International Science and Technology Cooperation Policies of South East Asian Countries

Consultation Paper Prepared for the EU Commission on the Occasion of the First Bi-Regional Science & Technology Policy Dialogue, EU-ASEAN, 19-20 November 2008, Paris

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Hamburg, Vienna and Amsterdam, October 2008

Executive Summary

General findings:

- South East Asia (SEA) is a region in transition, consisting of countries with huge differences in the degree of economic and scientific development. While some countries already belong to the front-runners of science and technology (S&T), others are rapidly catching up, leaving others behind.
- The importance of historical S&T ties, usually based on the colonial past, is rapidly diminishing.
- Leading global technology powers (for example, the US and Japan) and new emerging ones (such as China) are actively engaged in fostering new cooperation with ASEAN (Association of South East Asian Nations).
- In ASEAN's competitive S&T arena, countries that want to be at the forefront of S&T competition have to tackle the issues of brain gain and brain drain.
- Whilst most countries have a broad research agenda comparable to other countries in the world, each ASEAN country has its own appropriate thematic niche priority areas.

Findings related to ASEAN-5 member states' policies on international S&T cooperation:

- An institutional framework for international S&T cooperation can be found at the super-level of ASEAN, even though the countries themselves are free to pursue their own interests.
- While the individual ASEAN-5 countries have no official, published policies on international S&T-strategy, this issue has gained a lot of importance in recent years as countries have tried to position themselves regionally and globally as competitive players.
- As the global integration of the ASEAN-5 countries has become stronger, their choice of international cooperation partners has diversified.
- In international S&T collaboration ASEAN-5 policy makers and scientists strive for those cooperation partners with a leading global position in specific research fields.
- International S&T cooperation is in some ASEAN-5 member countries still strongly related to foreign policy issues.

Findings related to the view of ASEAN-5 scientists on international cooperation:

- Scientists in ASEAN-5 tend to pursue their own academic agenda in order to join international networks more or less regardless of official policy preferences.
- Due to the lack of information on international funding possibilities and lack of access to scientific networks, scientists in less developed ASEAN-5 countries often rely on established contacts with former colleagues and supervisors abroad.
- Personal contacts, as an important trust-building measure, frequently play a crucial role in establishing and maintaining scientific networks.
- Scientists find face-to-face monitoring accompanying cooperation projects more helpful than inflexible bureaucratic reporting procedures, which they consider to be a burden and to indicate a lack of trust.
- There is often an asymmetry of interests in international S&T cooperation as ASEAN scientists aim to work in long-term programmes with structural follow-up whereas non-ASEAN scientists tend to see the region as providing opportunities for short-term projects, case studies, and the collection of samples and data.

Introduction[1]

This consultation paper studies the international science and technology (S&T) cooperation policies of the ASEAN (Association of South East Asian Nations) member states. The strong interest of the European Commission (EC) in revitalising the EU's relations with ASEAN forms the strategic background of this paper. In the communication from the commission 'A new partnership with South East Asia' (COM 2003: 399/4) six strategic priorities have been identified. Among them, 'intensifying dialogue and cooperation in specific policy areas' has been listed. Within this strategic priority the dialogue on S&T is seen as an important way of reinvigorating EU relations with South East Asia (SEA) (EC 2003: 4). For both regions S&T represents a key element of sustainable economic growth and competitiveness and is, thus, of common interest. The EU expects that through bilateral S&T dialogue and cooperation and through the participation of SEA's institutes in the European Union (EU) research programmes the collaboration in this very important sectoral area can be expanded to the benefit of both regions (EC 2003: 21).

In this paper the analysis of SEA's international S&T collaboration policies is primarily a descriptive mapping exercise. In order to structure our findings, however, we put the questions of SEA's preferences for specific partners for S&T cooperation and specific research fields into a broader theoretical discussion. This allows us to differentiate between the national S&T policy level on the one hand, and the level of the individual scientists in research institutes and universities who have a different perspective on S&T cooperation on the other.

Section 1 of this paper provides an overview of the theoretical discussion on why countries are engaged in international S&T cooperation and what role the state plays in fostering the catching-up process in S&T. Before studying each country's international S&T policy separately, we provide an overview of the ASEAN's interregional and extra-regional S&T policies. Due to country-specific circumstances, for example, historical heritage, economic system, and the composition of the national innovation system (NIS[2]), the orientation of each ASEAN member country follows a different path. Therefore, Section 2 looks first into the key characteristics of the national S&T systems and policies. Complementary to this overview, based mainly on a review of the literature, we then present our findings about the international S&T policies of five ASEAN member countries which we visited in August/September 2008. The last section offers some final remarks and allows for a short glimpse at the next steps in the analytical work package in the South East Asian INCO-NET (SEA-EU-NET). This EC funded project

> …will increase the quality, quantity, profile and impact of bi-regional Science and Technology (S&T) cooperation between the ten member countries of the Association of South-east Asian Nations (ASEAN) and the Member- and Associated States of the European Union (EU). Excellent S&T is key to achieving sustainable development, prosperity and continued economic growth. It is essential for a strong knowledge-based economy, and underpins the policies necessary for good governance, and contributes to cohesive social visions and models. S&T excellence requires global connectivity and an ongoing dialogue. (www.sea-eu.net)

The findings and data we present in this report come from different sources. Besides those derived from easily accessible books, articles and other published materials with relevance to SEA's international S&T policies, we have collected country-specific data for ASEAN in two ways. First, we used online questionnaires directed at government institutions involved in S&T policy making and at government research institutes (GRIs). These data were then complemented during our fact-finding mission in face-to-face interviews with representatives from those institutions and with individual scientists. We have thus covered the whole range of views of government policy makers, government research institutes, and individual scientists.

The paper concentrates on the international S&T cooperation policies of five ASEAN member countries, currently participating in SEA-EU-NET, namely, Malaysia, Indonesia, Singapore, Thailand, and Vietnam (here called ASEAN-5).[3] We treat SEA countries and the

[1] **Acknowledgement**: We would like to express our thanks to Christopher Tan, Sam Myers, and Johan Stapel, who took part in the fact-finding mission in August/September 2008. Their comments and help throughout the field study in Asia and on this paper were extremely important to us. Special acknowledgement goes also to our ASEAN project partners in Malaysia, Indonesia, Singapore, Thailand, and Vietnam. Without their support this study would not have been possible. Last but not least, we thank all the representatives from governmental institutions and our colleagues from research institutes and universities for their time and effort in answering our online questionnaires and our questions during the field study in their countries.

[2] We use the NIS approach in understanding a national system of innovation as a 'network of institutions in the public and private sectors whose activities and actions initiate, import, modify and diffuse new technologies' (OECD 1994: 3, cited in Bezanson et al. 1999).

[3] ASEAN consists of Brunei, Cambodia, Lao, Malaysia, Myanmar, Indonesia, Singapore, Thailand, the Philippines, and Vietnam. South East Asia (SEA) is a subregion of Asia, lying to the east of the Indian subcontinent and south of China. The countries in this

member countries of ASEAN as one and the same group of countries. We do not include East Timor in our analysis due to lack of statistical data.

Although our fact-finding mission to the ASEAN-5 has brought to light new perspectives on these countries' international S&T cooperation preferences, we were not in a position to study all policy aspects systematically and in a thorough way. Time constraints whilst visiting each country limited the achievement of a comprehensive and more definite picture of ASEAN-5 countries' international S&T policies. Nonetheless, we hope that this paper's findings can be put to good use in further studies within SEA-EU-NET.

One impression that stands out is that some GRIs and scientists in the region have already achieved global research standards and can be treated as equal partners in joint research projects. S&T cooperation with ASEAN-5 can thus be of mutual interest to the EU and ASEAN. With other S&T actors in SEA who are still in the stage of capacity building, cooperation in their country-specific research niches, for example, biodiversity, offers attractive joint collaboration opportunities. The EU's main challenge in successful long-term cooperation with SEA countries seems to be finding an appropriate policy design which takes into account the various S&T development levels and country-specific conditions. This would contribute to a better positioning of the EU in this Asian region and hopefully lead to an increase in the rate of research programme applications.

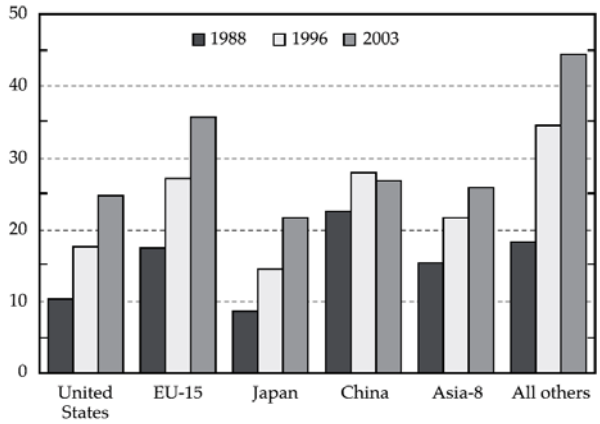
1 Review of South East Asia's S&T policies and systems

1.1 Why international S&T cooperation? Discussion of some theoretical concepts

International cooperation in S&T is regarded by most countries as a crucial policy device for achieving sustainable economic growth and tackling global challenges such as climate change and the cross-border spread of infectious diseases. International partnerships in S&T offer research institutes and scientists access to state-of-the-art research and allow governments to learn from best practices in research and development (R&D). New communication technologies has facilitated international S&T cooperation between scientists around the world. As an indicator of this process, the number of joint publications of research articles based on international S&T cooperation have increased remarkably over recent years (Bement 2005). When the shares of co-authored research articles worldwide in selected years are compared, it can be seen that approximately 45% of articles were published through international cooperation in 2003, more than double the share of 1988. The share of such articles in the Asia-8 region[4], which also includes some ASEAN countries, was only around 25% in 2003. Nevertheless, this is higher than the respective share in the US (see Figure 1).

region established the Association of South East Asian Nations (ASEAN) in 1967.

Figure 1: Share of research articles with international co-authorship by country and region, selected years



Source: Suttmeier (2008: 9).

National governments still play a predominant role in shaping international cooperation, despite the introduction of a more market-oriented S&T system and the diffusion of technologies through the expansion of transnational companies (TNCs) in high technology fields (Suttmeier 2008: 8). Based on foreign policy goals and country-specific needs, governments formulate international S&T policy cooperation goals and design programmes. Publicly funded research institutes and universities are the major vehicles for achieving the implicit or explicit agendas on international S&T cooperation. Seen from the national government policy perspective, international S&T cooperation can be either proactively pursued in order to profit from the cooperation with technologically more advanced countries or, so to say, left to the market. Governments of *latecomer* countries[5] often apply an interventionist set of industrial policy instruments in order to support the process of catching up with developed countries (Nee, Opper & Wong 2007). The degree of state intervention in the economy is regarded as the dividing line between those countries following a strategy of *technonationalism* and others that pursue a strategy of *technoliberalism*. Japan, South Korea, Taiwan, and Vietnam are known to have put much emphasis on the development of endogenous

[4] Asia-8 includes South Korea, India, Indonesia, Malaysia, the Philippines, Singapore, Taiwan, and Thailand (Suttmeier 2008: 9).

[5] The term *latecomer* refers to countries which are late industrialisers; it was originally applied to European countries in the 19th century and later to East Asian countries such as Japan, South Korea, Taiwan, Hong Kong, and Singapore in the 20th century. *Latecomer* countries have used state agencies to engineer their entry into export markets and high-tech sectors (Mathews 2002: 470).

technological competence. They have tried to avoid dependence on foreign technology and restricted the inflow of foreign direct investment. Industrial policy instruments applied in these economies have included both market incentives and non-market interventions. The strategy of technoliberalism, in contrast, is based on minimal state intervention, putting emphasis on liberalisation, privatisation, and deregulation. Foreign direct investment is regarded as an important means to increase technological capacity (Posadas 1999: 127-9).

According to Kang and Segal (2006), the strategy of technonationalism in Asia is motivated in large part by 'the desire of Asian states to free themselves from dependence on Western technologies.' The same countries are, however, confronted with the challenges of S&T globalisation, characterised by the market-driven R&D investment of multinational companies. In order to attract these investments and profit from the transfer of technology, even technonationalist countries push for liberalisation, leading to an 'open technonationalism'. The challenges of S&T globalisation manifest also in other areas (Archibugi and Michie 1997). Posadas (1999: 128) points, for example, to the international diffusion of technology at an earlier stage than in the past, the integration of technological complementarities through strategic alliances, and the international mobility of S&T professionals and students. Given these challenges, the technonationalist strategy needs to be adjusted. Whether countries in SEA follow a strategy of either technonationalism or technoliberalism will be analysed more closely in Section 2.

International S&T cooperation is, however, not only driven by national policies. In an open innovation system, scientists themselves seek cooperation with colleagues abroad, entering into research networks and projects. Governmental organisations and publicly funded research institutes and universities, as well as individual scientists, are thus the main targets of analysis in our study. Before presenting our research results, based on secondary data as well as field research findings, we will briefly look at other studies which explain international S&T cooperation. The theoretical discussion will help to structure the assessment of factors explaining international cooperation in the countries surveyed in our study.

Generally speaking, research on the growth of international cooperation in S&T has mainly focused on factors internal and external to science. In a critical overview of the literature, Wagner and Leydesdorff (2004: 1-7) have designed a matrix which includes different theoretical approaches and empirical findings. Authors who examine international cooperation related to factors internal or external to science are brought together with those studying the degree of interconnectedness of scientists within and across countries.

Basically, there are four 'traditional' theoretical approaches (Suttmeier 2008: 8-9): 1) The 'centre-periphery thesis' explains the growth of international cooperation with the shift in the centres of science. Countries in the periphery cooperate and learn from developed countries, resulting in a diffusion of S&T capabilities. 2) The 'S&T-for-development thesis' emphasises the role of S&T policy decision-making and investment strategies in strengthening scientific capabilities. This approach includes also the idea of active support for international S&T cooperation. 3) The 'specialisation–thesis' relates to factors internal to science and stresses the differentiation of scientific disciplines. This requires closer cooperation between specialised scientists and, in the case of mega-science projects, the cooperation of different specialisations. 4) The 'extra-scientific-factors thesis' points to a number of different factors that have an impact on international S&T cooperation, such as geographic proximity, colonial legacies, the growth in foreign trade, and information and communications technology (ICT).

Table 1: Factors explaining the growth of international S&T cooperation

	Factors internal to science	**Factors external to science**
Related to the diffusion of scientific capacity	• Countries lagging behind seek cooperation with leading ones **(Centre-periphery thesis)**	• Growth of investment in S&T leads to increased S&T capacity **(S&T-for-development thesis)**
Related to the inter-connectedness of scientists	• Disciplinary differentiation of science • Field-specific characteristic of mega-science • Professionalisation of research institutes **(Specialisation thesis)**	• Historical relationships due to geographic proximity or colonial experience • Growth of international trade and diffusion of new technologies (ICT) **(Extra-scientific-factors thesis)**
Related to the intellectual and social organisation of science	• Networks on international subfield-level of science, based on reputations and rewards within scientific cooperation **(Networks as self-organising systems thesis)**	• State support for international S&T networking **(Transaction cost)**

Source: Wagner and Leydesdorff (2004: 2-8) and Suttmeier (2008: 8-10).

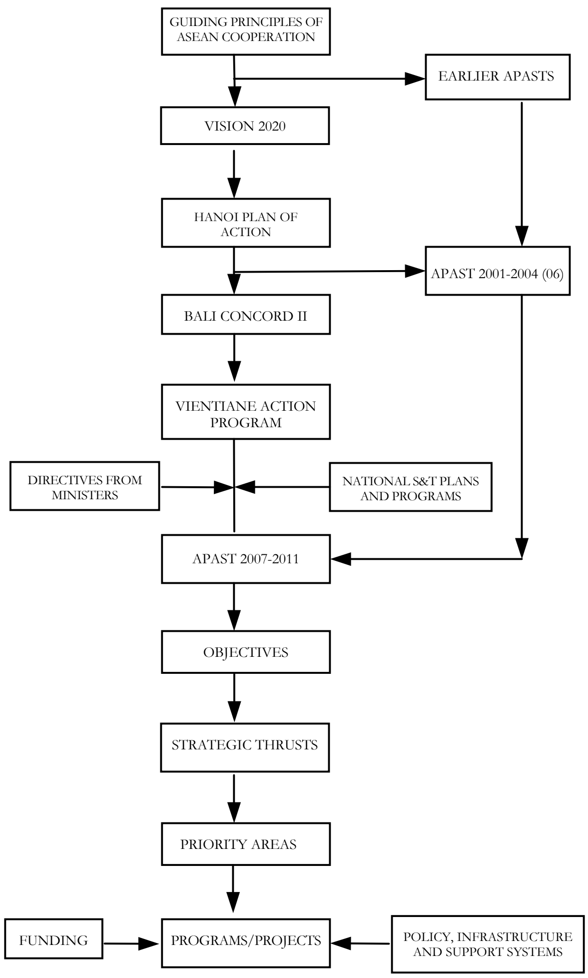
Wagner and Leydesdorff (2004: 21) are, however, not satisfied with 'traditional' explanations for the impressive growth in co-authorship at the global level. Based on their research on networks they argue that international cooperation seems to be more due to 'the dynamics at the subfield level created by individual scientists linking together for enhanced recognition and rewards than to other structural or policy-related factors.' Table 1 presents not only the 'traditional' approaches reviewed by Wagner and Leydesdorff but also their own approach. They emphasise factors internal to science – more precisely, internal to the intellectual and social organisation of science which offers incentives for individual scientists to cooperate within their own country and across countries. Although this approach highlights the role of individual actors, it neglects the transaction costs of international cooperation, especially the costs of forming and maintaining networks. Therefore, government and private sector intervention through financial and organisational support is still needed for the support of international cooperation (Suttmeier 2008: 11-13).

Finally, a short look at the motivations of technologically advanced countries for S&T cooperation in SEA is needed. There are multiple reasons for the interest of these countries in cooperating with ASEAN in S&T. Seen from the economic 'triad perspective', international S&T cooperation is part of the overall competition for markets between the EU, Japan, and the USA. Since the establishment of the European Committee on Scientific and Technology (EU COST) in 1970, countries outside the EU have been targeted as cooperation partners for research projects. The EU's framework programmes (FPs), established in 1984, offer a vehicle for financing international research cooperation and include developing countries as well (Langhammer 1998; Konstadakopulos 2003: 557).

1.2 ASEAN's interregional and extra-regional S&T policies

Since the Asian financial crises in 1997, economic integration in the ASEAN region has not been left only to the market but has been guided by the idea of the benefits of a stronger institutional framework. Pointing to the growing competitive pressure from China and India, Prime Minister Lee Hsien Loong of Singapore underlined in his speech at the ASEAN Summit in November 2007 that a 'more integrated ASEAN will be in a stronger position to engage external partners, and enhance our links to the major economies in the region and beyond.' (Lee Hsien Loong 2007; Volkmann 2008: 84). Due to the central role of S&T in economic development, closer technological cooperation has been supported in ASEAN through the establishment of the ASEAN Committee on Science and Technology (ASEAN COST). After its initial beginnings as a committee at the start of the 1970s, ASEAN COST was formally founded in 1978 and has since aimed to guide the formulation of the region's S&T policies and the establishment of programmes. Based on policy decisions made at the ASEAN summits and meetings of ASEAN Ministers for S&T, COST has designed a number of special programmes and actions. The latest is the action plan on S&T for the period 2007 to 2011 (*ASEAN Plan of Action on Science and Technology: 2007-2011, APAST*). Previous action plans (see Figure 2) have been incorporated and combined with directives from the ministers of S&T and with national S&T plans. The overall aim of the action plan is to 'provide guidelines for identification and formulation of programmes and projects to achieve better coordination and cooperation to strengthen the capabilities of S&T in ASEAN.' (ASEAN Secretariat, website).

Figure 2: Framework of the *ASEAN Plan of Action on S&T (APAST): 2007-2011*



Source: ASEAN Secretariat.

APAST contains not only policy objectives directed at the region itself, but also guidelines for stronger international cooperation on the part of ASEAN with countries and regions outside the so-called dialogue partners. In detail, *APAST* lists the following objectives: 1) creating intra-ASEAN S&T cooperation that has extensive synergies and is self-sustaining, with strong participation by the private sector; 2) establishing an S&T network supportive of public- and private-sector human resource development; 3) supporting technology transfer between institutions and industry; 4) increasing awareness of the crucial role S&T play in economic development in ASEAN; and 5) expanding S&T cooperation with the international community. This last objective shows that COST is pursuing an outward-looking S&T strategy.

In terms of actions, *APAST* explicitly requires support for closer cooperation with 'dialogue partners and other relevant organisations on regional projects' as one of its strategic thrusts. In order to achieve this objective, the following actions are proposed:

1) development of new strategies for partnership with dialogue partners;
2) facilitation of access to the resources of dialogue partners for regional projects, with a focus on the newer member countries of ASEAN; and
3) support for closer relationships with relevant '+3' S&T agencies for mutually beneficial development in East Asia.

The last action suggested in the *APAST* refers to relationships with Japan, South Korea, and China, often related to as the '+3' in the 'ASEAN+3' dialogue.

