplines	Graduates	Postgraduates
Natural Sciences	11980	2564
Engineering Sciences	27430	2633
Medical Sciences	17860	3548
Agriculture Sciences	14640	1340
Social Sciences	210923	20349

Source: Commission of Higher Education, 2004

Table 6: Salient Statistics on Higher Education Systems in Thailand, 2001

Limited Access	State affiliated	Open access	Rajabhat	Rajamonkol	Private Universities	Public Vocational	Private Vocational	Total
No of higher education institutions	18	4	2	41	35	51	341	782
No of students	292951	18419	644389	476733	88838	223810	197658	182214
Below bachelor	1777	--	16371					
Bachelor	212475	14759	607044					
Postgraduate	78699	3660	20974					
Ration of 2.1/2.2/2.3	1/72/27	0/80/20	3/94/3					
No of instructors	19527	650	1173					
Ration of students: instructors	15/1	28/1	549/1					

Source: Boonserm et al (2003)

Some of the other features of Thai higher education system are as follows according to NESDB and the World Bank (1998).

- At the level of bachelor degree, Thailand has shortages of S&T work force in almost all areas, especially in the engineering disciplines. The proportion of graduates in sciences and engineering to social sciences graduates remains consistently low at around 30:70 (32:68 in the year 2000).
- The situation in postgraduate studies is even worse. The proportion of graduates in science and engineering to those in social science actually decreased from 27:73 in 1990 to 19:81 in 2000. The total number of graduates with doctoral degrees is dismally low for a country of 65 million, namely 464 people, with only nine in engineering, in 2000.
- For vocational work force, shortages exist in certain specific areas, but the general assessment is one of over-supply. Since the late 1970s and early 1980s, the number of vocational students in Thailand rose dramatically. By 1992, there were over 400,000 vocational students. Yet, many of them remained unemployed, suggesting a disconnection between firm needs and vocational school's supply (Ritchie, 2001).

Weak University-Industry Linkages

Thai universities have rather poor research capability and most of their research has a low level of industrial relevance. Linkages between university and industry are based on personal connections between individual researchers and companies rather than organizational commitments. Development of long-term and formal links is still at early stage. Most university-industry links represent short-term training or ad-hoc use of consulting or research activities rather than longer-term, more extensive relationship. The range of activities and

mechanisms remains rather limited in terms of both nature and depth of activities, and institutional sophistication of mechanisms (Brooker Group, 1995: 19).

Main S&T Organisations in the Public Sector

The National Science and Technology Development Agency (NSTDA) is the Thai government's important actor to mobilise scientific and technological capabilities to promote and sustain the nation's economic, social development and growth through the promotion of linkage and collaboration between the public and private sectors. Since its inception in 1991, NSTDA has grown into an active organization with a diverse program focusing on cutting-edge S&T research, design, development and engineering. NSTDA offers a full potential and opportunity for cooperative challenges and investment. Through such a convergence, the organization brings a layered, multi-faceted approach to the scholarly and most practical description of scientific and technological discoveries and advancement to serve national needs and maintain a sustained linkage with the international community.

Thailand is strengthening its technological capabilities in three areas: genetic engineering and biotechnology, metallurgy and material science, electronics and computer. These centres are mainly responsible for developing technological capabilities and have actively operated the activities as well as coordinated with the advanced countries in these new emerging technological aspects.

National Nanotechnology Centre (NANOTEC)

This is an autonomous agency under the umbrella of NSTDA, Ministry of Science and Technology. The main objective of this Centre is to create "micro- and nanotechnologies" that would enrich Thai industries, protect the environment and give rise to niche innovative products, processes, and competitiveness in the global market. The main mission of this Centre is as follows:

- Prepare National Nanotechnology Road Map.
- Act as a national coordinating body between academia, industry and government, and promote inter-linkage.
- Set up collaborative network by assembling a critical mass of high-calibre researchers and educators on nanotechnology.
- Identify and focus on niche areas and products in nanotechnology, thus enhancing Thailand's competitiveness.
- Disseminate knowledge and transfer nanotechnology to industrial and governmental sectors and carry out research in certain core or common areas in nanotechnology.

National Centre for Genetic Engineering and Biotechnology (BIOTEC)

Recognizing the potentials of biotechnology to the government in 1983 established BIOTEC and the launched the Science and Technology Development Board (STDB) in 1985. The Centre, originally known as NCGEB, was first set up under the Ministry for Science, Technology and Energy on 20 September 1983. After the establishment of the National Science and Technology Development Agency (NSTDA) on 30 December 1991, BIOTEC became one of the NSTDA centres, operating outside the normal framework of civil service and state enterprises. This enabled the Centre to operate more effectively to support and transfer technology for the development of industry, agriculture, natural resources, environment and consequently the social and economic well-being of Thai people. The main objectives of BIOTEC are to induce dynamics in research, development and application of biotechnology in order to support technology development and adoption in both public and private institutions. (<http://www.biotec.or.th/biotechnology-en/about-BIOTEC.asp>).