Currently, there are eleven S&T dialogue partners listed in the ASEAN action plan on S&T. Dialogue partners in Asia are China, India, Japan, the Republic of Korea (RoK), and Pakistan (see Table 2). Australia, New Zealand, the EU, the USA, Canada, and Russia are also dialogue partners. Most of the dialogue partners have a specific S&T dialogue forum with ASEAN to jointly discuss activities which often takes the form of a joint working group. This is not the case for Japan, New Zealand, ROK or Pakistan. The bilateral fields of S&T cooperation are very similar, reflecting ASEAN's priority programme areas for S&T cooperation. These programme areas are 1) food S&T, 2) biotechnology, 3) meteorology and geophysics, 4) marine S&T, 5) non-conventional energy research, 6) microelectronics and information technology, 7) material S&T, 8) space technology and applications, and 9) S&T infrastructure and resource development (ASEAN Secretariat, website).

The list of dialogue partners and S&T priority areas demonstrate that ASEAN is actively seeking cooperation with technologically advanced countries, especially with Japan, the USA, and Europe. Not only are these countries important for the association's promotion of its

Table 2: ASEAN's S&T cooperation programmes with dialogue partners

Dialogue Partner	S&T Dialogue Forum	Programmes	Financial Support	Period
Australia	Regional Partnership Scheme (RPS)	Funding of S&T projects, no sectoral focus	Project funding between A$50,000-A$500,000	Start August 2002, five years
Canada	ASEAN-Canada Joint Cooperation Work Plan	Priority areas: biodiversity, biotechnology, nanotechnology, vaccine, drug- and herb-based medicine development, food sciences, materials technology, health and life sciences, ICT, environment, alternative clean energy	Not specified	2005-2007
China	ASEAN-China Joint S&T Cooperation (ACJSTC) --- ASEAN-China Strategy for Peace and Prosperity (2005-2010)	Priority areas: biotechnology, functional food, information technology, remote sensing, seismology, marine sciences, material science and traditional medicines --- Identified transfer of technology to small and medium-sized enterprises (SMEs) as priority for S&T cooperation	ASEAN-China Cooperation Fund for people-to-people interactions; cost-sharing arrangements for R&D	
European Union	READI (Regional EU-ASEAN Dialogue Instrument) --- EU Framework Programme for Research and Technological Development	Priority areas: information society, animal health, climate change, transport, communicable diseases --- Submission of proposals	No funding EU-FP (EC 2007)	No specific period In five-year periods
India	ASEAN-India Working Group on S&T	Priority areas: biotechnology, microelectronics, IT materials sciences, remote sensing, technology management, marine sciences, seismology, food science	Cost-sharing arrangements, HRD (human resource development)	No specific period

	--- ASEAN-India Partnership Agreement in 2004	--- Identified S&T fields: IT, biotechnology, space technology applications, biotechnology	activities	
Japan	No specific dialogue forum --- ASEAN-Japan Summit 2004 Plan of Action	No specific areas. Activities supported in the past: food technology, materials science, seismology, meteorology, technology management --- Identified S&T fields: ICT, energy, environment, HRD	Funding through: Japan-ASEAN Exchange Project (JAEP) Japan-ASEAN General Exchange Fund (JAGEF)	No specific period
New Zealand	No specific dialogue forum --- ASEAN-New Zealand Framework for Cooperation	No S&T projects supported since August 2003; in the past: biotechnology, materials science, non-conventional energy, technology management --- Identified S&T fields: transfer of technology to trade and development capacity building; sustainable energy, disaster mitigation and management	Cost-sharing arrangements	2005-2010
Republic of Korea (ROK)	No specific dialogue forum --- ASEAN-ROK Summit 2004: Declaration of Comprehensive Cooperation Partnership	No specific fields identified. Cooperation in the past: technology management, microelectronics, biotechnology, meteorology, marine science --- Identified S&T fields: support in information exchange, technology management, HRD; biotechnology, food technology, new materials, microelectronics, meteorology, marine biology, genetic engineering	ASEAN-RoK Special Cooperation Fund (SCF)	No specific period
Russia	ASEAN-Russia Working Group on S&T --- Concept paper on the convergence of interest in S&T, 2006	Priority areas: biotechnology, new materials, information technology, microelectronics, meteorology, geophysics --- Identified S&T fields: biotechnology, microelectronics, IT, meteorology, geophysics, nanotechnology, geoinformatics, environment management, energy technology and efficiency	ASEAN-Russia Dialogue Partnership Financial Fund	No specific period
United States	ASEAN Cooperation Plan (ACP)	Priority areas: biotechnology, health and infectious diseases, disaster response and management, ICT	Funding has to comply with US development-assistance policy	No specific period
Pakistan	No specific dialogue forum	Priority areas: remote sensing, food-processing technologies, materials science, new and renewable sources of energy, ICT	ASEAN-Pakistan Cooperation Fund	No specific period

Source: *APAST* , Annex 3.

regional technology development, but they also at the same time provide most of the official development aid (ODA) to the region and play predominant roles as trading partners (Konstadakopulos 2003: 552).

Despite the growing importance of COST as a dialogue forum for the coordination of the region's S&T programmes, the institutional and funding capacity of this committee remains rather limited. This holds true for the ASEAN Secretariat altogether, which has to cope with an heavy administrative burden resulting from the increasing pace and extent of regional cooperation and integration. The number of meetings ASEAN bureaucrats are involved in has grown to over 400 a year (Wah 2007: 399). In order to strengthen the capacity of the ASEAN Secretariat, the Asian Development Bank (ADB) is currently financing technical assistance for consulting services related to policy briefs and the setting up of databases on trade, investment and services, etc. (ADB 2007). With regard to the financing of S&T cooperation, most of the funding comes from dialogue partners, while the ASEAN Trust Fund for S&T (also called the ASEAN Science Fund) and the ASEAN Fund have less than $2 million each per year (Konstadakopulos 2003: 563).

Unlike the EU, which is a supranational institution, the ASEAN is an intergovernmental organisation and thus has no decision-making power of its own (Moeller 2007: 480). The ASEAN's international S&T policy is therefore strongly influenced by the interests of individual member countries. The fact that some of the ASEAN-5, the founding members of this regional grouping, have almost similar economic development levels explains, according to some scholars, the fact that they tend to compete in S&T rather than cooperate. Stronger regional cooperation is mostly concentrated in those countries which joined ASEAN last, namely, Cambodia, Laos, Myanmar and Vietnam. The ASEAN-help-ASEAN programme (2001-2004 action plan) has been especially designed to support these member countries' S&T development (Konstadakopulos 2003: 562-3).

ASEAN member countries' policies for promoting S&T development can be characterised as having a common basic understanding of the proactive role of the state. Despite some similarities in policy approach, strong variations exist, as 'each country has responded according to its own historical heritage, and unique economic and national innovation system' (Konstadakopulos 2002:. 103). The question of whether countries have a more inward- or outward-looking S&T cooperation policy is equally dependent on country-specific political and social conditions.

Applying the concepts of technoliberalism versus technonationalism to the ASEAN countries, Singapore, Thailand and the Philippines are assessed as countries which have pursued a strategy of technoliberalism. They rely heavily on foreign direct investment and technology transfer. An in-between strategy has been chosen by Malaysia and Indonesia, seeking both independence in some strategic technologies (Indonesia: small aircrafts) as well as international cooperation in national prestige projects (Malaysia: Multimedia Super Corridor) (Posadas 1999: 128). Whether SEA countries follow a strategy of technonationalism or technoliberalism will be analysed more closely in Section 2.

Statistics available from the ASEAN secretariat point to the heavy involvement of national governments in the funding and performance of S&T. When looking at the structure of gross expenditure on research and development (GERD) by source of funds and by performance sector, we find a predominant role on the part of the state in Brunei (92%), Indonesia (85%) and Vietnam (74%).

In Singapore and Thailand the government contributes about one-third of the total GERD, while the share is smaller in Malaysia (28%) and the Philippines (22%). Cambodia and Laos have an extremely low government share, but substantial contributions come from abroad (28% and 54%, respectively) as they are still eligible to receive ODA. The high shares of government funding correspond with the distribution of GERD across performance sectors. Again, Brunei, Indonesia and Vietnam show the highest ratios (92%, 81% and 66%) in this respect (see Table 3).

Table 3: The role of the government in financing and the performance of S&T (GERD by source of funds and by performance sector)

ASEAN	GERD by source of funds (in %)			GERD by performance sector (in %)		
	Industry	Government	Other Sources	Business Enterprises	Higher Education	Government
Brunei (2004)	1.580	92.02	6.400	0.0	8.420	91.58
Cambodia (2002)	0	18	54[1]	12[2]	12	25
Indonesia (2001)	14.69	84.51	0.15	14.29	4.64	81.07
Laos (2002)	36	8	2[1]	37	12	51
Malaysia (2004)	71.0	27.90	0.70[1]	71.5	18.1	10.4
Myanmar	n/a	n/a	n/a	n/a	n/a	n/a
Philippines (2003)	69.06	21.91	5.20[1]	67.99[2]	11.12	19.12
Singapore (2005)	58.750	36.410	0.470[1]	66.15	24.18	9.66
Thailand 2005)	48.64	31.48	3.11[1]	43.65[2]	38.28	17.16
Vietnam (2002)	18.06	74.11	0.66[1]	14.55[2]	17.91	66.43

Source: Data supplied by the Science and Technology Unit of the ASEAN Secretariat.
Note: [1] Share of GERD financed from abroad was 28% and 54% in Cambodia and Laos in 2002, 0.4% in Malaysia in 2004, 3.83% in the Philippines in 2003, 4.37% in Singapore in 2005, 1.84% in Thailand in 2005, and 6.33% in Vietnam in 2002. [2] Share of GERD by private non-profit sector was 51% in Cambodia in 2002, 1.77% in the Philippines in 2003, 0.95% in Thailand in 2005, and 1.11% in Vietnam in 2002.

1.3 Overview of SEA's economic and technological development

Within the ASEAN region huge differences exist between member countries in terms of their economic and technological development levels. Taking the gross national income (GNI) per capita as the strongest indicator of international competitiveness, representing a country's ability 'to earn income', the region can be divided into different groups of countries using the World Bank's and the OECD's classification systems.

Table 4: Classification of ASEAN member countries by income level (per capita GNI $ in 2007)

High-income Countries	Upper-middle-income Countries (GNI $3706-$11,455)	Lower-middle-income Countries (GNI $936-$3705)	Other Low-income Countries (GNI <$935)	Least Developed Countries
Singapore ($29,320)	Malaysia	Indonesia	Vietnam	Cambodia
		Philippines		Laos
		Thailand		Myanmar
Brunei ($16,125*)				

* Refers to 2006, USD.
Source: OECD (2008): DAC List of ODA Recipients; World Bank (2008); World Development Report 2008, pp. 331-5; Ministry of Development, Brunei (2008).

Singapore and Brunei belong to the group of high-income countries, while Malaysia is the only country in the group of upper-middle-income countries from the ASEAN region on the Development Assistance Committee's list of ODA recipients. ODA for Singapore was phased out in 1996, and Malaysia, too, has grown out of foreign aid in the last few years. The remaining countries are, however, eligible to some extent for ODA.

Table 5: Classification of ASEAN member countries in terms of openness to foreign companies (Indicator: FDI inflow, million USD)

High-level inflow of FDI	Medium-level inflow of FDI	Low-level inflow of FDI
Singapore (24,055)	Philippines (2,345)	Laos (187)
Thailand (10,756)	Vietnam (2,360)	Brunei (434)
Malaysia (6,060)		Cambodia (483)
Indonesia (5,556)		Myanmar (143)

Source: ASEAN Statistics, Selected Basic ASEAN Indicators (http://www.aseansec.og/stat/Tabl1.xls, 11.08.08), as of 30 April 2008. Note: The statistics include equity and inter-company loans. Brunei, Cambodia, Malaysia, and Indonesia (2004-2006 Q1); the Philippines (1999-2006 Q 1) and Myanmar as well as Vietnam (2003-2005) include reinvested earnings. Indonesia (2005), Singapore (2002-2005) and Thailand (2001-2005) had been revised due to their Balance of payment survey.

In the group of lower-middle-income countries, three ASEAN member countries can be found, namely, Indonesia, the Philippines, and Thailand. In the next few years, Thailand will also be phased out as an ODA recipient. Vietnam belongs to the group of other low-income countries, whereas Cambodia, Laos and Myanmar fall into the group of least developed countries (see Table 4). It is interesting to note that Japan has been by far the largest donor of ODA for countries in this region (OECD 2008).

Much of the economic disparity within the ASEAN region has been attributed to different economic policies, especially openness to foreign direct investment (FDI) (Remoe 2008: 7) as an important source for technology transfer. Looking at the inflow of FDI as an indictor of openness, Singapore, Malaysia, Thailand, and Indonesia have traditionally been more open to FDI than the remaining member countries of ASEAN. The flow of FDI to these four countries is the highest in the ASEAN region, although Vietnam is rapidly catching up. (see Table 5).

The economic disparities within the ASEAN region are accompanied by huge differences in S&T development. Singapore's S&T indicators demonstrate that S&T has already become a major driving force for economic growth for this most advanced economy in the ASEAN region. When analysing and comparing the S&T indicators of these SEA countries, we have to keep in mind that most of them do not have a long tradition of collecting S&T data. Only in recent years have ASEAN member countries begun to use the 'Frascati Manual', as a reference for their S&T statistical reporting. Therefore, the incomplete S&T statistics of some ASEAN member countries are difficult to compare with those of advanced countries with a well-developed reporting system.[6]

In contrast to the situation in Singapore, Brunei's high GNI per capita does not correspond to an equally high ratio of R&D to gross domestic product (GDP). Brunei's economy is strongly dependent on oil and gas (with income from oil contributing approximately 53% to total GDP in 2004, cf. Ministry of Development, Brunei). The highest ratio of GERD was achieved by Singapore (2.15%) in 2005, followed by Malaysia (0.63%) and Thailand (0.24%). Although the remaining countries have been able to increase the ratio of GERD to some extent in recent years, their expenditure for R&D is still very low (see Table 6).

The number of researchers and the share of the total labour force they represent, respectively, and the share of researchers employed in the public sector represent important indicators of S&T development. Generally speaking, the supply of R&D personnel in most ASEAN countries is rather limited; only Singapore and Malaysia have a share of R&D personnel which is

[6] For the coverage of S&T indicators in ASEAN member countries see the report in the ASEAN Science and Technology Network, *S&T Indicators* (http://www.astnet.org).

closer to that in developed countries. Nevertheless, due to strong demand in high-tech R&D, both are actively seeking scientists from outside the country.

Table 6: ASEAN member countries' technological development level

ASEAN	Year	GERD as % of GDP	Researchers (per 1,000 employees)	Researchers in GRIs as % of national total	Patents (2004)*
Brunei	2004	0.05	0.32	n/a	0
Cambodia	2002	0.05	0.12	n/a	0
Indonesia	2005	0.07	0.12	n/a	72
Laos	2002	0.04	0.03	35.6	0
Malaysia	2004	0.63	1.21	16.8	27
Myanmar	n/a	n/a	n/a	n/a	n/a
Philippines	2003	0.14	0.18	34.4	6
Singapore	2005	2.15	10.0	5.7	110
Thailand	2005	0.24	0.58	15.22	4
Vietnam	2002	0.19	0.24	56.5	17

* Patents granted to residents.

Source: Science and Technology Unit of the ASEAN Secretariat; Remoe 2008: 9; RISTEK 2006.

In some countries, such as Vietnam, Cambodia, and Brunei, the public employment of researchers plays a predominant role. In contrast, in technologically more advanced economies this share is relatively low (Singapore 5.7%, Thailand 15%, Malaysia 17%), pointing to the more important role of the business sector for overall S&T development. In addition to the so-called input indicators of S&T such as GERD and the number of researchers, statistics on patent registration point to the outcome of R&D. Again, Singapore holds a leading position in patent registration in the ASEAN region. While Indonesia, Malaysia, and Vietnam have begun to pay stronger attention to patenting, other member countries are still lagging behind and/or their patent performance is not reported.

2 Survey of SEA's preferences in international S&T cooperation

2.1 Notes from the field

Having reviewed the S&T policies of SEA countries on the basis of secondary data, we now present our findings from the field research for each country separately. Our research concentrates on the reasons given by our interview partners for international cooperation, and on their preferences for specific countries or regions as partners and for specific S&T fields.

Based on preparatory work through online questionnaires, our fact-finding mission relied on face-to face interviews with representatives from the ASEAN-5 members' S&T ministries and GRIs as well as with individual scientists. This two-level-approach allowed us to gain a better understanding of the national policies and of individual scientists' preferences in international S&T cooperation.

The quality of information obtained during our fact-finding mission varied, however. The decentralised and relatively autonomous structure of S&T institutions in some countries combined with a weak tradition of S&T data collection explain the difficulties in getting satisfactory responses to questionnaires.

2.2 Indonesia

2.2.1 Key characteristics of Indonesia's S&T system and policy

Indonesia is not only the largest archipelago country, with about 17,500 islands, but also the most populous nation in ASEAN (population in 2007: million 245; Indonesia Facts). The Asian financial crisis in summer 1997 shook Indonesia's economy quite severely and led to an increase in poverty and unemployment and to insufficient infrastructure (Taufik 2007: 1). Although the country has basically been able to overcome the economic turbulence, the government's R&D budget has been drastically reduced. This has led to a decline in the ratio of the GERD. While R&D accounted for 0.5% of GDP in 1982 (LIPI 2006: 116), this percentage shrank to only 0.05% in 2001. According to the latest statistics from the Ministry of Research and Technology (RISTEK), the GERD saw a small increase which amounted to 0.07% in 2005 (RISTEK 2006: 3). That Indonesia is still lagging behind in terms of industrial technological capabilities compared to other ASEAN-5 member countries (with the exception of Vietnam) is reflected in its low share of high-technology exports as a percentage of total manufactured exports. In 2003 this share was only 14% in Indonesia, whereas Singapore and Malaysia achieved shares of 59% and 58%, respectively (Wie 2006: 347).

Indonesia's government sector remains the most important driving force for the country's S&T. However, the government has essentially followed a strategy of technoliberalism, emphasising technology transfer from abroad and markets to create attractive investment conditions for multinational companies (MNCs). In some S&T fields, however, the endogenous development of technologies has been supported. The policy of 'strategic industries', introduced under the former RISTEK minister B.J. Habibie (1978-1998), advocated the picking of winners among industries that were most likely to play a crucial role in economic development. The execution of this policy required the Agency for Strategic Industries (BPIS) to anticipate shifts from resource- to knowledge-based international business (Gammeltoft and Aminullah 2006: 162-3).

Although some scholars (for example, Lall 1998) remark that Indonesia does not have a technological strategy in terms of a 'coherent set of policies', others demonstrate the opposite. S&T policy concepts were included in the overall industrial policy as early as the 1970s, when the Indonesian government adopted a system of five-year development plans. The first R&D activities were supported in the fields of agriculture, industry, and mining (Krishna/Report Indonesia). Over recent decades policy planning has become more sophisticated and has been extended to new areas. According to Gammeltoft and Aminullah (2006: 162-3) both the five-year development plans and the 25-year development plan contained development targets for S&T. Implementation policies were published by RISTEK (Punas Ristek or National Priority Program for Research and Technology), and planning was based on the proposals by the National Research Council (NRC or DRN), with many GRIs involved. Gammeltoft and Aminullah agree, however, with the critics of Habibie's idea of 'technological leapfrogging'. The fact that the targeted industries were isolated from private industry reduced their prospects for success.

Following the example of the more technologically advanced countries in the region, the Indonesian government has also defined S&T as the main driver in the catching-up process of the country. Today, RISTEK's vision and mission statement points to S&T 'as the main force for sustainable prosperity'. The ministry explicitly adopts the concept of NIS in its statement, with the objective of 'creat[ing] [a] solid national system of innovation for increasing the global competitive ability'. The mission statement bows further to the NIS approach by pointing to the need to 'increase Science and Technology diffusion through the consolidation of the network of its actors and institutions, including the development of its mechanism and institutionalization of its intermediary'. In order to achieve these goals, RISTEK is required to 'build quality and competitive human resources, infrastructures, and institutions for Science and Technology' (RISTEK website).

A number of S&T policies and programmes reflect the objectives and instruments of the Indonesian government. The most recent five-year plan to promote S&T activities is the *National Mid-term Development Plan (NMDP) 2004-2009*, which has the following objectives:

- To sharpen R&D and engineering priorities in S&T to be oriented towards the demand of the private sector and the need of society, following a clear roadmap.
- To enhance S&T capacity and capability by strengthening S&T institutions, resources and networks at the central and regional level.
- To create a suitable innovation climate with an effective incentive scheme to foster industrial restructuring.
- To implant and foster S&T culture in order to enhance Indonesia's civil development (Taufik 2007: 7).

The S&T priorities included in the *NMDP* (called 'Six Focus Programs' on RISTEK's website) are 1) food security, 2) new and renewable energy, 3) transportation system and management, 4) ICT, 5) medicine and health technology, 6) defence technology. For each area the government has published a 'White Paper' which sets quantitative targets for each priority for different periods and defines the role of the government, GRIs, and universities (Simamora and Aiman 2006). The *NMDP* includes several programmes. For instance, the S&T Research and Development Programme aims to advance the quality of national R&D activities in the fields of basic and applied sciences. The objective of the S&T Diffusion and Utilization Programme is to enhance the dissemination and utilisation of research findings by the corporate sector and society. The S&T Institutional Strengthening Programme fosters S&T-related organisational capabilities and the Production System S&T Capacity Enhancement Programme enhances the technological capacity of production systems in the corporate sector (Taufik 2007: 7).

Some S&T support programmes concentrate on the development of new technologies, for example:

- RUT (funding of basic and applied research by GRIs)
- RUKK (funding of research in humanities and social sciences)
- RUTI (funding of research by Indonesian scientists in bilateral projects with foreign partners)

In addition, there are various programmes which aim to support the introduction of new technology in the manufacturing industry, to strengthen the framework conditions and the supply of information on existing technologies (GATE 2006: 25-6).

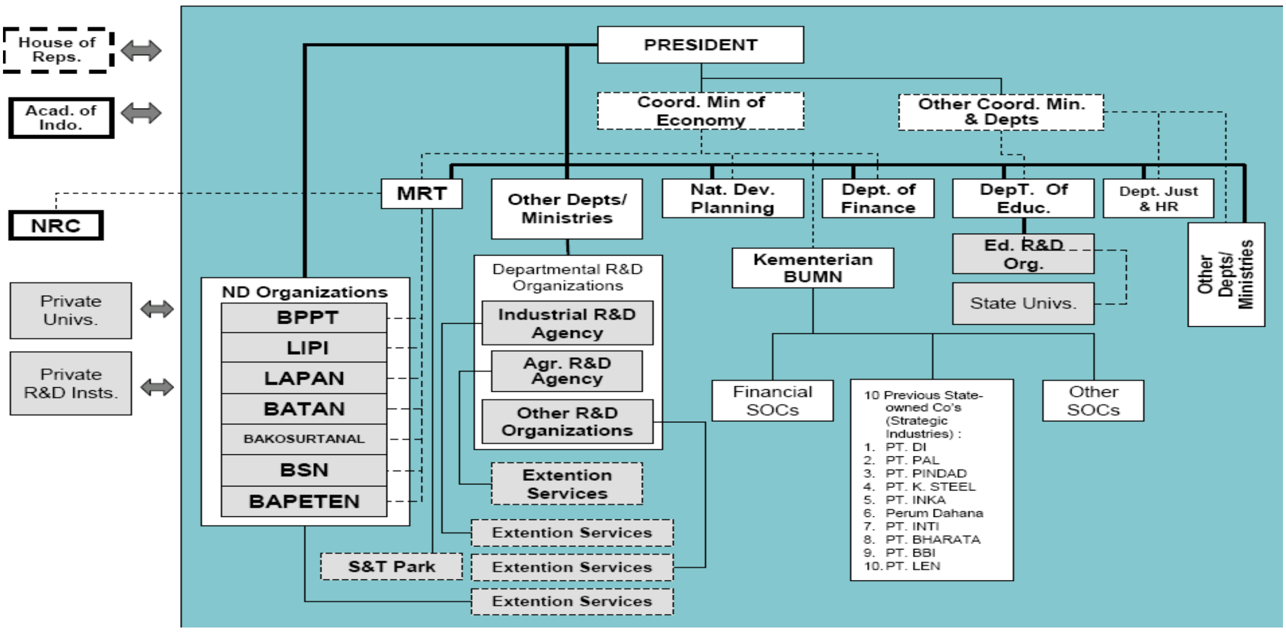
Another characteristic of Indonesia's S&T policy and system is the large number of actors, including governmental and research institutions (see Figure 3). Ministries other than RISTEK are involved in policy making as well, and some have their own (departmental) research institutes. In addition, seven non-departmental research institutes report directly to the president and are coordinated by RISTEK (GATE 2006: 18-9):

- BBPT (Agency for the Assessment and Application of Technology)
- LIPI (Indonesian Institute of Sciences)
- LAPAN (National Institute of Aeronautics and Space)
- BATAN (National Nuclear Energy Agency)
- BAKOSURTANAL (National Coordination Agency for Surveys and Mapping)
- BSN (National Standardization Agency of Indonesia)
- BAPETEN (Nuclear Energy Control Board)

The role of the BBPT is to formulate and implement policies for industrial and technology development. Some of the non-departmental research institutes are centrally administered by the Center for Research, Science and Technology (PUSPIPTEK), located at Serpong near Jakarta. Six BBPT laboratories and four LIPI institutes were initially established in this science city (Gammeltoft and Aminullah 2006: 170). The number has increased to 30 institutes, which jointly employ a total staff of 3,000 (PUSPIPTEK 2008). Another research institute of national importance is the Eijkman Institute of Molecular Biology, originally founded in 1888 by the Netherlands. In order to support research in biomedical and biotechnology, the institute was reopened in 1992/93, concentrating on tropical diseases (GATE 2006: 18-20).

To better coordinate the various S&T policies and programmes, the NRC was established in 2002. The 108 NRC members come from academia as well as from the business sector and the government, and are specialised in the S&T areas of the 'Six Focus Programmes'. As an advisory body, the NRC develops policy suggestions and recommendations. The NRC has just published a report evaluating the 2005-2009 National Research Agenda. The council acts as an intermediary between industrial needs and the national research agenda. Due to Indonesia's large geographical size, regional research councils (RRCs) exist also at the local level, and are designed to coordinate regional S&T policies. In an assessment of Indonesia's innovation challenges, the NRC comes to the following conclusions: The problems at the national level are the predominance of public R&D, sector-development approaches, weak linkages among S&T actors, few techno-economic cluster initiatives, and limited access to knowledge pools. The reasons for these shortcomings are presented in the report as 1) a lack of policy coherence on the national and local level, 2) the absence of an innovation policy does, and 3) the poor basic conditions of the innovation system in terms of quality of education, infrastructure, law enforcement and asymmetric development (NRC 2008).

Figure 3: Indonesia's S&T System



Source: Taufik 2007: 15.

According to a survey of GRIs' R&D (see Table 7), departmental GRIs play an outstanding role in R&D. Their estimated share amounts to 70% of total R&D expenditure in the government sector. The ratio of departmental research institutes' expenditure to GDP was 0.048% in 2005. An additional 28% of the total R&D budget was assigned to the non-departmental research institutes, subordinated to RISTEK. The remaining 2% went to local governments' S&T activities. Among all the GRIs, those under the Department of Agriculture received the largest share, followed by LIPI and the research institutes under the Department of Energy and Natural Resources.

The private sector plays a marginal role in financing and undertaking R&D. Aiman (2007) explains this distorted structure with the lack of large enterprises, which are generally more engaged in R&D than smaller ones. In the Indonesian industry sector, almost all companies are very small or medium-sized and seem hardly able to invest in the development of new products and processes.

Government-sector funding of R&D includes universities and other institutes of higher education as well. In 2004, approximately 71% of the latters' R&D funding came from the government (LIPI 2006: 56). The four most renowned state universities are the Universitas

Indonesia (UI), the Universitas Gadja Mada (UGM), the Institut Partanian Bogor (IPB), and the Institut Teknologi Bandung (ITB).

Table 7: R&D performance of GRIs in Indonesia in 2005

Indicators	
GERD	**0.07**
Government's R&D Expenditure to GDP	**0.048**
Distribution of R&D by Type (%)	
Experimental Development	43
Applied Research	46
Basic Research	11
Distribution of R&D by S&T Field (%)	
Engineering and Technology	32
Medical Sciences (1%) and Humanities (1%)	2
Natural Sciences	18
Agricultural and Environmental Sciences	30
Engineering and Technology	32
Social Sciences	18
Patenting Activities (number of patents)	
Patent Applications	24
Patent Awards	15
R&D Personnel (researchers, technicians and supporting staff)	26.229
Researchers	11.141

Source: RISTEK: R&D of Government Research Institutions – 2006.

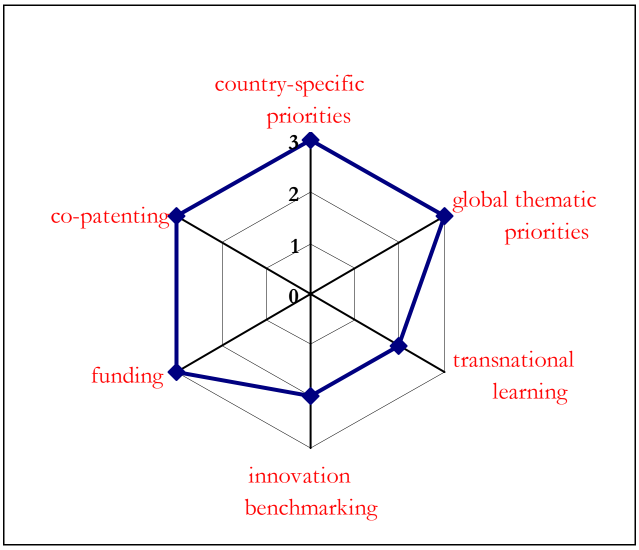
The higher-education sector has expanded steadily over recent decades. In 1970, for instance, only 237,000 students were enrolled in 450 private and government-funded institutes of higher education. By 1990, the number of students enrolled rose to 1.5 million and the number of institutes of higher education increased to 900. Universities' share of GERD performed, however, remained at the rather low level of 5.6% for the period 2000-2002 (UNESCO 2008: 20-1).

2.2.2 Indonesia's international S&T cooperation policy

We now turn to the question of what the reasons for international S&T cooperation in Indonesia are. In the last section we discussed the complex net of institutions involved in S&T in Indonesia. This makes a coordinated policy approach rather difficult and could have a negative impact on the development of a consistent strategy for international S&T cooperation. Political instability in the past also contributed to changes in policies and led to inconsistency in the overall approach. The results of our online questionnaires and interviews during the field study tend to support this assumption. Representatives from the NRC stressed the weak institutional linkages among GRIs and a general lack of research focus. According to the NRC's survey on innovation policy, approximately one-third of the projects are not in line with the national agenda. This can be explained to some extent by the preferences of individual scientists who influence the pattern of international S&T cooperation through a bottom-up process.

Based on the online questionnaires and interviews with representatives from governmental institutions, we conclude that no clear preference is given as to why international S&T cooperation should be pursued. There was a strong emphasis on both *country-specific* and *global thematic priorities*, and on *co-patenting* as well as *funding*. *Transnational learning* and *innovation benchmarking*, in contrast, were rated lower in the assessment of why international S&T cooperation is important (see Figure 4).

Figure 4: Reasons for international S&T cooperation: The view of governmental institutions in Indonesia



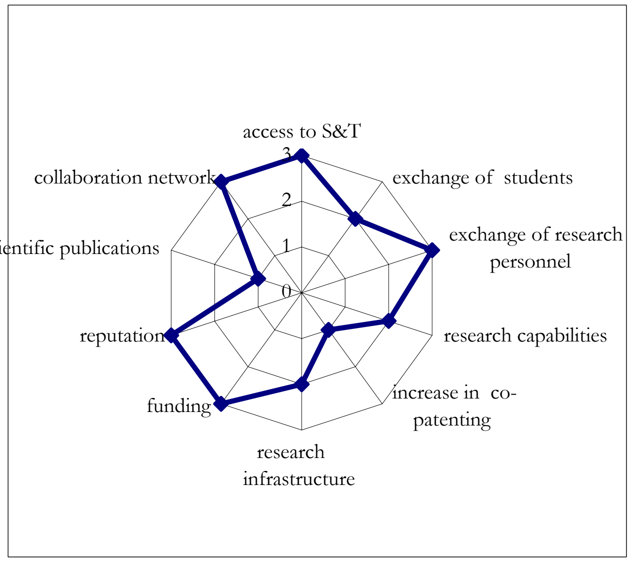
Source: Authors' assessment based on information from interviews and questionnaires.

Funding and access to high-tech research equipment were the major concerns during our visits to various departmental and non-departmental GRIs and universities. In 2000, the Indonesian government decided to give autonomy to the four largest universities (UI, UGM, IPB and ITB), turning them into independent legal entities which are responsible for their own budgets.

This policy decision aimed to increase cooperation between universities and industry in R&D and might reduce the share of basic research in favour of applied research at universities (GATE 2006: 26). We could also expect a positive influence from the universities' autonomy on international cooperation as external research funding becomes more important than before.

On the individual scientist level, the reasons for international cooperation diverged to some extent from the pattern given by the government representatives. Up until recently, promotion at GRIs and universities was based not only on academic performance but also on teaching and community service.

Figure 5: Reasons for international S&T cooperation: The view of scientists in Indonesia



Source: Authors' assessment based on information from interviews and questionnaires.

The latter term is used to describe small-scale projects that have a positive impact on the community the GRI or university is located in. These projects include, for example, the development of devices for the reduction of environmental problems, the diffusion of agricultural technology, etc. Given such an incentive structure, most of the scientists did not assess 'co-patenting' as a very important reason to enter international cooperation (see figures 5). In contrast, access to new S&T knowledge, cooperation networks, exchange of research personnel, access to funding, and an increase in reputation were most strongly emphasised by individual scientists. The categories scientific publication, research capabilities, research infrastructure, and exchange of students were regarded as important, but to a lesser extent.

Which fields of international S&T cooperation are most important for Indonesia?

The most important thematic focus areas for international S&T cooperation presented to us by the NRC were climate change, global warming, and deforestation. These topics might be easily funded through international cooperation, but they do not reflect a long-term strategy with clear objectives and a consistent top-down approach in international S&T. We have also found that some government officials and scientists still think of international S&T cooperation in terms of development aid funding and not so much in terms of participating and competing in a demanding application process. Therefore, international cooperation with Indonesia can be implemented primarily with a few outstanding research institutes and scientists. Due to the slow process of change, there is a lack of human resources and funding. Capacity-building programmes are necessary to support Indonesia's transition to international research standards in certain S&T fields.

Preferences for specific partners in international S&T cooperation

Our findings are based on interviews with representatives from governmental organisations, GRIs, and universities and with individual scientists. The interview material is complemented by written information, such as annual reports or research programmes, given to us during the field study.

Generally speaking, the GRIs' level of S&T development had an impact on international cooperation with specific countries or regions. Some of these institutes were still in the capacity-building stage, with research networks located only in ASEAN member states. They still were publishing most of their research findings within Indonesia in the national language and not in international journals. These GRIs prefer to enter into 'real cooperation', which includes a long-term approach with training of students and post-docs, co-publication, and eventually co-patenting. Research cooperation experience with EU projects and scientists, respectively, left many Indonesian scientists with the impression that the European counterpart only followed a short-term cooperation strategy.

Some of these GRIs in the initial capacity-building stage are engaged in traditional S&T cooperation with multinational or regional organisations, for example, with the UNDP and the ADB, working on topics such as the global environment. Other GRIs were already iwell connected internationally and had very ambitious research agendas, including biotechnology, ICT, renewable energy, and environmental sciences. Joint projects financed by the EU FPs, however, were very difficult for them. Some of the GRIs applied, but most failed to obtain funding. Application procedures are regarded as too difficult to meet, requiring a lot of bureaucratic work. Knowledge about application to the FPs was generally lacking in most GRIs. Generally speaking, there was a lack of information about the FP financing mechanisms and application requirements among scientists and GRIs. National S&T organisations failed to offer the support necessary to enable a better understanding of the programmes.

A common feature in GRIs' international S&T cooperation was, however, that all had rather strong relationships with Japan and some traditional ties with the Netherlands. At the institutional level, the relationship was first established through personal contacts by students or researchers, supported by exchange programmes and post-doc training. Alumni networks for students and long-term personal relationships between Japanese PhD supervisors and their students from Indonesia helped to keep the cooperation alive. Funding through the Japanese Science Programme and travel grants from the Indonesian government smoothed the establishment of an S&T partnership between Indonesia and Japan. In contrast to other countries, Japan also offered funding to initiate such cooperation.

Indonesia's strong relationship with Japan is also reflected in the list of the current international cooperation agreements and S&T cooperation of BBPT, LIPI and LAPAN, collected by RISTEK during its visits to these organisations, the largest non-departmental GRIs. Research cooperation between these GRIs and Japan occurs mainly in the fields of marine science, biotechnology, and communications technology. Cooperation takes place on the basis of a memorandum of understanding (MoU), and it is often not clear to what extent these framework agreements are active or if joint research projects are executed.

Box: Voices from governmental institutions and scientists in Indonesia

Governmental institutions:
We need support for the identification of potential research partners in the EU. It is difficult to define what the research priorities are in each of the EU countries.
Access to funding should be easier, and should consider the thematic research priorities in Indonesia.
The exchange of research personnel and students should be less bureaucratic and better funded.
(Source: Face-to face interviews)

Scientists:
When S&T cooperation with the EU and Japan are compared, funding from the Japanese side is much easier to obtain. Research networks with Japanese scientists are based more on personal relationships, are long-term oriented, and involve mutual trust. The EU' FPs are too bureaucratic, and many of the regulations give the impression of mutual distrust.
(Source: Face-to-face interviews).

LAPAN's international cooperation activities focus more on multilateral agencies such as the Asia-Pacific Network for Global Change Research (APN), the ASEAN Sub-Committee on Space Technology and Applications (SCOSA), etc. At the bilateral level, a mixture of S&T partners from different countries exist in space technology research, including Germany, India, China, Japan, and Russia. When studying the list of LIPI's international collaborations, it becomes clear that quite a number of cooperation projects fall into the category of capacity building because they concentrate on training, exchange of researchers, and general networking.

Cooperation with ASEAN extends to a number of fields and includes scientist mobility programmes, especially travel grants. Universities are also active in the ASEAN university network, but cooperation is mostly at the faculty level and is strongly diversified. Each faculty has its own programmes, which act independently from each other. There is a growing interest in the S&T cooperation with China.

Research cooperation with the USA is not well developed. Until the 1960s, many students and scientists went to the US, but this relationship later cooled down for a number of political reasons. Only recently has there been renewed interest on the side of both the US and the Indonesian government. According to NRC, most students want to go to the US, Australia, or Canada to study.

Traditional S&T cooperation with the Netherlands still exists, but its importance seems to have diminished due to more cooperation with Japan, ASEAN, and other European countries.

Summary of findings in Indonesia

In sum, the questions of why Indonesia is engaged in international S&T cooperation, what the most important partners or regions in S&T are, and which fields of cooperation are preferred can be answered as follows:

- International S&T cooperation is viewed by both government representatives and scientists as being very important in order to compensate for existing deficiencies in S&T, especially S&T research capabilities, infrastructure, and funding.
- There is no specific international S&T cooperation policy, but extra-scientific reasons for collaboration, such as historical relationships/colonial experience (with the Netherlands), and political objectives, such as regional cooperation policy (ASEAN COST-activity), shape the collaboration pattern to some extent.
- Cooperation with Japan predominates in Indonesia's international S&T cooperation activities. Compared to other partner countries, funding is easier to obtain in cooperation with Japan and cooperation is based on long-term personal relationships, the mode of collaboration preferred by Indonesian scientists.
- S&T collaboration with the EU and European scientists, respectively, has basically taken place within the framework of a centre-periphery relationship; in the past, funding was mostly offered through development aid projects.
- Among Indonesian scientists there is strong resentment at being treated as an outdoor laboratory and second-grade scientists. The EU FP-7 is seen as an opportunity for closer participation on an equal level.

2.3 Malaysia

2.3.1 Key characteristics of Malaysia's S&T system and policy

Since the introduction of the first development plan in the 1960s, the Malaysian government has emphasised the crucial role of S&T. Initially, the support of S&T development was pursued within the framework of the country's overall industrial policy, which changed from import substitution in the 1960s and 1970s to export-oriented industrialisation in the 1980s. In order to improve the level of industrial technological development and attract more FDI, export processing zones and more S&T institutions were established (Asgari and Yuan 2007, 171-3).

In the 1980s and 1990s S&T policies were integrated into the industrial development plans. In the *Fifth Malaysia Plan* (1986-1990), S&T policies were clearly specified, but according to some scholars, not all objectives of the plan were achieved due to minimal budget allocation and a shortage of S&T institutions (Asgari and Yuan 2007, 179). In the following five-year period (1991-95) emphasis was placed on the provision of basic infrastructure and services for the sciences and technology. Another important goal was to ensure that public R&D programmes became more market-oriented (Govindaraju et al. 2005: 2). Parallel to the national five-year plan, special S&T plans were introduced.

Malaysia's first long-term S&T plan *(Action Plan for Industrial Technology Development, 1990-2000)* was designed to tackle the shortcomings in the innovation system by introducing new S&T institutions.[7] Financial schemes to promote S&T development in strategic sectors and key priority areas were implemented. After a review of the first S&T plan, the *Second National S&T Plan* was published in 2003 and will be in effect until 2010.

One of the main objectives is to bring government, industry, universities, and GRIs closer together. By 2010, the R&D expenditure as a percentage of GDP should have increased to 1.5%. Furthermore, the plan requests that the human resource intensity in R&D should rise to 6 researchers per 1,000 members of the labour force. Various goals for S&T development have been specified in the following key priority areas (Krishna/Report Malaysia):

- Improvement of research and technological capacity and capability
- Support for faster commercialisation of research outputs
- Strengthening of human resource capacity
- Creating a culture of S&T development and techno-entrepreneurship
- Creating a more efficient institutional framework with management of S&T and monitoring of S&T policy implementation
- Better diffusion and application of technology with stronger market-driven R&D activity
- Support of competence building in key emerging technologies

Today, the importance of S&T to the economy has even increased. In the vision statement of the Ministry of Science, Technology and Information (MOSTI), the central role of S&T is reflected in the following sentence: 'Science, Technology and Innovation for knowledge generation, wealth creation and societal well-being'. MOSTI's mission is then summarised as 'Harnessing Science and Technology through Innovation (STI) and human capital to value-add the agricultural and industrial sectors for economic advancement, particularly through Biotechnology, Information and Communications Technology (ICT)' (MOSTI website). This statement points to the three major fields of S&T on which the government is concentrating.