In FY 2005, BIOTEC's operational budget was USD 18.48 million, which was sourced from government direct funding, revenue from providing services and commercial projects, as well as competitive grants from both national and international sources. USD 16.37 million was devoted to R&D funds, which encompass research grants, human resource development, technology transfer and infrastructure development.

National Electronics and Computer Technology Centre (NECTEC)

This Centre was founded on 16th September 1986 as a project under the Ministry of Science, Technology, and Environment (MOSTE). On December 30th 1991, NECTEC underwent a transition from being a non-statutory agency to become a specialised national centre under NSTDA. (<http://ntl.nectec.or.th/nectec/>)

The Science and Technology Park

This Project was approved by the government in 1989. MOSTE signed a contract with the Asian Institute of technology (AIT) and Thammasart University to conduct the feasibility study aiming to establish S&T Park in Thailand. This park is regarded as the complex centre of R&D institutions, which are facilitated with equipment and services in support of R&D undertaking. The aim of the park is to catalyze the cooperation between government sectors, private sectors and research institutes in order to conduct research and development in strengthening S&T capability for commercialization both in agricultural and industrial sectors.

Thailand Institute of Scientific and Technological Research (TISTR)

With the aid of the United Nations, the plan for developing a research institute in Thailand was hatched from the study of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia. The Applied Scientific Research Corporation of Thailand was founded with both the government and UN funding in 1963 and later changed the name to Thailand Institute of Scientific and Technological Research. As the country's first research agency, Thailand Institute of Scientific and Technological Research was established to promote government's vision to advance scientific and technological expertise. TISTR is a non-profit state enterprise under the umbrella of the Ministry of Science and Technology. At TISTR, a diverse range of research from agricultural technology, biotechnology to materials technology is generated to cover areas to improve the economy and the community.

TISTR has the responsibility for conducting research and providing services to state agencies and private enterprises and for "propagating the results of scientific and technological research to benefit the country in agriculture, industry and commerce" (TISTR, 1985). In attempting to perform these tasks, as well as to provide a wide range of packaging, testing, computer, and other support services, TISTR has probably been the most important institution in the field of technology commercialization. In order to achieve this goal TISTR has been actively examining ways and means to transfer their results to private use for the last three years and are fully committed to the idea of commercialization. TISTR has undertaken the following related activities to develop outlets for the commercialization attempts: (http://www.stepan.org/india/22paper_luangwatanakit.doc).

- Stepped up their efforts to cooperate and coordinate their own research efforts with universities and other research institutes.
- Attempted to develop better links with important players in the private sector through participating in Board of Investment regional seminars, attending meetings held by local chambers of commerce and the Federation of Thai Industries, and contacting provincial governors to identify possibilities for commercialization of rural, small-scale technologies.
- Acting as a transfer agent to purchase, modify, and package technology from abroad on behalf of or to sell to local companies (in this activity, they have been cooperating with the Korean Advanced Institute of Science and Technology (KAIST)).

- Making very specific contacts through informal channels with knowledgeable executives, financiers, and "deal-makers" in an attempt to obtain a better private sector perspective on opportunities and the best ways to exploit them.

R&D Output

The Table 7 shows the R&D output of Thailand for three years from 2002 to 2004. Table 8 shows the science publications of Thailand from 1998 to 2005 in comparison to a select group of Asian countries. As this Table shows, Thailand science publications at the international level more than doubled during 1998 and 2005.

Table7: R&D Output of Thailand 2002-2004

R&D Output	2002	2003	2004
Publications	562	785	858
Citations	686	714	783
Patents	18	15	38
Prototypes	94	210	182

Table8: Publication Profiles of Selected Countries in the Asian Region

Country	1998	1999	2000	2001	2002	2003	2004	2005
Malaysia	798	869	814	922	934	1171	1254	1,586
Mongolia	34	38	45	39	41	105	97	54
Pakistan	601	577	596	531	691	763	903	1,060
Philippines	311	344	351	315	410	440	424	486
Singapore	2490	3046	3392	3802	4238	4846	5109	5,419
Sri Lanka	124	168	167	157	176	264	226	290
Taiwan	8745	9152	9346	10780	11011	12675	13146	14,057
Thailand	935	1043	1185	1331	1591	2048	2047	2,543
Vietnam	239	249	322	356	346	497	412	573

Source: Web of Science, SCI database

Concluding Remarks

Thailand is evolving a national innovation system and the government is making considerable efforts in bringing together various actors to interact. Whilst the government is serious in its S&T policy discourse to induce the systemic basis of innovation in the national S&T system, the government has not devoted appropriate R&D funding that is desirable for creating an innovation system. The current GERD/GDP ratio of 0.24% in 2002 is quite low compared to South Korea, Malaysia and Singapore and other countries. Almost all the high technology projects under the national centres of NSTDA on nanotechnology, bio and genetic

engineering, material science and electronics are becoming science intensive requiring huge investments for evolving 'minimum level' of technological capabilities. The most ambitious objectives of Thai government to build knowledge based society and systemic based innovation demands the increase of GERD/GDP ratio to at least 0.6% to 1.0% in the coming three years. In the absence of this R&D expenditure, various S&T policy planks and actors in the innovation system will remain disparate.