Malaysia also has long-term development ambitions, as stated by the government in the *VISION 2020*. This policy document envisions Malaysia as a fully developed country by the year 2020. *Vision 2020* focuses on nine strategic challenges, the sixth being innovation: Malaysia

> must confront the challenge of establishing a scientific and progressive society, innovative and forward-looking, which is not only a consumer of technology but also a contributor to the scientific and technological civilisation of the future (ETCI 2006: 31-5).

The current five-year plan (2006-2010) emphasises greater participation of women in science and innovation. This does not sound very special, but as Malaysia is a Muslim country, this policy decision aims to strengthen the incentives for women to go into sciences and, thus, to compensate for shortages of skilled labour. The plan also emphasises the promotion of international standards in tertiary education through the enhancement of the public service system and international cooperation. In addition, the five-year plan announces that a National Innovation Council (NIC) and a National Brain Gain Programme are to be established, raising the number of researchers to 50 per 10,000 labour force members by the year 2010. Another project is also

[7] According to Asgari and Yuan (2007: 180), one of these newly established institutions was the Malaysian Industry-Government Group for High Technology (MIGHT), established in 1993. This organisation was created to address specific issues of high-technology industries' development such as research priorities, funding, grants, etc. Another important institution promoting R&D activities was the Malaysian Technology Development Corporation (MTDC), established in 1992. In the same year, the Malaysian Science and Technology Information Centre (MASTIC) was founded, with the task of conducting national surveys on S&T development.

included, namely, the founding of a biotechnology centre in the region of Bandar Baru Nilai.

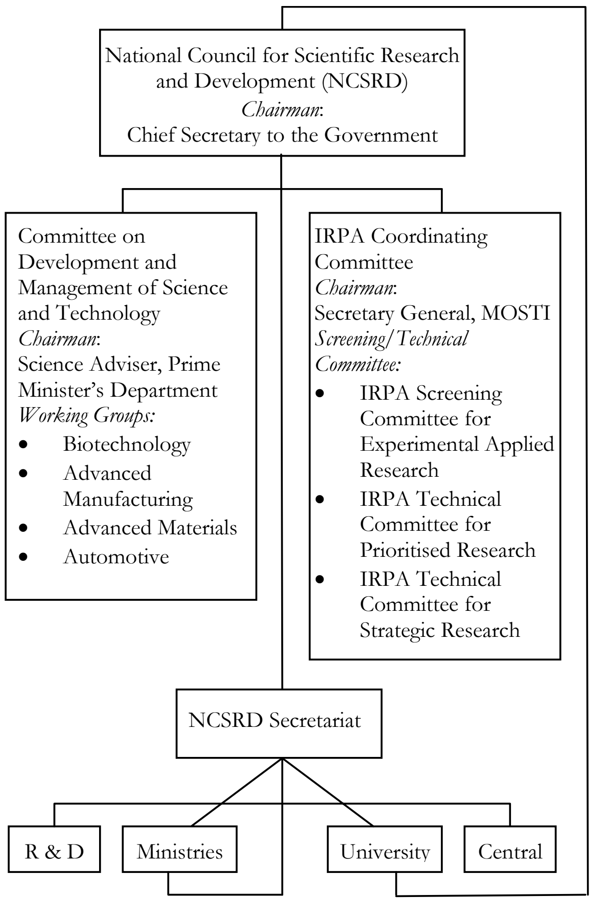
To summarise, S&T policy has been given high priority in overall economic policy making by the Malaysian government. Strengthening technological capacity has attracted more FDI and allowed for spill-over-effects in the transfer of technology from foreign companies to domestic firms. Despite the growing share of the private sector (including foreign companies) in the financing of R&D, the government sector, especially the GRIs, continue to be of crucial importance. Since the beginning of the 1990s, the private sector's position in the NIS has grown remarkably and reflects the transition from a government-driven innovation system to a more market-oriented system. Between 1992 and 2004 the business sector's share of overall R&D investment grew from approximately 45% to 71%. In the same period, the government sector's share fell from 46% to 28% (MASTIC 2006: 17).

Foreign companies investing in Malaysia have offered new technologies and management know-how to local industries in the context of joint ventures or OEM (original equipment manufacturing) cooperation. Through learning processes, local companies have strengthened their technological capabilities and incorporated this source of innovation into their R&D activities. This external orientation of the industry has represented, however, a challenge to the traditional role of GRIs as the most important channel for the transfer and diffusion of knowledge in Malaysia. In order to support the transition from a traditional agriculture-based economy to an economy relying more on knowledge-intensive industries, the government has supported the founding of new GRIs for industrial research.

New GRIs have been established by the government in various fields in the last few years, with the special mission of supporting sectors of strategic importance. Traditionally, GRIs concentrated on agriculture (for example, research in commodity crops such as rubber, palm oil and cocoa).[8] Newly established GRIs have been oriented towards the strengthening of industrial development in fields such as ICT, microelectronics, nuclear technology, and biotechnology.[9] In addition, a specific research institute with the mission of supporting technology transfer to SMEs and guaranteeing improvements in the areas of industrial standardisation and quality was established in 1996 (SIRIM, Standard and Industrial Research Institute for Malaysia). This institute's research personnel more than doubled between 1992 and 2002 (from 54 to 124). In 2002, however, the largest GRIs in terms of the number of research personnel were still found in the area of agricultural research.[10]

Figure 6 provides an overview of Malaysia's S&T system. The Ministry of Science, Technology and Innovation (MOSTI) is the leading governmental institution in policy formulating and programme implementation. As an advisory body, the National Council for Scientific Research and Development (NCSRD) provides advice and policy directions on S&T to MOSTI. The ministry itself acts as the secretariat to the NCSRD, which is chaired by the chief secretary to the government and includes representatives from GRIs and universities.

Figure 6: Organisation chart of Malaysia's S&T system



Source: Krishna/Report Malaysia.

Malaysia's S&T indicators reflect the progress made over recent decades. R&D expenditure as a percentage of GDP almost doubled between 1992 to 2004 from 0.37%

[8] The most well-known GRIs in this field were the Rubber Research Institute of Malaysia (RRIM); the Palm Oil Research Institute Malaysia (PORIM), which was merged in 2000 with the Palm Oil Licensing Authority into the Malaysian Palm Oil Board; the Malaysian Cocoa Board; and the Malaysian Agricultural Research and Development Institution (MARDI).

[9] Examples are the Malaysian R&D in ICT and Microelectronics (MIMOS); the Malaysian Institute for Nuclear Technology Research; and the Institute for Medical Research.

[10] In 2002, the Malaysian Agricultural Research and Development Institute employed 407 personnel; 358 R&D personnel were working in the Palm Oil Research Institute of Malaysia and 295 in the Forest Research Institute Malaysia.

to 0.64%. The business sector became the most important actor in the financing financing and undertaking of R&D. In 2004, 71% of total R&D was funded by the business sector and 28% by the government. In addition to GRIs and the private sector, universities also conduct R&D. The government subsidises research by public universities, but only a limited number of universities are important for R&D and for the provision of scientific, technological, and engineering courses and training (Asgari and Yuan, 2007: 86; Krishna/Report Malaysia).[11] Malaysia's institutes of higher learning (IHL) saw strong upward movements of their share of R&D conducted, from 9.2% in 1992 to 18% in 2004 (see Table 8). Despite the increased participation of universities in R&D, some Indonesian scholars point to the weak university-industry linkage and the low rate of commercialisation of research findings by universities. Taking the example of life sciences, even the University Teknologi Malaysia (UTM), the premier engineering institution in the country, was not able to obtain any significant licensing revenue from the commercialisation of its patents. Two major reasons were given to explain this phenomenon: 1) there is a lack of interest on the part of the industrial sector to invest in technology and buy domestically developed inventions on the one hand, while 2) university researchers are not fully aware of the commercialisation potential of R&D activities on the other (Rasli 2005: 1-4).

Table 8: Malaysia's R&D performance in 2004/5

Indicators	
GERD (2005)	0.64
GERD by Performance Sector (2004, %)	
Business Enterprise Sector	71.5
Government	10.4
Higher Education	18.1
Distribution of R&D by Type (%)	
Experimental Development	28.5
Applied Research	55.2
Basic Research	16.2
Patenting Activities (number of patents, 2005)	
Patent Applications	6,286
Patent Awards	2,508
Non-resident Patent Applications	5,764
Non-resident Patent Awards	2,471
Number of Universities	28
Number of GRIs	44

Source: MASTIC 2006.

Malaysia's R&D expenditure by type of research demonstratedsome change between 1992 and 2004 as well. The share of basic research increased in this period from 12.5% to 16.2%. In contrast, the shares of applied research and experimental development declined from 62.7% to 55.2% and from 38.2% to 28.5%, respectively (MASTIC 2006: 20; 35). Patenting increased rapidly, but patents registered by non-residents constituted the majority of the total patents granted. This points to the outstanding role of MNCs.

2.3.2 Malaysia's international S&T cooperation policy

We now turn to the question of what the reasons for international S&T cooperation in Malaysia are. International S&T cooperation was assessed by most representatives from governmental institutions as being very important. As an open economy which relies heavily on technology transfer from abroad, government policy has been designed to increase the country's absorptive capacity and to cooperate with foreign partners in R&D. Looking at the reasons for international cooperation in more detail, we come to the conclusion that *country-specific priorities* play a crucial role. The heavy emphasis on agro-biotechnology (with the highest share of government funding, see MASTIC 2006:8) can be explained by Malaysia's large and well-developed agricultural sector. *Global thematic priorities*, on the other hand, are important as well, especially with regard to ICT. *Transnational learning, innovation benchmarking,* and *co-patenting* are ranked as being equally important (see Figure 7).

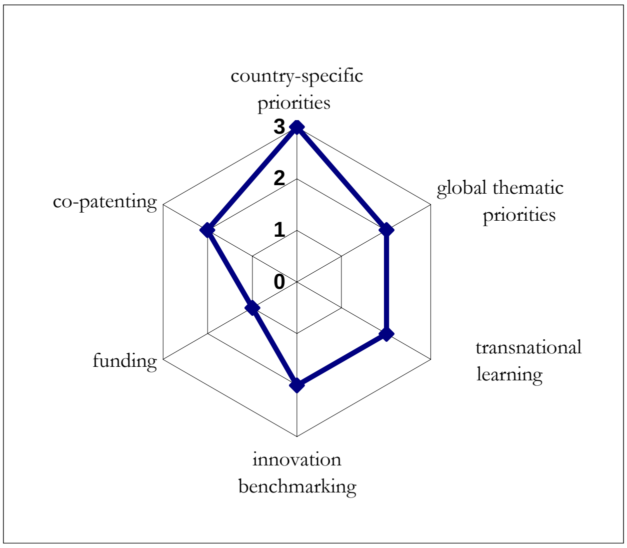
As is the case in Singapore, the shortage of skilled labour is an additional driver for international cooperation. The Malaysian government is paying great attention to this topic and established a special programme (Brain Gain Malaysia) at the beginning of December 2006. On the programme's website (http://bgm.mosti.gov.my/index.php?page=aboutbg/about_nbgp) the objective of this initiative is stated as follows: 'leveraging the talent pool of Malaysian Diaspora and/or foreign Researchers, Scientists, Engineers and Technopreneurs (RSETs) residing abroad through incentive offerings for mutual benefit.' The focus of this programme is on obtaining experts in the key industries Malaysia wants to become internationally competitive in, namely, biotechnology, ICT, industry (advanced material, advanced manufacturing, nanotechnology, and alternative energy), oceanography, and aerospace.

Like Singapore but in contrast to other countries in the region, Malaysia does not give *research funding* a high ranking for international cooperation, as it is able to finance research independently. From the perspective of individual scientists, the reasons for international S&T collaboration diverge to some extent from those given by government representatives (see Figure 8). Due to the fact that GRIs and universities have good access to funding and that the research *infrastructure* is well developed, these two factors do not rank high as triggers for international S&T cooperation. That co-patenting is also not regarded as very important for international

[11] According to Asgari and Yuan (2007: 184), these universities are the University of Malaya (UM), the University Putra Malaysia (UPM), the National University of Malaysia (UKM), the University of Science Malaysia (USM), and the University of Technology Malaysia (UTM).

S&T cooperation fits with the critique mentioned above regarding the lack of commercialisation of research findings on the part of scientists mentioned.

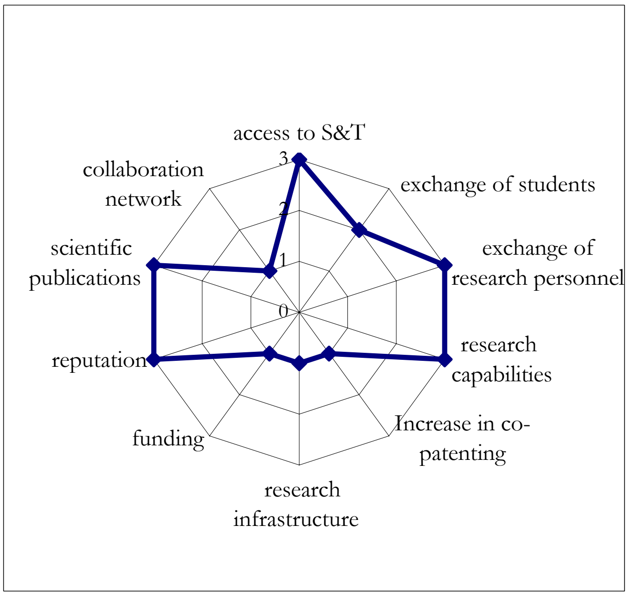
Figure 7: Reasons for international S&T cooperation: The view of governmental institutions in Malaysia



Source: Authors' assessment based on interviews.

Those factors ranking high as individual scientists' motivation for S&T cooperation with foreign partners (*scientific publications, reputation, research capabilities, exchange of research personnel* and *access to new S&T*) reflect the new incentive system at research institutes and universities (see Figure 8). Academic performance is strongly rated by superiors and forms the basis for further promotion.

Figure 8: Reasons for international S&T cooperation: The view of scientists in Malaysia



Source:. Authors' assessment based on interviews.

That international collaboration networks are not regarded as being very important can be explained by the internally oriented perspective of many scientists and the existence of international collaboration networks with specific countries due to historical and political ties.

Which fields of international S&T cooperation are most important for Malaysia?

The most important thematic focus areas for international S&T cooperation presented to us during the discussion in Malaysia were 1) genomics and molecular biology, 2) nutraceuticals and pharmaceuticals, and 3) agricultural biotechnology. These areas are politically defined by MOSTI in order to ensure funding can be focuses on these key research fields.

Preferences for specific partners in international S&T

Preferences for specific partners in international S&T cooperation do not exist according to representatives from the Malaysian government. They instead describe the choice of collaboration partners as being 'researcher driven'. However, mobility funds and funding for international collaboration networks by the government are rather limited and not very encouraging. The government concentrates on creating a suitable framework for scientists' international cooperation through officially established bilateral S&T agreements with other countries. On MOSTI's website, specific bilateral agreements on science, technological and environmental cooperation with various countries are listed. Within the wider Asian region, these agreements exist with China, the Democratic Republic of Korea (DPR) Korea, India, South Korea, Vietnam, Australia, and New Zealand. In Europe, Denmark, Germany, Hungary, and Poland are listed as partners. The remaining countries are Egypt, Pakistan, Syria, Tunisia, Russia, and Brazil. While S&T cooperation agreements (MoUs) with Australia and Korea had already been established in the middle of the 1980s, most other agreements were signed in the 1990s and those with Russia, Pakistan, and the DPR Korea between 2002-2005. Not surprisingly, no such agreement exists with the USA. Relations with the USA have traditionally been more difficult and stagnated to some extent after 9/11. The political climate for bilateral relations seems to have changed in the last few years, though. This is reflected in the renewed interest of Malaysian scientists to work with colleagues in the US and an ongoing discussion in the USA about closer cooperation with Islamic countries.[12]

[12] There is also a discussion underway in the USA about S&T relationships with Islamic countries, and the US government is being urged to expand cooperation with these countries. D'Arcy and Levi (2005).

Traditionally, cooperation in S&T was strongest with the UK, due to colonial ties and language advantage. The widespread use of English and the similarities in the educational systems have positively contributed to an intensive exchange of students between the UK and Malaysia. Built on alumni networks with UK research institutions and supported by common research programmes financed by the UK, the historically strong S&T collaboration has been maintained without the existence of a formal bilateral S&T agreement between the two countries.

In the 1980s, Japan was the blueprint for Malaysia's industrial policy and, because of its technological leadership position, a preferred partner in S&T collaboration. In the following decades S&T cooperation was extended to many other countries, such as South Korea, Taiwan, and China in Asia and the Netherlands and Germany in Europe.

Extra-scientific S&T relationships also exist with other ASEAN member countries and with the Organisation of Islamic Countries (OIC). The tie with the latter organisation is perceived as part of Malaysia's South-South cooperation, which also involves countries such as Kenya and might explain cooperation agreements with Syria, Egypt, Tunisia, Pakistan, and, in ICT, with Libya and Morocco (since 2002) (MOSTI Facts & Figures 2006: 9).

Box: Voices from governmental institutions in Malaysia

MOSTI, Malaysia:
'The key players in R&D, or in knowledge production, have traditionally been the USA, Europe, and Japan. However, the GERD of the USA and Europe is gradually declining, and instead, China is coming up as an emerging economy, along with, to a lesser extent, India. Among the Asian countries, the Republic of Korea, the Republic of Taiwan, and Singapore have all broken the 2% barrier in terms of percentage of GDP spent on research and development, while China is on its way to achieving its target of 1.5%.'
(Source: MOSTI (2006), *National Survey of Research & Development – 2006 Report,* p. 63)

MASTIC, Malaysia:
'Scientists in Malaysia mostly collaborated with colleagues in the country, producing 13,386 joint papers. Collaboration with foreign scientists saw Malaysian scientists working more with those from the United Kingdom (1,043 papers), followed by collaboration with scientists from the USA (790 papers), Australia (531 papers), Japan (530 papers), China (426 papers), India (351 papers), Singapore (269 papers), Thailand (211 papers), and Scotland (199 papers).'
(Source: MASTIC (2003), *Science and Technology Knowledge Productivity in Malaysia, Bibliometric Study,* p. 6).

From the individual scientists' perspective, MoUs between universities are creating a supportive framework for intensifying international cooperation, as the commitment from both sides is usually stronger. Personal relationships with scientists are regarded as important and helpful. Cooperation with partners in Japan and South Korea has shown good results, due also to close monitoring and constructive intervention. Cooperation with ASEAN is geared to Singapore on the one hand, because of interest in collaboration with well-equipped research labs and well-known scientists, and to technologically less developed ASEAN member states such as Vietnam and Myanmar on the other hand, because of joint projects within the ASEAN COST programmes.

Participation in the FPs of the EU has been rather limited. There are several factors influencing this phenomenon. The lack of knowledge about FP research areas and funding mechanisms seems to be widespread, and those who have experience in EU funding complain about an inflexible bureaucracy. As the success rate of applications is low, not much incentive exists to apply when local research funds or funds from other countries are more easily available.

Summary of findings in Malaysia

In sum, the questions of why Malaysia is engaged in international S&T cooperation, what the most important partners or regions in S&T are, and which fields of cooperation are preferred can be answered as follows:

- International S&T cooperation was viewed by both government representatives and scientists as being very important. In contrast to other low-income ASEAN member states, funding and S&T infrastructure were not as important to Malaysia's international cooperation.
- For scientists, reputation, scientific publications, and access to new S&T were important reasons for S&T cooperation.
- No specific international S&T cooperation policy exists, but extra-scientific reasons for collaboration such as historical relationships/colonial experience (with the UK),;political objectives, such as regional cooperation policy (ASEAN COST-activity); and cultural linkages (cooperation with other Muslim countries) shape the collaboration pattern to some extent.
- There has been a shift in S&T partners from Japan (look-East policy) to other countries in Asia and Europe. The expansion of scientists' global S&T networks is, however, limited due to the small-scale of mobility funding available from the government.
- Knowledge about FPs and participation rates in FPs are low. Easily obtained funding for domestic research projects from sources within Malaysia and

more successful cooperation with countries with more flexible bureaucracies (regarding application and funding procedures) explain this situation to some extent.

2.4 Singapore

2.4.1 Key characteristics of Singapore's S&T system and policy

Singapore is the leader in S&T development within ASEAN. Industrial policy played a crucial role in turning the city-state first into an international manufacturing centre and then into a knowledge-based economy, overcoming its small size and very limited natural resource endowment (Yue and Lim 2003: 259). The government's industrial policy put much emphasis on the facilitation of technological learning from MNCs (Wong 1999). Targeted efforts were made by the government to provide MNCs with skilled labour through the establishment of specific programmes. The transfer and diffusion of technology from MNCs to local industries helped to increase the international competitiveness of Singaporean companies. Despite strong state support for S&T development through market and non-market intervention, Singapore did not follow a technonationalist approach. Industrial policy concentrated mainly on setting the framework condition for this success story, especially on human resource development and the strengthening of infrastructure for transport and telecommunication. The government also liberalised access to domestic industries for MNCs and guaranteed an open economy, which was necessary to attract foreign direct investment in manufacturing and R&D. Based on the literature review, we conclude that international cooperation played a very prominent role in the formulation of Singapore's S&T policy.

Long-term visions and plans combined with short-term interventions in some areas are characteristic of Singapore's innovation policy. One example is the targeting of the IT industry and IT research. In the middle of the 1980s, the National Computer Board introduced the National IT Plan for Singapore, emphasising the development of IT professionals and experts and ICT infrastructure and application. One important element of the IT policy was the liberalisation of the telecommunications industry in the following years and the development of broadband infrastructure. The introduction of an e-Government Action Plan in the 1990s helped the diffusion of e-commerce (Yue and Lim 2003: 285-93).

Since the 1990s, the strategic focus of S&T policy has been changed to some extent and the development of indigenous technological innovation capabilities has been given stronger support. In order to achieve its ambitious goal of becoming the region's R&D hub, the government has begun to restructure the NIS by founding new research institutes and broadening its international S&T cooperation in the last few years (Monroe 2006: 6-7). One of the main focuses of this policy is the support for biotechnology, and especially biomedical science as a particular sector. The government has invested about US$20 billion in research and industrial parks and has introduced financial assistance for start-up companies. A strong role in this new direction has been played by the Economic Development Board (EDB) and the National Science and Technology Board (NSTB) – in 2001 reorganised into the A*STAR (Agency for Science, Technology and Research) – both of which report to the Ministry of Trade and Industry (MTI), and the Singapore Productivity and Standards Board (SPSB). These governmental agencies worked together on the design of Singapore's National Innovation Framework of Action, adopted in 1998. Subsequently, A*STAR has been responsible for designing the five-year plans on S&T. The S&T 2005 Plan underlines the new focus on R&D capabilities in niche areas such as biomedical R&D. An important element in the support of this S&T field is the emphasis on the recruitment of global talent and on strong international relationships and networks. Policies in support of biomedical development include not only financial incentives but also the attraction of foreign experts and close cooperation with private firms (Chaturvedi 2005: 109-11).

With the growing competition in the ASEAN region, S&T has become more crucial than ever to Singapore's economic development. The latest vision and mission statements by A*STAR, which is responsible for the design and implementation of innovation policies and research projects, represent the government's ambitious goals in this policy field. A*STAR's *vision* is 'A prosperous and vibrant Singapore built upon a knowledge-based economy'. A*STAR announces in its *mission statement* that it will foster 'world-class scientific research and talent for a vibrant knowledge-based Singapore' (A*STAR website).

The *Science and Technology Plan 2010 (STP 2010)*, introduced in 2006, is the fourth five-year national S&T development plan since Singapore began to focus its policy on the enhancement of its technological capabilities in 1991.[13] This strategic plan aims to secure sustained economic growth and strengthen international competitiveness. It has identified five so-called 'key strategic thrusts' of R&D (MTI 2006: Chapter 3):

- More resources for R&D
- Focus on selected areas of economic importance

[13] The first five-year S&T plan ('National Technology Plan') ran from 1991-1995 and had a budget of $2 billion. The second S&T plan (*National Science and Technology Plan*) has a budget of $4 billion and lasted from 1996-2000. The third S&T plan (*Science and Technology Plan 2005*) was funded with $6 billion and ran from 2001-2005 (MTI 2006: 8).

- Balance of investigator-led and mission-oriented research
- Encouragement of more private sector R&D
- Strengthening of linkages between knowledge institutions and industry

The *STP 2010* also includes some quantitative targets. For instance, the government aims to increase the GERD to 3%. The private sector should be the most important driver for S&T, funding two-thirds of total R&D. In addition, the *STP 2010* aims for an increase in the number of research personnel and the scientific output (MTI 2006: Chapter 11). In order to achieve these goals, the government will invest $13.55 billion over the programme's runtime. The National Research Foundation (NRF), founded in January 2006 as a department under the Prime Minister's Office, will receive $5 billion to fund new growth areas such as water and digital media technologies and strategic programmes. The Ministry of Education will be allotted $1.05 billion for its academic institutions. The MTI will be provided with the largest share of $7.5 billion to promote R&D through A*STAR and EDB.

Under the *STP 2010* various programmes are to be conducted to enhance the identified strategic thrusts. For instance, in order to encourage more private sector R&D, the government plans to strengthen the technological capabilities of SMEs through several technical, human resource, and financial assistance programmes. The plan also requests that the Technical Advisory Support (TAS) establish linkages between SMEs and research institutes. Furthermore, the Operation and Technology Roadmapping (OTR) supports SMEs in developing their own technology plans, while the Local Enterprise Finance Scheme (LEFS) finances the business operations of local SMEs at fixed interest rates (MTI 2006: 45). The establishment of the NRF as a new governmental actor, reporting directly to the prime minister's Research, Innovation and Enterprise Council (RIEC), should guarantee better coordination of the research activities of different agencies as well as better implementation of the national innovations strategies approved by RIEC (MTI 2006).

S&T input and output indicators clearly show the outstanding position of Singapore among the member countries of ASEAN. Based on the latest national survey of R&D in Singapore, the ratio of gross expenditure of R&D to GDP (GERD) was 2.39% in 2006 (see Table 9), the highest among the countries within ASEAN. Despite stronger support for GRIs in recent years, the private business sector is still the main driving force for S&T. In 2006, private sector expenditure on R&D accounted for 66% of the total, while the share of the government was 10%, that of the higher-education sector 11%, and that of GRIs 12%. The division of R&D expenditure by type and across fields of S&T shows the following: experimental development absorbed 47% of total R&D, applied research 32%, and basic research 21%. The basic research percentage is relatively high, even when compared to Western economies, and there is a pronounced government emphasis on translational research. The field of engineering and technology reported the highest share with 58% of total R&D, followed by biomedical and related sciences (21%), natural sciences (10%), agricultural and food sciences (1%). The remaining 11% was distributed to various fields of S&T. Singapore also has a strong record in patenting. In 2006, 2,036 patent applications and 933 patent awards were reported. Most of the patents were registered by the private sector (77% of applications and 83% of awards). The higher-education sector was awarded the same share of patents as the GRIs (A*STAR 2006).

Within the higher-education sector, two universities are of crucial importance for R&D: the National University of Singapore (NUS) and the Nanyang Technological University (NTU). Approximately 90 % of R&D expenditures by the higher-education sector comes from the government. About 95 % of the R&D spending of public research institutes is also covered by governmental funding (A*STAR 2006: 11).

Table 9: Singapore's R&D performance in 2006

Indicators	
GERD	2.39
Distribution of R&D across Institutional Sectors (%)	
Private Sector	66
Government	10
Higher Education	11
GRIs	12
Distribution of R&D by Type (%)	
Experimental Development	47
Applied Research	32
Basic Research	21
Distribution of R&D by S&T Rield (%)	
Engineering and Technology	58
Biomedical and Related Sciences	21
Natural Sciences (without biological sciences)	10
Agricultural and Food Sciences	1
Other Fields of Science	11
Patenting Activities (number of patents)	
Patent Applications	2,046
Patent Awards	933
Private Sector's Share of Patent Applications (%)	77
Private Sector's Share of Patent Awards (%)	83
GRIs' Share Patent Applications (%)	13
GRIs' Share of Patent Awards (%)	8
Higher-education Sector's Share of Patent Applications (%)	10
Higher-education Sector's Share of Patent Awards (%)	8

Source: A*STAR (2006), *National Survey of R&D in Singapore 2006*.

Given the strong performance of the private sector in R&D, it is not surprising that it employed the majority (61%) of the Singapore's researcher and engineers (total:

22,675) in 2006. Out of the total number of researchers and engineers, 85% were from Singapore. The higher-education sector absorbed 20% of total R&D manpower, especially those with a PhD (50% of all PhD holders). GRIs employed 10% of the R&D manpower, but only 24% of those scientists with a PhD. In the government sector, 9% of scientists were employed (5% of those with a PhD.)

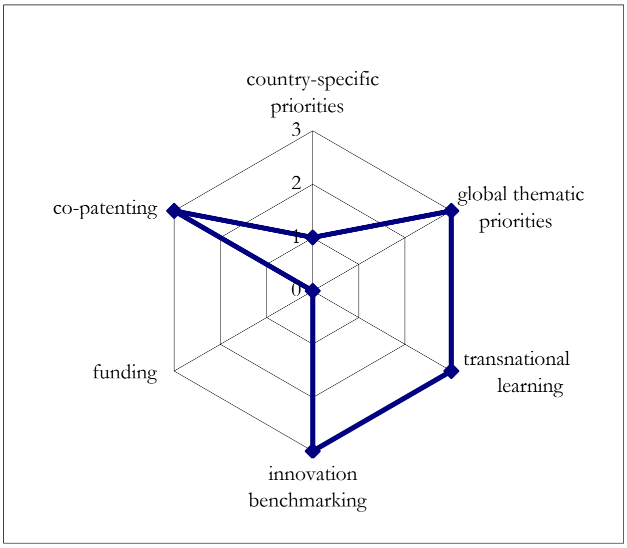
2.4.2 Singapore's international S&T cooperation policy

We now turn to the question of what the reasons for international S&T cooperation in Singapore are. Our field research findings confirmed our initial assessment based on the literature review: international S&T cooperation is seen as a high priority by the Singaporean government and by scientists in Singapore. In the interviews with governmental organisations (A*STAR and NRF) involved in S&T policy formulation and execution, two topics dominated: first, the concentration on new or emerging fields of S&T and, second, the shortage of skilled manpower for R&D and strategies to overcome this constraint. In both cases international cooperation is regarded as crucial. Up to the highest level of government, the experience of foreign experts and advisors from the academic arena and from leading international companies is actively sought. Foreign experts, for example, were involved in the discussion about the S&T fields Singapore should concentrate on, providing advice on future technology trends.

In our graphical assessment of the reasons why Singapore cooperates in S&T with other countries, governmental organisations placed great emphasis on *transnational learning, innovation benchmarking* and *co-patenting* (see Figure 9). In all three areas, the government has designed special policies, including a strict regime for the protection of intellectual property rights (IPR) and incentives for foreign companies to invest in R&D. In contrast to most other ASEAN-5 member countries, *global thematic priorities* are regarded as much more important than *country-specific priorities*, which fits with the city-state's overall policy of seeking specific S&T niches. It is interesting to note that funding receives a secondary ranking as a reason for international S&T cooperation. Considering Singapore's overall budget for R&D, this is not a surprising finding.

In discussions with governmental agencies the shortage of skilled manpower for R&D was stressed as one of the central motivations for Singapore's international S&T cooperation. With the growth of knowledge-intensive industries relying on R&D, this problem has become very urgent. In order to be attractive for investment by high-tech TNCs, the shortage of home-grown scientists has had to be addressed. Currently, around 80% of PhD students come from other countries. The main reason for this development is the strong preference of local graduates to enter directly into the business world instead of becoming PhD students. The Singaporean government has reacted to this problem and has designed a special programme ('Singha' programme for graduates) enabling to study abroad or to enter global networks. In addition, activities to attract foreign researchers and students to work and study in Singapore have been intensified.

Figure 9: Reasons for international S&T cooperation: The view of governmental institutions in Singapore

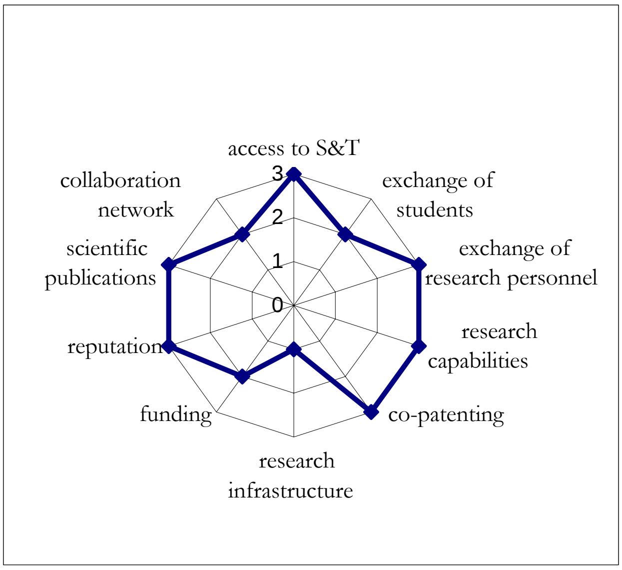


Source: Authors' assessment based on interviews.

A complex web of capacity-building programmes at universities, polytechnic institutes, and research institutes are offered by the government in order to increase international cooperation. A*STAR is heavily involved in attracting foreign scientists and encourages students from Singapore at all levels to go abroad. The NRF provides block grants for specific S&T fields. The NRF Research Fellowship Scheme is a globally competitive programme for young researchers to undertake independent research in Singapore. The programme CREATE (Campus for Research Excellence and Technological Enterprise) aims to bring the world's top research universities to Singapore to work together with Singapore's universities and research institutions. NRF also encourages the establishment of Research Centres of Excellence (RCEs) at Singapore universities with renowned international scientists. The RCE's directors are given an attractive R&D budget (€74 million. for a period of 7 to 10 years), which they can spend independently, for example, to invite top scientists from around the world.

Seen from the perspective of individual scientists, international S&T cooperation is mainly pursued due to factors internal to science and related to the intellectual and social organisation of science (see Figure 10). Scientists put a strong emphasis on the following: *access to S&T, scientific publications, reputation, increase in co-patenting,* *increase in research capabilities*, and *exchange of research personnel,* While the *exchange of students* is rated as quite important, access to *funding* and *research infrastructure* are of little importance to scientists in Singapore.

Figure 10: Reasons for international S&T cooperation: The view of scientists in Singapore



Source: Authors' assessment based on interviews.

For scientists working in high-level positions in GRIs or universities, the problem of finding well-trained researchers and students for laboratory work is one of the major challenges. Foreign scientists, for example, from Europe and the US, appreciate the comfortable funding situation and the well-equipped labs very much. Most of them find the environment they work in very conducive to R&D. However, some of them have their doubts about whether the administration has a comprehensive understanding of the requirements and benefits of basic research and its long-term design.

Which fields of international S&T coorporation are most important for Singapore?

The government's preferences in international S&R cooperation are based on the following three strategic areas of research:

1. Biomedical sciences translational and clinical research
   This programme concentrates on basic research and drug discovery. The biomedical industry cluster and the well-developed healthcare services system play supporting roles.
2. Environmental and water technologies
   These programmes have a focus on water recycling and water management as well as on clean energy development.
3. Interactive and digital media
   This programme includes research on animation, games and effects, computer-aided education, and media services.

For the biomedical sciences, a centre of research called Biopolis has been established. The first phase of Biopolis was finished in 2003 and saw the construction of seven buildings for around 2,000 researchers. The second phase of Biopolis began in 2005 with the enlargement of the original size of 200,000 square feet with an additional 400,000 square feet for private sector laboratories. The focal location of the other programmes will be Fusionopolis, a two-tower building with a total area of 120,000 square metres (A*STAR 2006).

In addition to this top-down approach, the NRF supports individual research activities through various programmes (see those mentioned above) such as CREATE, RCEs, and fellowship schemes. This bottom-up approach should make sure that new areas of research other than those currently supported can be identified (NRF 2008).

Preferences for specific partners in international S&T cooperation

We now turn to the preferences for specific countries or regions as partners in international S&T cooperation in Singapore. Our findings are based on interviews with representatives from governmental organisations, GRIs, and universities and with individual scientists. The interview material is complemented by written information, such as annual reports or research programmes, given to us during the field study.

Generally speaking, cooperation with specific countries is still related to Singapore's colonial ties with the UK and Japan. Quite a strong relationship therefore exists with research institutes and universities from these countries, and they pay a lot of attention to S&T cooperation with Singapore, for example, by having subsidiaries of their universities in Singapore. In June 2008, for example, the UK's Medical Research Council (MRC) announced the establishment of a Collaborative Research Fund with Singapore with a budget of $6 million for the study of infectious diseases. Both sides (MRC and A*STAR) will contribute half of the fund. The establishment of this research fund builds on the existing 'UK-Singapore Partners in Science' programme, which offers workshop and travel grants (Joint Press Release, 17 June 2008). In January 2006 a joint PhD training programme in biomedical sciences between A*STAR and the university of Dundee in the UK was established (Biome, 2006: 10).

Japan is also involved in Singapore's biomedical research network. In September 2005 RIKEN (Japan's network of public research institutes) and A*STAR signed an MoU with the aim of fostering exchange between researchers at RIKEN and Singapore's Biopolis (Biome, 2006:8).

EU-Singapore cooperation seems to be strong in some specific areas, such as ICT. In December 2004 the EU announced the GAPFILL initiative (Getting more Asian Participants involved in IST/Information Society Technologies) in Singapore and offered €1.8 billion for collaboration between Singaporean research institutes and companies in two IST grants (Euro-Singapore Media release, 27-28 January 2005). According to a joint report by Singapore and the EU, under FP-6 nearly 90% of applications from Singapore for funding on ICT themes were accepted (EU 2007: 9), demonstrating Singapore's strong development level in this area.

In addition to the UK, Singapore has also intensified S&T cooperation with other EU member countries in recent years. In May 2006, A*STAR and a consortium of Swedish research foundations signed a Memorandum of Intent (MoI) to promote and support bilateral R&D. Long-standing ties between the Karolinska Institute in Sweden and Singapore exist, as the president of Karolinska (Prof. Harriet Wallberg-Henriksson) is a member of the Singapore Biomedical Science International Advisory Council (Joint Press Release, 11 May 2006). An MoI was also signed between A*STAR and the National Office for Research and Technology (NKTH) of Hungary in 2006. It aims to promote research cooperation in engineering and biotechnical research through workshops and student exchanges.

Singapore has an extensive cooperation network with the US because of the latter's prominent position as the leader in many S&T fields. One example is the collaboration between A*STAR, the NUS, and the University of California in six research fields, including cancer research and stem cell biology (Biome, 2006: 8). Various top scientists from the University of California and from the US National Institute of Health have joined A*STAR to work in the Institute of Molecular Cell Biology and the Institute of Clinical Sciences (Biome, 2006: 10).

Historical and cultural ties between China and the Chinese diaspora in Singapore explain the large extent of exchange programmes for students and scientists at the NTU with China. Other extra-scientific factors explain why Singapore cooperates closely with its neighbours. As the most technologically advanced country within ASEAN, the Singaporean government is committed to cooperating with other ASEAN member states. Research cooperation is concentrated on more advanced neighbours such as Malaysia, while exchange programmes at universities and polytechnic institutes are offered to scientists in other ASEAN member countries which are still in the capacity-building stage.

In looking at the situation of Singapore's international S&T cooperation policy in detail, we have found that national S&T policy does not specify any preferences for S&T cooperation partner countries or regions. Singapore's government agencies are globally oriented. A*STAR, for example, picks the best scientists in each research field and approaches them directly for cooperation. NRF has no special funding for international networking among scientists. They describe the way of finding partners for S&T as a bottom-up-process, with universities establishing international cooperation for student and researcher exchanges. For GRIs, in contrast, some special incentives exist to cooperate with foreign partners in cutting-edge technologies. Although students from Singapore can chose whatever country they want to study in, they prefer the UK or the US due to the lack of language barriers. Most of them speak only English as a 'foreign language' and not any other European language. That Singaporeans have a strong tendency to study and cooperate in S&T with the USA instead of Europe is seen by some scholars as being based on a lack of knowledge about existing academic and research opportunities. Besides the UK and the US, according to some interview partners, the third most important geographical destination for students wanting to study abroad is Japan.

Universities' international cooperation policies have traditionally been oriented towards bilateral S&T relations as the preferred mode of cooperation, not towards regional entities. The NTU, for example, besides its traditional S&T relationship with the UK, undertakes bilateral cooperation with specific countries in the EU such as Germany, France, Switzerland, Hungary, Italy, the Netherlands, Norway, and Sweden. It is currently extending its cooperation partners to include Croatia and Russia.. Within the ASEAN region, research cooperation exists with scientists from Malaysia and the Philippines. Recently, universities in China and India have become attractive for cooperation due to the rapid technological development in these countries. Besides student exchange programmes, the NTU runs a Masters of Public Administration, which city mayors from mainland China can also participate in. The research priority areas at the NTU include nanotechnology and nanoscience, interactive & digital media, and life sciences (NTU, Research Report 07).

Research at the National University of Singapore (NUS) is strongly oriented towards English-speaking countries, especially the US and the UK, but the university also collaborates with other EU countries such as France. Research areas at the NUS include biological science, chemistry, pharmacy, mathematics, and physics. Within ASEAN, research ties with Thailand (Chulangkorn University) are the strongest. In terms of the number of foreign students studying at NUS, most of them come from China and India. The university's student exchange programme (SEP) offers the opportunity to study one or two semesters at the University of California, the University of British Columbia, King's College, the Karolinsaka Institute, or the University of Melbourne. A double degree programme with the French Grandes Ecoles exists also; it is designed as an elite programme for top students in engineering and science.

Box: Voices from governmental institutions and scientists in Singapore

Government representatives:
'Traditionally, we have approached Europe on a country-by-country basis, often concentrating on the UK due to close historical ties. There is an obvious transition in the role the EU is playing as a representative body of all EU member countries. For most scientists and students in Singapore, however, there are still too many barriers to cooperation, such as a lack of knowledge about the FPs, language barriers, and the lack of traditional networks…'
(Source: Face-to-face interviews).

Nanyang University:
'NTU has a considerable presence in Europe and is frequently viewed as a partner of choice for top Europe-based institutions and organisations. Coupled with that is the growing number of high-calibre European faculty and research students joining the university.
Europe continues to be a major source of funding for NTU research. The university has submitted proposals to the French Embassy´s science and technology funding initiative, the Merlion Programme, and has also made successful bids under EU´s Asia Link Programme and its Framework Programme for Research and Technological Development.'
(Source: Nanyang Technological University, *Annual Report 2007*)

For individual scientists, the choice of cooperation partners depends basically on a complementary exchange of knowledge. They themselves look for scientists they want to work and form partnerships with. The capability of assessing the quality of foreign research partners – which was stressed by most interview partners – is quite strong in Singapore. International research cooperation with the EU already exists on different levels, but some scholars and representatives of GRIs and universities pointed to a surprising lack of knowledge about the EU in general and about EU research-funding schemes in particular. Those who are familiar with the FPs stressed the heavy administrative burden for large projects with various partners in the EU and Asia and the fact that the chances of obtaining funding are not as good when compared to the funding schemes in Singapore. To some very critical interview partners (from Europe), the evaluation procedures of the FPs show more resemblance to 'a lottery than to an evaluation'. As Singapore is no longer eligible to receive funding for research projects under FP-7, incentives for scientists to apply for project funding are limited. This was viewed quite critically by those foreign scientists we interviewed in Singapore. Because of the city-state's role as an S&T portal for the whole of ASEAN, they suggest giving Singapore an intermediary role and continuing the FP funding to scientists. In the perspective of some foreign experts, EU officials ignore the high state-of-the-art in many S&T fields in Singapore. For scientists in Singapore, the intended objective of cooperation in the FPs – to get to know and to enter research networks with the EU – is not very attractive as most of them already have well-established networks with their academic community.

Summary of findings in Singapore

In sum, the questions of why Singapore is engaged in international S&T cooperation, what its most important partners or regions in S&T are, and which fields of cooperation are preferred can be answered as follows:

- International S&T cooperation is the key to Singapore's economic and technological success and is strongly supported by the government.
- Attracting and keeping experts in those S&T fields in which Singapore wants to become internationally competitive is one of the biggest challenges facing the city-state in the global race for the best experts.
- Biomedical research in particular requires highly qualified scientists with a good reputation who can serve a pull-function and attract other well-known scientists to come to Singapore.
- As the government offers comprehensive funding for the strategic fields of S&T, the inflow of foreign researchers has grown in the last few years.
- While the EU acknowledges that 'Singapore has emerged as a world-class research performer in its own right', the incentive problem for scientists in Singapore because they are no longer eligible for direct FP funding is often overlooked as a barrier to cooperation.

2.5 Thailand

2.5.1 Key characteristics of Thailand's S&T policy and system

The Asian crisis at the end of the 1990s revealed Thailand's structural weaknesses and the need to increase its innovative capacity. Although the country was able to achieve high economic growth rates in the 1980s and 1990s, economic development was predominantly based on factor inputs and not on productivity (Altenburg et al. 2004: II). That the innovation system is government-driven is reflected in the fact that the business sector is still investing very little in technological development. Between 1999 and 2005 the business sector's share of financed and executed GERD even declined. This seems to be a reflection of both structural problems in the manufacturing industry, which increased after the Asian crises, and the predominance of small enterprises not willing or able to invest in R&D. The percentage of Thai firms doing process innovation is very low (2.9%) compared, for example, to companies in South Korea (21%). Only recently does this situation appear to have changed to some extent with more large conglomerates investing in R&D and a stronger R&D collaboration between small firms and universities (Intarakumnerd 2005: 17).

The Thai government has included the idea of S&T-based development in its five-year plans since the beginning of the 1980s, but no specific policy instruments were initially designed or agencies established to enforce the guidelines. The founding of the National Science and Technology Development Agency (NSTDA) as an autonomous organisation operating under the policy guidance of its own board and chaired by the Ministry of Science and Technology (MOST) in 1991 is regarded as the first step towards a profound change in the Thai NIS. Confronted with the economic crisis in 1997 and the need to strengthen S&T development as a source of further economic growth, the collaboration between public and private institutes and industries was given high priority. Among the new policy measures to support the interaction between scientific institutions and firms were the establishment of intermediary institutions such as incubators, the provision of better S&T networks and services, and the transfer and diffusion of technology. The ninth development plan (2002-2006) acknowledged this policy in detail (Altenburg et al. 2004; 42-43).

Thailand's latest S&T policy document (*The National Science and Technology Strategic Plan 2004-2013*, issued by the National Science and Technology Policy Committee, NSTPC) presents the main objective of transforming the country into a knowledge-based society as follows:

> to enhance Thailand's capability to be able to effectively respond to rapid changes in the age of globalization and to strengthen the country's long-term competitiveness under the vision: Thailand is economically competent, being a knowledge based society, globally competitive, socially secured and all the citizens have good quality of life'. (NSTPC 2004: iii)

The objectives of this plan, as well as MOST's 'vision' – statement, can be interpreted as an adjustment of the government's S&T policy in order to better cope with the increased competition from within the Asian region – especially from China – and on the world market. The plan points to four factors that should be emphasised in future development: 1) the strength of the NIS; 2) the strength of human resources; 3) an appropriate environment for development; and 4) capability in four core future technologies, namely, ICT, bio- and nanotechnology and new materials technology.

Five strategies are outlined in the policy document for the development of the NIS:

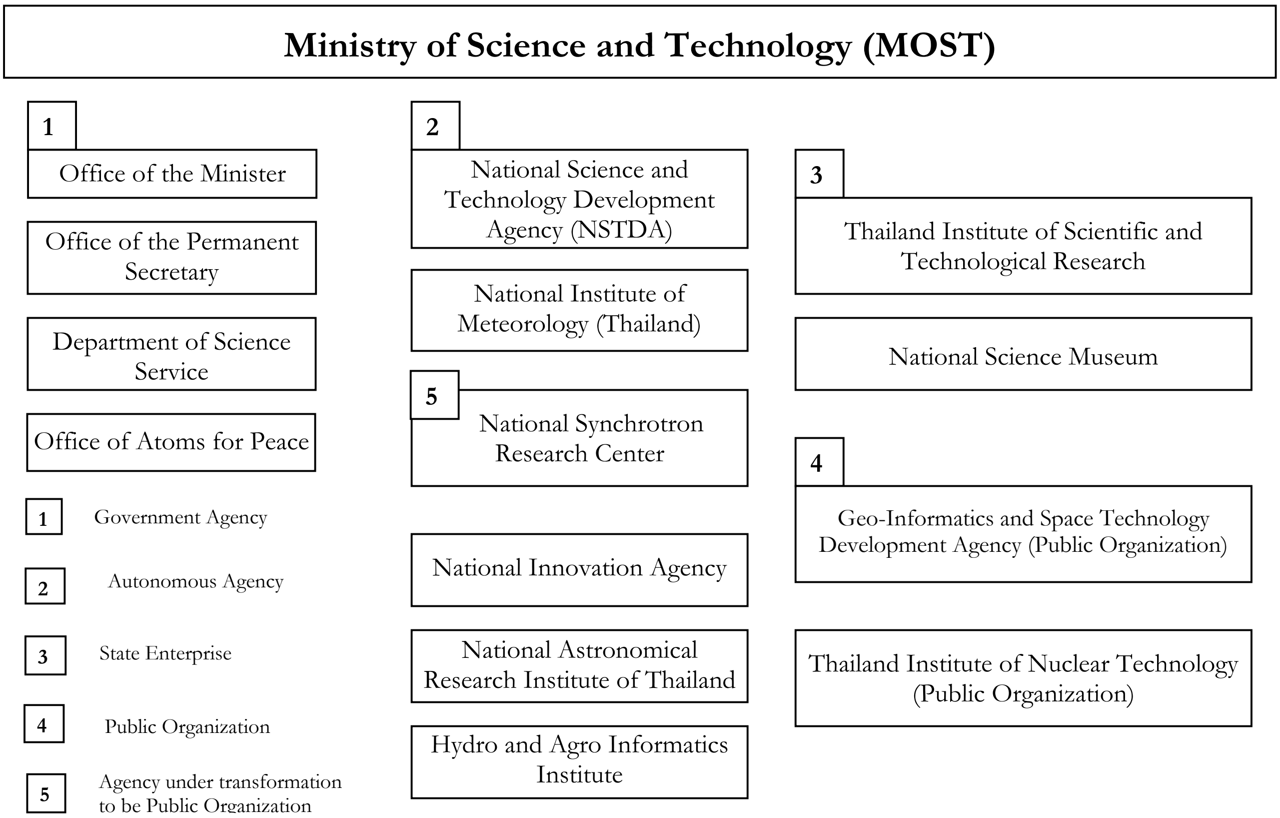
1. Development of industrial clusters, community economy and quality of life
2. Development of S&T human resources
3. Development of S&T infrastructure and institutions
4. Promotion of public awareness of S&T
5. Reform of the S&T management system

A broad range of new incentives were introduced by the plan as well, such as the development of centres of excellence with international standards, the founding of science parks, and income tax deductions for R&D expenditures (NSTPC 2004: iii; 33-34).

Comparing previous policy approaches with this long-term strategic plan, experts on the Thai innovation system see a broadening of this policy focus. Instead of a narrow concentration on R&D, human resource development, technology transfer and S&T infrastructure only, a cluster-development approach is being pursued. The difference between these two approaches lies in the perception of the firms as 'users' of S&T knowledge, which is supplied by GRIs and universities, in contrast to the innovation system approach of creating networks and interaction between actors within the NIS. In addition, the new policy approach supports the creation of scientific knowledge in areas such as life sciences and physical sciences that can provide a foundation for technological development instead of supporting only the four core technologies: ICT, biotechnology, materials technology, and nanotechnology (Ellis 2007: 10-11). In a recent contribution on Thailand's innovation system and policy, Intarakumnerd and Chaminade (2007: 210) point to the urgency of educating policy makers and mainstream academics that the old linear model of innovation needs to be replaced by a systems approach to innovation if the desired goal of international competitiveness is to be achieved. Although the new systems approach has been officially introduced, the authors note, critically, that old practices still predominate.

The changes in S&T policy over time have been accompanied by a restructuring of the innovation system, with new actors moving in or old actors adjusting their functions within the system (see Figure 11). The first institution was the National Research Council (NRC), established in 1956, which was responsible for the funding of research at universities, the coordination of private research programmes, and government advising. Some of these functions were than transferred to the Ministry of Science, Technology and Energy (MOSTE), which established in 1979 and later renamed MOST. The NRC now reports directly to the prime minister and is especially involved in the development of national research policy. The National Science and Technology Development Agency (NSTDA) is an autonomous agency under MOST and since 1992 has been responsible for the formulation of national S&T policy, the funding of R&D projects, and the administration of four national research centres.

Figure 11: Organisation chart of MOST, Thailand



Source: NSTDA. Note: The recent establishment of the new S&T agency is not included is this chart.

The four centres, established between 1993 and 2005, represent the core technologies on which the government support is concentrated, namely, BIOTEC, MTEC (for metal and materials), NECTEC (for electronics and computer technology), NANOTEC and TMC (Technology Management Center). MOST controls NSTDA through the National Science and Technology Board (composed of an equal number of representatives from the private sector and government), which it chairs (Krisha 2006; Ellis 2007: 12-14; Youngsuksathaporn 2005: 4-6).

The latest step in the readjustment of the governmental structure is the establishment of a new agency for science, technology and information that is to coordinate S&T policies and advise the government on how the S&T budget should be allocated. The core group of this new agency will consist of experts from the NSTDA's policy-making department. This restructuring comes as a reaction to criticisms that the NSTDA was both a policy-making and an implementing agency (with the GRIs subordinated to the NSTDA).

The ratio of Thailand's expenditure on R&D in relation to GDP amounted to only 0.24% in 2005 and does not compare very favourably with the situation in 1999 (0.22%). Basic research in GDP was almost negligible, amounting to a share of only 0.03%. The importance of the higher-education sector in R&D performance has grown in the last few years; its share increased from 16% to 38% between 2001 and 2005 (see Table 10). The higher-education sector includes 20 public and 33 private universities. Since 2003, universities have been the responsibility of the Ministry of Education. The list of leading Thai universities is headed by Chulalongkorn University, followed by Thammasat University and Kasetsart University (Krishna and Krishna/Report Thailand).

Critics of the performance of the higher-education sector point to the low proportion of S&T graduates compared to social science graduates and to the insufficient participation of industry in curriculum development at universities. This has led to the industrial sector's negative perception of the role that the higher-education sector could play in the cooperation with companies. Due to a change in government policy towards the higher-education sector, which included an increase in the universities' autonomy; the introduction a performance-based budgeting system; and the establishment of the University Business Incubator programme, closer cooperation between companies and universities have been expected (Intarakumnerd 2002: 1451). Close university-industry linkages are, however, still found only in a few large firms. That the programmes have not been very successful so far is indicated by the small share of income from the business sector in the universities' R&D budgets (Ellies 2007: 40).

Table 10: Thailand's R&D performance in 2005

Indicators	
GERD	**0.24**
GERD by performance sectors (%)	
Business Enterprise Sector	43.61
Government	17.16
Higher Education	38.28
Private Non-profit Sector	0.95
GERD by source of funds (%)	
Industry-financed	48.64
Government-financed	31.48
Financed by other national sources	3.11
Financed by sources from abroad	1.84

Source: Data supplied by the Science and Technology Unit of the ASEAN Secretariat.

MNCs still plays an important role in the transfer of technology. According to information from the NSTDA, about half of the R&D occurring in the business sector can be attributed to foreign companies. Japan is the largest investor in Thailand and thus important in technological cooperation. However, the low absorptive capacity of local firms has not allowed for many spillover effects from FDI. This capacity problem is related to the lack of skilled labour, weak knowledge linkages between actors in the innovation system, and too little investment in education. The development of human resources to better serve the market demand is one of the strategies in the long-term S&T policy plan. The ambitious aim of the plan is to increase the ratio of R&D personnel per 10,000 population to 10 (Ellis 2007: 11).

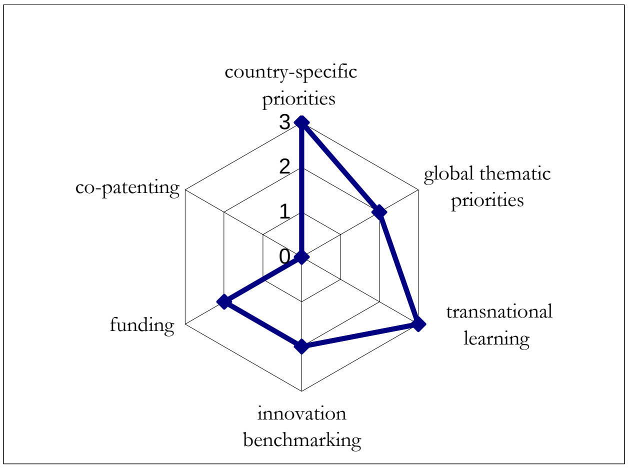
To summarise, Thailand has been continuously adjusting its S&T policy over recent decades. An important new policy direction began with the introduction of the concept of NIS, because it supported the establishment of new intermediaries such as science parks and funding institutions. The problem, however, is that these institutions (approximately 80 public and private sector agencies) are only very loosely connected with each other, resulting in an overlapping of functions and ineffective resource allocation (Ellis 2007: 40).

2.5.2 Thailand's international S&T cooperation policy

We now turn to the question of what the reasons for international S&T cooperation in Thailand are. Thailand has traditionally been open to the transfer of technology by MNCs, which required liberal economic policies. Faced with a low level of innovation capability, international S&T cooperation has become more important than before in order 'to effectively respond to rapid changes in the age of globalisation' (NSTPC 2004: iii). In top-level discussions about the best policy approach for establishing an effective system of interaction between the various actors in the innovation system foreign advisors are already playing an important role. The international advisory committee at NSTDA includes a chairman from Japan, two members from Germany, and others from the UK, India, the US, and Taiwan (NSTDA interview).

From the perspective of the government representatives reflected in the online questionnaire answered by MOST and NSTDA and in the face-to-face interviews, *transnational learning* and *country-specific priorities* were most strongly emphasised as reasons for international S&T cooperation. Other factors such as *innovation benchmarking, funding,* and *global thematic priorities* are rated important as well but to a lower extent. Co-patenting has was not seen to be a trigger for S&T cooperation.

Figure 12: Reasons for international S&T cooperation: The view of governmental institutions in Thailand



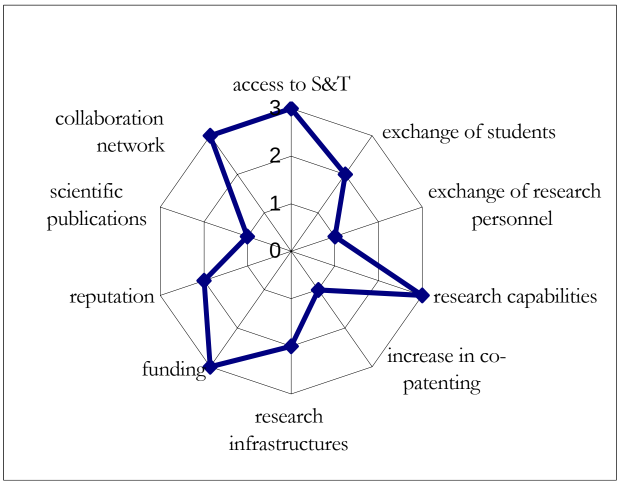
Source: Authors' assessment based on information from interviews and questionnaires.

Thai scientists' views on the reasons for international S&T diverge to some extent from those of the government representatives (see Figure 13).

From the perspective of the scientists, the three most important reasons for collaborating with foreign colleagues are *access to new S&T*, access *to collaboration networks, research capabilities* and *funding.* Still important, but placed on a lower level are *access to research infrastructure*, *exchange of students*, and *reputation. Exchange of research personnel* and increases in *co-patenting* and *scientific publications* were rated as being of lowest importance.

That the e*xchange of research personnel* received such a low rating as a reason for international S&T cooperation has been a surprise to us. Thai people in general – this was explained to us – are not very eager to live abroad because of adverse living conditions, and scientists seem to be no exception to this rule. In contrast to other ASEAN-5 member countries, Thailand has a problem not of 'brain drain' but rather of 'reverse brain gain': students and scholars doing research abroad tend to undertake short-term stays only and return home early, making the establishment of sustainable networks abroad difficult.

Figure 13: Reasons for international S&T cooperation: The view of scientists in Thailand



Source: Authors' assessment based on information from interviews and questionnaires.

Which fields of international S&T cooperation are most important for Thailand?

Table 11: S&T fields in international cooperation

S&T Field	MOST	NSTDA
Health	3	3
Food, Agriculture, Fisheries, Biotechnology	3	3
Biotechnology, Life Sciences	3	3
Nanosciences, Nanotechnologies, Materials, New Production Technologies	3	3
Energy	2	3
Environment (Climate Change)	2	3
Transport and Aeronautics	2	2
Socio-economic Sciences and Humanities	1	2
Security	1	2
Space	2	1
ICT	3	3

Note: 3: high importance; 2: medium importance; and 1: low importance.
Source: based on online questionnaires completed by MOST and NSTDA representatives.

When discussing international cooperation, both government organisations listed almost the same fields of S&T as priorities: health; food, including agriculture; bio- and nanotechnology; energy; environment; and ICT (see Table 11).

Preferences for specific partners in international S&T cooperation

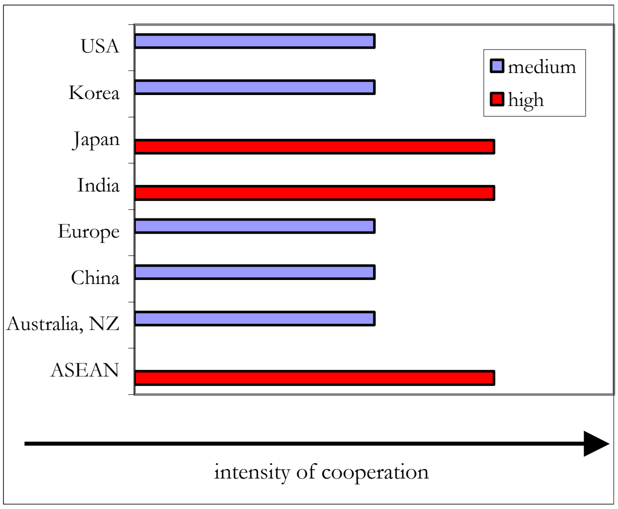
The NSTA has included a chapter titled 'International Collaboration Strategy' on its website which says that it works with more than 15 countries as well as with multilateral agencies and programmes (for example, ASEAN COST and the Asia-Pacific Economic Cooperation (APEC) Industrial Science and Technology Working Group (ISTWG)) but does not state any preferences for specific countries or regions. In interviews with government representatives we learned that countries are basically chosen as cooperation partners on the basis of their S&T strength in particular technologies.

In MOST's assessment of the intensity of S&T cooperation with specific countries or regions, ASEAN, India, and Japan were given the highest rating. Networking and the mobility of researchers were chosen as the most important reasons for cooperation. Only in relation to cooperation with ASEAN was access to funding also mentioned as a reason for cooperation.

A strong S&T relationship exists with Japan (see Figure 14) the technological leader in Asia. Japan is also one of Thailand's most important economic partners, and FDI from Japan constitutes the largest share of total investment from overseas. The institutional relationship between the NSTDA and Japan (with the National Institute of Advanced Industrial Science and Technology, AIST) evolves around an MoU discussed in February 2004 by these two organisations. AIST's chairman Yoshikawa attended the NSTDA's meeting of the international advisory board in August 2007 (information on AIST's website). Japan is also driving the discussion on international cooperation in SEA. The Japanese Society for the Promotion of Science (JSPS) organised a conference in Bangkok in February 2008 titled 'International Collaboration for Formation and Development of Science and Technology Community in Southeast Asia'. Not only the NSTDA but also S&T organisations from Indonesia, Singapore, Vietnam, and the Philippines attended.

Thailand also has a long-standing S&T relationship with the USA based on an S&T agreement signed in 1984. Through a Thai-US network (Wisconsin Alumni Association of Thailand (WAAT) and the Wisconsin Alumni Thailand Foundation (WATF)), human resource development is supported. The official network partners in the Thai government are the NSTDA and the Ministry of Education (MoE) is the funder for the Thailand Royal Golden Jubilee Program, while WAAT and WATF are the matchmakers which link Thai institutions with the University of Wisconsin-Madison in the USA. The length of the scholarship is one year; participants are scholars and university administrators (Wisconsin Alumni Association, website).

Figure 14: Intensity of cooperation with specific countries or regions.



Note: The online questionnaire offered three grades for ranking the intensity of S&T cooperation (low, medium, and high) with partners. The representatives from MOST only chose the last two categories. In the questionnaire answered by the NSTDA, all countries and regions were given the same grade (high). Therefore, a rating of the intensity of S&T cooperation with partners by NSTDA was not possible.

Source: Based on online questionnaires completed by the MOST.

Special programmes initiated by MOST for sending students abroad aim to change the inward-looking attitude among academics to a more global orientation. To support the establishment of more extensive Thai student networks overseas, the government has launched a trial initiative and supported the creation of a website for the Greater Boston Organization of Thai Students and Scholars. The aim of this organisation is 'to develop and promote network[s] among Thai scholars and students in Greater Boston and with other organization[s] both locally and internationally.' The long-term goal is 'to enhance Thailand's capability and competitiveness in science and technology' (Greater Boston Organization of Thai Students and Scholars, website). Because of the location of Harvard University and the MIT (Massachusetts Institute of Technology) in Boston, this network aims to reach the top-level students and scholars in the US.

Several European countries are among Thailand's cooperation partners, and before the Asian crisis Thailand maintained an office in Brussels in order to be more closely connected with the EU. The selection of European cooperation partners is also based on the latter's specific strengths in S&T. Among the EU countries mentioned as Thailand's major S&T partners are France, Germany, Hungary, the Netherlands, Sweden, and the UK.

With France, for example, Thailand undertakes cooperation in aeronautics. France (together with Japan) is also a cooperation partner in the new training and education programme 'Space Technology: Application and Research' by AIT (Asian Institute of Technology) and is engaged in ICT projects with Thailand.

Based on the online questionnaire responses from MOST and NSTDA representatives, an overview of the most important collaboration partners is given in Table 12). Although India was mentioned as one of the most important partners, it does not appear in this table. We can only assume that up until now no concrete S&T cooperation is underway.

Table 12: Thailand's most important partner countries and regions in selected S&T fields

S&T Field	ASEAN	Australia New Z.	China	EU	Japan	Korea	USA
Health			X				
Food, Agriculture and Fisheries, Biotechnology	X				X		
Biotechnology, Life Sciences				X	X		
Nanosciences, Nanotechnologies, Materials and New Production Technologies							X*
Energy					X X*		
Environment (Climate Change)		X			X		

Source: MOST , online questionaire. Note: * Programme under preparation. France was named the most important partner in the field of transport and aeronautics.

Many Thai scientists are trained in the US and in Europe, and there was a strong bias among those scientists we interviewed towards European countries. From the scientists' perspective, funding from Japan is more easily accessed, but it can also be obtained from other research funding institutions such as the Rockefeller Foundation. These institutions have offices in Bangkok; therefore, it is relatively easy to apply, and the success rate of applications is quite high. However, in FPs with partners from Europe the finances are centrally administered (Ministry of Finance) within the S&T institutions, and scientists have to 'beg' for their share in the project from the financing administration. In addition, applying to the FPs is regarded as being very difficult, with a low success rate. One problem is obtaining information on potential project partners in the EU. Japan fares better than European countries as regards S&T cooperation with Thailand. The main difference is that research projects with Japanese partners generally have substantive follow-up and a research relationship that continues after the end of the project (NSTDA representative).

Box: Voices from governmental institutions and scientists in Thailand on international S&T cooperation

Governmental institutions:
'The ideal partner in S&T cooperation is Japan because of cultural similarities. We are both very flexible, are interested in long-term relationships, do not look too much into details but rather into the outcome of a project, and prefer low bureaucratic involvement.'
(Source: Face-to-face interviews).

Scientists:
'Europe is the preferred location for study and research, but S&T networks with European partners are difficult to establish because of a lack of project follow-up. The greatest challenge is funding, which is much more difficult to obtain compared to other partner organisations.'
(Source: Face-to. face interviews).

In sum, the questions of why Thailand is engaged in international S&T cooperation, what the most important partners or regions in S&T are, and which fields of cooperation are preferred can be answered as follows:

- International S&T cooperation is regarded as crucial for Thailand's technological catching-up.
- The choice of cooperation partners is primarily based on their strength in a particular S&T field, not on historical or extra-scientific reasons.
- Japan is Thailand's largest source of direct investment and ODA and its most important S&T partner.
- Thai scientists seem to be reluctant to study and do research outside Asia and prefer working with Japanese counterparts.
- The FP application procedures are regarded as being very difficult; and access to information on potential cooperation partners in Europe is limited.

2.6 Vietnam

2.6.1 Key characteristics of Vietnam's S&T policy and system

Since the middle of the 1980s, Vietnam's economic system has been undergoing a transition from a centrally planned to a market economy. Domestic economic reforms have been accompanied by an open-market policy in order to attract FDI, which has played an increasingly important role in the development of the country. In 2005, TNCs contributed 37.2% of Vietnam's total exports and 16.7% of the country's GDP (Hong 2007: 8). In November 2006 Vietnam became a member of the World Trade Organization (WTO), marking a final step towards integration into the global economy.

As in other countries in transition, the change from the state planning system to a market-oriented system led to a change in S&T policy directions and institutional actors. In their comprehensive analysis of the importance of S&T for Vietnam at the end of the 1990s, Bezanson et al. (1999: chapter 14) came to the conclusion that 1) there was a strong political commitment to integrate S&T instruments into the overall economic policy, 2) a network of S&T-related institutions existed, and 3) the government was committed to making S&T a driving force in the country's development. The biggest challenge for Vietnam was that the S&T system was not sufficiently adjusted to meet the increasing competition from within the region and on the global level. The report was especially critical with regard to the technological capacity and fragmentation of the R&D system and suggested a number of policies that were later integrated into the long-term S&T strategy by the Vietnamese government.[14]

Since the end of the 1990s, a number of important reform policies have been introduced, including the following (Hong 2007: 28-32):

- The creation of a legal framework (2000: Law on Science and Technology; 2005: Law on intellectual property rights; 2006: Law on Technological Tansfer)
- The introduction of new S&T intermediaries (2000: building of 16 national laboratories; 2002: Ho Chi Minh City high-tech park; 2003: establishment of the National S&T Development Support Fund)
- The design of new policy incentives (2004: reform of state management of S&T; 2005: autonomy of R&D public institutions and promotion of firms located in high-tech parks).

The above-mentioned policy measures are included in the medium-term S&T policy strategy document published by MOST in 2003.[15] The document, called *Vietnam Science and Technology Strategy by 2010* strives for the country to (MOST, Vietnam 2003) 'reach the average advanced level in the region by 2010, making S&T really

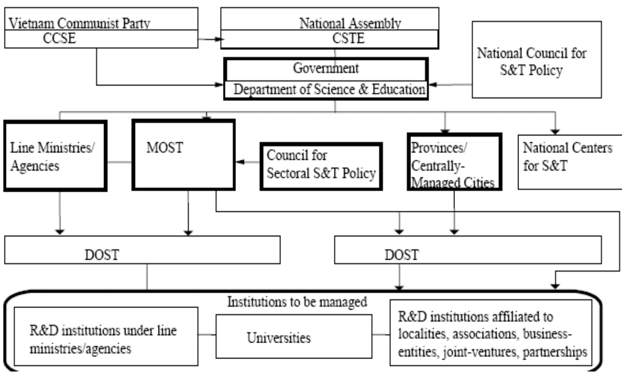
[14] The development of recommendations for Vietnam's long-term S&T policy was the explicit purpose of the report by Bezonson et al. (1999). A short overview of their study can be found on MOST's website (Systems of Innovation and International Collaboration).

[15] The 2006 policy document *Directions, objectives and key science and technology tasks for the 5-year period of 2006-2010* (MOST [Vietnam] 2006) is based on this original S&T strategy document from 2003.

become a foundation and motivation for speeding up the country's industrialization and modernization process.'

Among the S&T development objectives for the year 2010 is the selection of specific high-tech industries to be established, such as ICT and biotechnology. By 2010, research capabilities in the areas of ICT, biotechnology, advanced materials technology, automation technology, and mechanic-electronic technology should be improved as well. These fields have been selected as the key research fields in the natural sciences. The long-term plan requires an increase in the total investment in S&T in order to reach 1% of GDP by 2005 and 1.5% by 2010. No quantitative goal is set for the development of human resources, but the plan stresses that 'by 2010 the quality of S&T staff should be improved and developed at the average advanced level of other countries in the region.' Based on the concept of NIS, the medium-term strategy requires the establishment of a network of S&T organisations which can integrate internationally and have linkages to the education and business sectors.

Figure 15: Vietnam's national system of innovation



Source: Presentation by Nguyeng Thanh Tung, MOST.

Looking at the various actors in Vietnam's NIS (see Figure 15), MOST is responsible for the formulation of S&T policies and incentive programmes and the monitoring of their implementation. Other ministries are also involved, for example, the Ministry of Planning and Investment (MPI) and the Ministry of Finance (MoF) as well as some line ministries (such as the Ministry of Industry (MoI), the Ministry of Agriculture and Rural Development (MARD), and the Ministry of Post and Telecommunication (MOPT)).

The total number of R&D institutes has increased remarkably, while there has been a decline in the share of GRIs. Between 1995 and 2005 the total number of R&D institutes grew from 519 to 1220. GRIs' share shrank from 72% to 52%. Within the group of public research institutes, the number of research institutes subordinated to line ministries increased in number but their share in in the total number of this group of R&D institutes went down from 57% to 37%. In contrast, non-governmental institutes and private institutes became more important in R&D, with a joint share of about 48% of total R&D institutes in 2005 (Hong 2007: 14-15). An overview of Vietnam's R&D performance is given in table 13.

Incentives for public R&D institutes to commercialise research findings, introduced at the end of the 1990s, did not show the expected results as research institutes remained subsidised by the state. In 2005, the separation between those GRIs working in the field of public policy and basic research from those working in applied research and technological development was then introduced as a new policy instrument in order to fundamentally change the situation. The first group of GRIs were still to be financed though the state budget but were to have more autonomy with regard to personnel and organisational and financial management. The second group could either join a state-owned enterprise or remain a self-financing public institute (Hong 2007: 22-23; 31).

Table 13: Vietnam's R&D performance in 2002

Indicators	
GERD 2002	0.19
GERD by performance sector (%)	
Business Enterprise Sector	14.5
Government	66.4
Higher Education	17.9
Private Non-profit Sector	1.1
GERD by source of funds (5)	
Financed by industry	18.1
Financed by government	74.1
Financed by other national sources	0.7
Financed by sources from abroad	6.3

Source: Data supplied by the Science and Technology Unit of the ASEAN Secretariat.

The largest organisations among all research institutes are the two national research centres. One is for natural and engineering sciences (Vietnamese Academy of Science and Technology; VAST) and receives direct funding from the central government in order to carry out the so-called 'state S&T missions' (Krishna and Krishna/Report Vietnam). The VAST has 18 research institutes and 9 regional branches in different parts of Vietnam and a staff of around 3,000 employees (in 2003). Most of these affiliates are, however, located in Hanoi and Ho Chi Minh City. With the reform of the S&T structure allowing GRIs to establish commercial spin-offs as of 1992, VAST established 16 enterprises, 21 scientific centres, and 16 institutions of higher education. The other national research centre concentrates on social sciences (Vietnamese Academy of Social Sciences, VASS). In 2003, this research centre employed a staff of 1,380 and was made up of 26 research and support institutes and 15 institutions of higher education (Krishna and Krishna/Report Vietnam; Hung and Ca 2005: 6).

Institutions of higher education are under the administration of the Ministry of Education and Training (MOET). The number of universities and colleges increased between 2000 and 2004 from 178 to 230. University research activities are financed only to a limited extent by the government, which supplies 15.3% of their expenditure for R&D. This is about 4% of total expenditure for S&T. Additional funding comes from contract with enterprises (29.2%) or with other organisations (6.7%) and almost half (48.8%) from international sources. Research at universities is faced with several problems, such as lack of autonomy in their operations and R&D facilities; heavy teaching loads; and ageing staff, with the majority of professors and associate professors being older than 55 years (Hung and Ca 2005: 8-9).

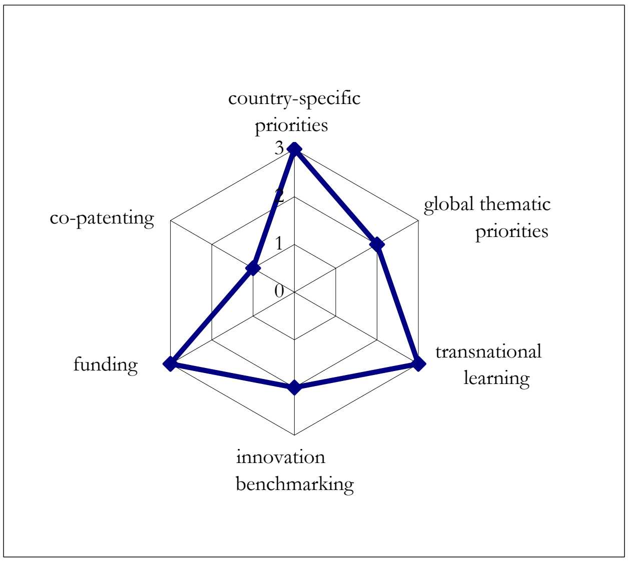
2.6.2 Vietnam's international S&T cooperation policy

We now turn to the question of what the reasons for international S&T cooperation in Vietnam are. Vietnam's integration into the global economy has required both a liberalisation of the economy and increased efforts towards international S&T cooperation. That the country should incorporate the issue of international collaboration into its long-term S&T strategy had already been suggested by Bezanson et al. in their review of Vietnam's NIS in 1999 (Bezanson et al. 2006). The Vietnamese government has in fact given this policy a prominent place in overall policy making, referring explicitly to the necessity of 'strengthening the international S&T integration' in the introduction to its long-term S&T development strategy.

During our mission to Vietnam we found that government representatives were very much in favour of international collaboration. They see an urgent need to bring Vietnamese scientists closer to the global community by creating and supporting networks. In addition to the MOET scholarship programme for Vietnamese students to train abroad, and special programmes by a number of line ministries, MOST itself has a budget for matching selected projects. To assist scientists in their research, the ministry recently acquired the licences for the Web of Sciences, the world's leading citation databases. The National Centre for Scientific and Technological Information (NACESTI), part of MOST, organises training courses on how to publish in international journals from time to time.

When discussing some major reasons for international collaboration, government representatives put the most emphasis on *transnational learning*, c*ountry-specific priorities* and *funding* (see Figure 16). Other important reasons included thematic priorities and *innovation benchmarking*, while *co-patenting* was ranked as being less important for international collaboration in S&T.

Figure 16: Reasons for international S&T cooperation: The view of governmental institutions in Vietnam

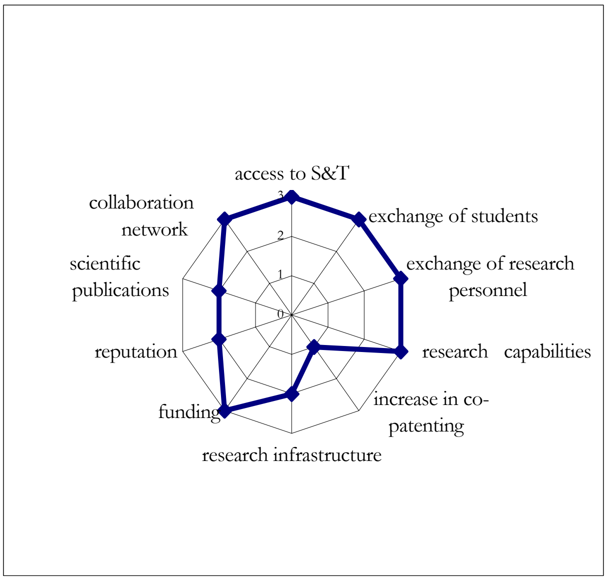


Source: Authors' assessment based on information from interviews and questionnaires.

Seen from the perspective of individual scientists (see Figure 17), the most important factors in international cooperation were *access to collaboration networks* and *new S&T, the exchange of research personnel* and *students, the expansion of research capabilities* and *funding.* Remaining factors such as *scientific publications, reputation*, and *research infrastructure* were ranked as being less important. *Co-patenting* was seen as almost unimportant for international S&T cooperation. The last factor was, however, given highest priority by those GRIs which completed our online questionnaire (the Hanoi School of Public Health, the Forest Science Institute of Vietnam, and the Institute of Oceanography). In contrast to those individual scientists we interviewed, GRIs heavily emphasised the factors *access to research infrastructure of partners, increase in reputation* and *scientific publication* as important reasons for S&T collaboration.

With the exception of some very well-connected scientists who have experience publishing in international journals, most of those interviewed publish their research findings predominantly in national language and domestic journals. Research collaboration with foreign partners had not resulted in many joint publications. In addition to the language difficulties of publishing in international journals, some of those interviewed find it difficult to choose the appropriate foreign journal to publish in for their research field. In addition, financial support from the government for international networking, for example, for participation in international workshops and conferences, was assessed as being very limited.

Figure 17: Reasons for international S&T cooperation: The view of scientists in Vietnam



Source: Authors' assessment based on information from interviews and questionnaires.

Which fields of international S&T cooperation are most important for Vietnam?

The main areas of international S&T cooperation cited by our interviews partners, which are also listed in the long-term strategy to 2010 are as follows: 1) ICT, with a focus on software development; 2) biotechnology, with a focus on the application of biotechnology, new crops, seeds, etc.; 3) health, with a focus on tropical diseases; 4) advanced materials; 5) automation and electronic-mechanic technologies; 6) atomic energy and new energy; 7) cosmology technologies; and 8) mechanic-machinery technologies.

Preferences for specific partners in international S&T cooperation

In our discussions with government representatives we learned that a shift in partners and regions in international S&T cooperation has taken place over the last few decades. Before the Vietnam War (which began in 1959) and directly after it (it ended in 1975), collaboration with European countries in the form of technical assistance predominated. Projects were sponsored mainly by France, the UK, Germany, Italy, the Netherlands, Sweden, and Finland. In addition, France and the UK sponsored training for public personnel. Cooperation with Russia and with a number of Eastern European countries was quite strong during the cold war and still exists, especially with Poland and the Czech Republic. In terms of funding, Japan, the US, and the EU are the most important cooperation partners today. Because of the limited S&T budget and the lack of human resources, there is still a strong interest on the side of the government in capacity-building projects, especially the training of Vietnamese scientists. Bilateral and multilateral cooperation projects (with the UN, UNIDO, Red Cross, ADB and the World Bank) are therefore often still financed through ODA.

In their report, Bezanson et al. (1999) also pointed to a shift in S&T cooperation partners. While until the end of the 1980s the former Soviet Union and Eastern Europe were the most important S&T partners for Vietnam, more collaboration with Asia, Europe, and North America has taken place since then. Each of the institutes the authors visited had S&T cooperation linkages with these countries and regions. Their report suggested that the government diversify its network of international collaboration partners (MOST website) and 'assess carefully [its] collaboration strategy with other countries in East and Southeast Asia. It should aim to produce a Vietnamese strategy for international collaboration.'

For political reasons, official research collaboration with the USA only began in 2001 with the signing of the Vietnam–US Agreement on Science and Technology Cooperation. In May 2006, a 'Vietnam–US Science and Technology Day' was held, and research fields and initial findings were presented. According to MOST, cooperation in the following fields was included: 'information technology, standardization and measurement, marine studies, hydrometeorology and environment, public health, agriculture, biology technology, education and research exchange.' Through the Vietnam Education Fund, masters- and doctoral-level courses were offered in the US (MOST website, 2006). Compared to bilateral cooperation with other S&T partners, bilateral S&T cooperation with the USA is quite different, according to our interview partners from MOST, because most players are from private enterprises. Funding comes from different sources such as universities (for example, the high-ranking Harvard University) and philanthropic foundations which have offered support for education and public health

Box: Voices from governmental institutions and scientists in Vietnam on international S&T cooperation

Governmental institutions:
'Regarding the participation in previous FPs, the top down approach of the government failed. The ministry itself did not have a comprehensive understanding of the programme and was not focused on the collaboration with the EU. Now that Europe has completed its regional integration and is becoming an increasingly important S&T partner for Vietnam, the government will put more energy into supporting scientists' applications to FP-7.'
(Source: Face-to-face interview with representatives from MOST)

Vietnamese Academy of Science and Technology:
'In VAST, international cooperation is always regarded as an important factor to build its capabilities. From 1991 to 2004, VAST established new partnerships with JSPS, JAIST, AIST (Japan), KOSEF (Korea), CSIRO and RMIT (Australia), CNR (Italy), CEA (France), and some other foreign institutions, which provided funds for VAST's staff training and research. This cooperation has been of great significance to VAST's capacity building. In addition, many scientific institutions in Asia, Europe, and America signed agreements of cooperation with VAST…'
(Source: Vietnamese Academy of Science and Technology/International Cooperation)

Cooperation with ASEAN states has just started, and there are some collaborative projects, for example, with Thailand in the field of agriculture and health care. Research collaboration with the EU is regarded as becoming very important now that the process of integration within the EU has been basically completed and several of Vietnam's former Eastern European cooperation partners are now part of the union. From the perspective of the government representatives interviewed, S&T collaboration with Vietnamese scientists could be of interest to European partners for many reasons; for example, because it could serve as a scientific testing ground in environmental management, bio fuels, etc. Our Vietnamese interview partners interpreted the very existence of the SEA-EU-NET project as evidence that the EU has a new regional policy perspective which includes cooperation with various ASEAN member countries.

From the scientists' perspective, strong research ties, based on either study or research networks, exist with Europe. They feel culturally close to Europe and would prefer to extend cooperation. Experience with FPs, however, was very limited, and applications to become consortia leaders in research projects have not been made so far. However, scientists would be willing to join project applications with European partners and other colleagues from ASEAN.

Cooperation with Japan has been expanding recently, and both countries have developed a common institutional framework. In August 2006, the two countries signed a cooperation agreement on S&T and subsequently held the first meeting of the Japan-Vietnam Joint Committee on S&T Cooperation in March 2007. Japan is Vietnam's biggest donor of ODA and the largest investor in the country. Many projects funded by the Japanese involve training and capacity building (Hanoi University of Agriculture). Japan is also supplying the funding for a network of four important universities that have a long-standing Confucian tradition, namely, Hanoi, Tokio, Seoul, and Beijing (information from the Vietnam National University).

In sum, the questions of why Vietnam is engaged in international S&T cooperation, what the most important partners or regions in S&T are, and which fields of cooperation are preferred can be answered as follows:

- With the transition to an outward-oriented market economy, there has been a shift towards a strategy of open technonationalism.
- S&T cooperation is assessed as being of crucial importance and is supported by the government.
- The choice of cooperation partners has diversified from Eastern European countries and Russia to include other European countries and the USA.
- Access to funding, research infrastructure, and research capabilities all play a major role in scientists' choice of cooperation partners.
- Although there is a positive perception of Europe, cooperation with Japan and China is increasing significantly. The geographic and cultural proximity are among the reasons for this.
- Vietnamese GRIs and individual scientists are eager to cooperate and are prepared to take on a 'junior-partner role' for the time being.

3 Final remarks and next steps in policy analysis

Our analysis has shown that ASEAN-5 governments and most scientists are prepared to expand international S&T cooperation.

They are aware of the opportunities and challenges in the globalisation of R&D. Support for the international networking of scientists through scholarships and mobility funds exists in all of the ASEAN-5 member states, although to different degrees and in accordance with the economic development level and country-specific policy focus.

The cost to individual scientists of setting up scientific networks is reduced mostly through bilateral S&T agreements and MoUs established by governments and research institutes in SEA countries.

Preferences for S&T collaboration with specific countries or regions have been shifting in most of the ASEAN-5 states in recent years. Historical ties with EU countries, based for example on the colonial past, are rapidly diminishing. Changes in foreign policy relations and increasing global competitive pressure have definitely had an influence on the design of bilateral S&T cooperation.

Regional cooperation in S&T is increasing, not only within ASEAN, through ASEAN COST, but also and more importantly with SEA countries and Japan, China, and South Korea. This creates a very competitive environment in which the EU has to define its position.

Not only Japan but also the USA has recently been expanding its collaboration networks with SEA countries. Successful mechanisms of cooperation used by Japan and the US should be studied.

At the level of individual scientists, collaboration tends to be significantly connected with alumni networks, personal ties to foreign academic supervisors, and access to funding. In addition, there is some brain drain, for example to Singapore on account of excellent research facilities and an attractive social environment.

EU strategies for closer S&T cooperation with SEA countries should take into account not only different economic and S&T development levels but also different cultural approaches to cooperation. Personal contacts, as an important trust-building measure, frequently play a crucial role in establishing and maintaining scientific networks.

Scientists find face-to-face monitoring accompanying cooperation projects more helpful than inflexible bureaucratic reporting procedures, which they consider to be a burden and to indicate a lack of trust.

Next steps:

Our analysis within the SEA-EU-NET project will include the following next steps:

In addition to this consultation paper, the team is working on a 'state-of-the-art' report on existing publications on national S&T statistics and statistical capacities in SEA. A draft of this report will be presented together with the consultation paper at the 1st Bi-Regional Science and Technology Policy Dialogue EU-ASEAN, 19-20 November 2008 in Paris, France.

In 2009, the team will provide a report on 'South East Asian S&T statistics', intended for policy makers, which will include national definitions of 'essential' indicators. In this way, the project aims to contribute to the comparability of data, not only between different countries in SEA but also with the wider world.

Furthermore, a brochure will be published on systematically selected research institutions in SEA that have the potential to engage in successful cooperation with European partners. This information, which will also be published on the SEA-EU-NET website, will be made available to the European National Contact Points.

As a direct continuation of the consultation paper, a report on the success factors and barriers of existing programmes and R&D cooperation between the two regions of Europe and SEA will be drafted. The main methodology used, among others, will be an analysis of strengths, weaknesses, opportunities, and threats (SWOT).

In 2010 the project team will publish three reports:

1. Policy recommendations for the enhancement of S&T cooperation between the EU and SEA.

2. Report on the relationship between national policies and STI-related global issues and the role of EU-SEA collaboration in generating innovative solutions.

3. Delphi-based Futures Paper on S&T cooperation between the EU and SEA.

It is already foreseen that this consultation paper will be updated and expanded in 2010 to include other ASEAN countries that are not presently project partners in SEA-EU-NET.

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List of abbreviations:	
ACJSTC	ASEAN-China Joint S&T Cooperation
ACP	ASEAN Cooperation Plan
ADB	Asian Development Bank
AIST	Advanced Industrial Science and Technology
AIT	Asian Institute of Technology
APAST	ASEAN Plan of Action on Science and Technology
APEC	Asia-Pacific Economic Cooperation
APN*	Asia-Pacific Network for Global Change Research
ASEAN	Association of Southeast Asian Nations
A*STAR	Agency for Science, Technology and Research
BAKOSURTANAL*	National Coordination Agency for Surveys and Mapping
BAPETEN*	Nuclear Energy Control Board
BATAN*	National Nuclear Energy Agency
BBPT*	Agency for the Assessment and Application of Technology
BOP	Balance of Payments
BPIS*	Agency for Strategic Industries
BSN*	National Standardization Agency of Indonesia
CORDIS	Community Research and Development Information Service
COST	Committee on Science and Technology
CREATE	Campus for Research Excellence and Technological Enterprise
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DRN*	National Research Council
EDB	Economic Development Board
ETCI	European Trend Chart on Innovation
EU	European Union
FDI	Foreign Direct Investment
FP	Framework Program
GAPFILL	Getting more Asian Participants involved in IST/Information Society Technologies
GDP	Gross Domectic Product
GERD	Gross Expenditure on R&D
GNI	Gross National Income
GRI	Government research institutes
HRD	Human Resource Development
ICT	Information and Communications Technology
IHL	Institutes of Higher Learning
IPB	Institut Partanian Bogor
IPR	Intellectual Property Rights
ISTWG	Industrial Science and Technology Working Group
IT	Information Technology
ITB	Institut Teknologi Bandung
JAEP	Japan-ASEAN Exchange Project
JAGEF	Japan-ASEAN General Exchange Fund
JAIST	Japan Advanced Institute of Science and Technology
JSPS	Japanese Society for the Promotion of Science
KOSEF	Korea Science and Engineering Foundation
LAPAN*	Nat. Institute of Aeronautics and Space
LEFS	Local Enterprise Finance Scheme
LIPI	Indonesian Institute of Sciences
MARD	Ministry of Agriculture and Rural Development
MARDI	Malaysian Agricultural Research and Development Institution
MASTIC	Malaysian Science and Technology Information Centre
MIGHT	Malaysian Industry-Government Group for High Technology
MIMOS	Malaysian R&D in ICT and Microelectronics
MIT	Massachusetts Institute of Technology
MNC	Multi National Corporation
MOET	Ministry of Education and Training
MoF	Ministry of Finance
MoI	Memorandum of Intent
MOI	Ministry of Industry
MOPT	Ministry of Post and Telekommunikation
MOST	Ministry of Science and Technology
MOSTE	Ministry of Science, Technology and Energy
MOSTI	Ministry of Science, Technology and Information
MoU	Memorandum of Understanding
MPI	Ministry of Planning and Investment
MRC	Medical Research Council
MTDC	Malaysian Technology Development Corporation
MTI	Ministry of Trade and Industry
NACESTI	National Center for Scientific and Technological Information (Viet Nam)
NANOTEC	National Nanotechnology Center
NCSRD	National Council for Scientific Research and Development
NECTEC	National Electronics and Computer Technology Center
NIC	National Innovation Council
NIS	National System of Innovation
NKTH	National Office for Research and Technology
NMDP	National Mid-term Development Plan
NRC	National Research Council
NRF	National Research Foundation
NSTDA	National Science and Technology Development Agency
NSTB	National Science and Technology Board
NSTPC	National Science and Technology Policy Committee
NTU	Nanyang Technological University
NUS	National University of Singapore
NZ	New Zealand
OECD	Organisation for Economic Cooperation and Development
OEM	Original Equipment Manufacturing
ODA	Official Development Assistance
OIC	Organisation of Islamic Countries
OTR	Operation and Technology Road Mapping
PORIM	Palm Oil Research Institute Malaysia
PUSPIPTEK*	Center for Research, Science and Technology
RCE	Research Centres of Excellence
R&D	Research & Development

RIEC	Research, Innovation and Enterprise Council
RISTEK*	Ministry of Research and Technology
ROK	Republic of Korea
RPS	Regional Partnership Scheme
RRC	Regional Research Council
RRIM	Rubber Research Institute of Malaysia
RSET	Researchers, scientist, Engineers and Technopreneur
RUT*	National Priority Research
RUKK*	Funding of Research in Humanities and Social Sciences
RUTI*	Funding of Research of Indonesian Scientists in Bilateral Projects with Foreign Partners
SCF	Special Cooperation Fund
SCOSA	Sub-Committee on Space Technology and Applications
S&T	Sciences & Technology
SEA	South East Asia
SEP	Student Exchange Programme
SME	Small and Medium Enterprise
SIRIM	Standard and Industrial Research Institute for Malaysia
SPSB	Singapore Productivity and Standards Board
S&T	Science & Technology
STI	Science and Technology through Innovation
STP	Science and Technology Plan 2010
SWOT	Strengths, Weaknesses, Opportunities, and Treats
TAS	Technical Advisory Support
TMC	Technology Management Center
TNC	Transnational Company
UGM	Universitas Gadja Mada
UI	University Indonesia
UK	United Kingdom
UKM	University of Malaysia
UM	University of Malaya
UNDP	United Nations Development Plan
UNESCO	United Nations Educational Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
UPM	University Putra Malaysia
US	United States
USA	United States of America
USM	University of Science Malaysia
UTM	University Teknologi Malaysia
VASS	Viet Nam Academy of Social Sciences
VAST	Viet Nam Academy of Science and Technology
WAAT	Wisconcin Alumni Association of Thailand
WATF	Wisconsin Alumni Thailand Foundation
WTO	World Trade Organisation

Note: * refers to the abbreviation in the respective national language.

References:

A*STAR (Agency for Science, Technology and Research) (2006), *National Survey of R&D in Singapore 2006,* http://www.a-star.edu.sg/astar/front/media/content_uploads/R&D_Survey_Booklets_2006.pdf, accessed July 10, 2008.

A*STAR (Agency for Science, Technology and Research) (2006a), *S&T 2010, Scientific Research for a Knowledge-based Economy*, Singapore.

Aiman, S. (2007), "Innovation: A key factor to increasing the competitiveness of SMEs - Indonesia case", Expert Group Meeting on Promoting Trade Between Asian Subregions, Kunming, China, power point presentation, http://www.unescap.org/tid/projects/protrade_s3aiman.pdf, accessed October 14, 2008.

AIST Today (2008), http://www.aist.go.jp/aist_e/aist_today/2008_27/in_brief.html, accessed October 31, 2008.

Altenburg, Tilman et al (2004), S*trengthening Knowlege-based Competitive Advantages in Thailand*, German Development Institute, Berlin.

Archibugi, Daniele and Jonathan Michie (1997), "Technological Globalisation or National Systems of Innovation?", *Futures*, Vol. 29, No. 2, pp. 121-137, http://www.danielearchibugi.org/downloads/papers/Globalisation_of_techn_and_science/Technological_Globalisation.pdf, accessed October 12, 2008.

ASEAN COST, *ASEAN Plan of Action on Science and Technology (APAST) 2007-2011*, http://www.aseansec.org/8504.pdf, accessed October 10, 2008.

Asian Development Bank (ADB) (2007), "Strengthening Capacity of the ASEAN Secretariat in Regional Economic Integration and Policy Dialogue", *Technical Assistance Report*, project no. 40566, http://www.adb.org/Documents/TARs/REG/40566-REG-TAR.pdf, accessed October 10, 2008.

Asgari, Behrooz and Yuan, Wong Chan (2007), "Depicting the Technology and Economic Development of Modern Malaysia", *Asian Journal of Technology Innovation*, Vol. 15, No. 1, pp. 167-193.

Bement, Arden L. (2005), "Global Connections: National Science Foundation International Programs and Activitites", Global Conference of Environment, Science, Technology and Health Officers, U.S. Department of State, Washington, D.C. June 22, accessed October 10, 2008, http://www.africaarray.psu.edu/publications/bement.pdf.

Bezanson, K. et al. (1999), *Viet Nam at the Crossroads. The Role of Science and Technology.* International Development Centre, Canada.

Bezanson, K. et al. (2006), "Systems of Innovation and International Collaboration", MOST website, http://www.most.gov.vn/publications/mldocument.2006-07-13.4454120624/mlnews_view, accessed October 20, 2008.

Biome – A Newsletter of The Agency for Science, Technology and Research (A*STAR) Singapore, July 2006, Issue 6.

Brain Gain Malaysia, MOSTI homepage, http://bgm.mosti.gov.my/index.php?page=programmes/doctoral_prog, accessed 26.09.2008.

Chaturvedi, Sachin (2005), "Evolving a National System of Biotechnology Innovation: Some Evidence from Singapore", *Science, Technology and Society*, Vol. 10, No. 1, pp.105-27.

D'Arcy, Michael B. And Michael A. Levi (2006), *Untapped Potential: US Science and Technology Cooperation with the Islamic World*, Brookings Analysis Paper, March, No. 8, http://www.brookings.edu/~/media/Files/rc/papers/2005/04islamicworld_levi/darcy20050419.pdf , accessed October 2, 2008.

Ellis, Wyn (2007), *Thailand's Innovation Landscape.* Internal Report to the Thai-German Programme for Enterprise Competitiveness, Bangkok.
European Commission (2003) *Communication from the Commission: A new partnership with South East Asia*, COM (2003) 399/4. Brussels.

European Commission (2007), *A New Approach to International S&T Cooperation in the EU's 7th Framework Programme (2007-2013),* http://www.kowi.de/Portaldata/2/Resources/fp7/fp7-newapproach-inco.pdf, accessed October 1, 2008.

European Trend Chart on Innovation (ETCI) (2006), Annual Innovation Policy Trend Report for SE Asia Countries, http://www.proinno-europe.eu/docs/reports/documents/Country_Report_ASIA_COUNTRIES_2006.pdf, accessed August 10, 2008.

EU-Singapore Media release (2005), "EuroSingapore 2005 poised to boost stronger ties with European-based research organisations", January 27-28, 2005.

Gammeltoft, Peter and Erman Aminullah (2006), "The Indonesian innovation system at a crossroads", in: Lundvall, Bengt-Ake, Patarapong Intarakumnerd, and Jan Vang (Eds), *Asia's Innovation Systems in Transition*, Cheltenahm, Northampton, pp. 148-77.

GATE Germany (2006), "Länderinformation für internationales Marketing für Bildung und Forschung in Deutschland – Indonesien", Bonn.

Govindaraju, Chandran V.G.R et al (2005), "Science, Technology and Innovation in Malaysia: What do the key indicators suggest?", Seminar IRPA, http://www.vgrchandran.com/11.pdf, accessed October 3, 2008.

Hong, Vu Xuan Nguyet (2007), *Promoting Innovation in Vietnam : Trends and Issues*, Central Institute for Economic Management (CIEM), Hanoi-Vietnam.

Hung, Nguyen Vo and Tran Ngoc Ca (2005), "The Role of Academic Institutions in Economic Development: The Case of Vietnam", http://www.fpi.lu.se/_media/en/research/universidad06-vietnam.pdf, accessed October 10, 2008.

Indonesia Facts, World Press, http://www.worldpress.org/profiles2/Indonesia.cfm, accessed October 20, 2008.

Intarakumnerd, Patarapong et. al. (2002), "National Innovation System in Less Successful Developing Countries: the Case of Thailand", *Research Policy*, Vol. 31, No. 8-9, pp. 1445-1457.

Intarakumnerd, Patarapong (2005), "Government Mediation and Transformation of Thailand's National Innovation System", *Science, Technology & Society*, Vol. 10, No. 1.

Intarakumnerd, Patarapong and Chaminade, Christina (2007), "Strategy versus Practice in Innovation Systems Policy: the Case of Thailand", *Asian Journal of Technology Innovation*, Vol. 15, No. 2, pp. 197-213.

Konstadakopulos, Dimitrios (2002), "The Challenge of Technological Development for ASEAN: Intraregional and International Cooperation", *ASEAN Economic Bulletin*, Vol. 19, No. 1, pp. 100-110.

Konstadakopulos, Dimitrios (2003), "The evolution, substance and priorities of EU and ASEAN cooperation in science and technology", *Asia Europe Journal*, December, pp. 551-572.

Krishna, V.V (Report Malaysia)., "The Science and Technology System of Malaysia", Website of the UNESCO, http://portal.unesco.org/education/en/files/55597/11999609765MALAYSIA.pdf/MALAYSIA.pdf, accessed October 1, 2008.

Krishna, V.V. (Report Thailand), "The Kingdom of Thailand", Website of the UNESCO, http://portal.unesco.org/education/en/files/55605/11999621755THAILAND.pdf/THAILAND.pdf, accessed October 1, 2008.

Krishna, V.V. (Report Indonesia), "The Republic of Indonesia", Website of the UNESCO, http://portal.unesco.org/education/en/files/55596/11999604295Indonesia.pdf/Indonesia.pdf, accessed October 1, 2008.

Krishna, V.V. and Usha Krishna (Report Vietnam), "The Socialist Republic of Vietnam", Website of the UNESCO, http://portal.unesco.org/education/en/files/55606/11999623895VIETNAM.pdf/VIETNAM.pdf, accessed October 1, 2008.

Krishna, V.V. and Usha Krishna (Report Singapore), "The Republic of Singapore", Website of the UNESCO, http://portal.unesco.org/education/en/files/55603/11999618795Singapore.pdf/Singapore.pdf, accessed October 1, 2008.

Langhammer, Rolf, J. (1998), "Europe's trade, investment and strategic policy interests in Asia and APEC", in: Drysdale, P., Vienes, D. (eds.), *Europe, East Asia and APEC: A Shared Global Agenda?*, Cambridge, pp. 223-243.

Lee Hsien Loong (2007), "Opening Plenary Remarks at the ASEAN Summit, Singapore 20 November 2007, www.41amm.sg/amm/index..php/web/press_room/13th_asean_summit_document_archive/sppeches_statements/opening_plenary_remarks_byprime_minister_lee_hsien_loong_at_the_asean_summit_9am, accessed October 2, 2008.

LIPI (Indonesian Institute of Sciences) (2006), *Indonesian Science and Technology Indicators* 2006, LIPI, Jarkarta.

MASTIC (Malaysian Science and Technology Information Centre) (2003), *Science and Technology Knowledge Productivity in Malaysia, Bibliometric Study,* Kuala Lumpur

MASTIC (2006), *MOSTI Facts & Figures 2006*.

Mathews, John A. (2002), "Competitive Advantages of the Latecomer Firm: A Resource-Based Account of Industrial Catch-Up Strategies", *Asia Pacific Journal of Management*, Vol. 19, pp. 467-488.

Ministry of Trade and Industry (MTI) (2006), *Science & Technology Plan 2010: Sustaining Innovation-Driven Growth*, Report of the S&T 2010 Committee, Singapore.

Moeller, Joergen Oerstroem (2007), "ASEAN's Relations with the European Union: Obstacles and Opportunities, *Contemporary Southeast Asia*, Vol. 29, No. 3, pp. 465-482.

Monroe, Trevor (2006), *The National Innovation Systems of Singapore and Malaysia*, Manuscript.

MOST [Vietnam] (2003), "Vietnam Science and Technology Development Strategy by 2010", issued enclosed with Decision No. 272/2003/QD-TTg, http://www.most..gov.vn(mlfolder.2006-07-13.8523759789/Mlfolder.2006-07-13.1746877991/, accessed October 20, 2008.

Ministry of Science, Technology and Innovation (MOSTI) (Malaysia), http://www.mosti.gov.my, accessed August 20, 2008.

National Research Council (NRC or DRN), "National Research Council of Indonesia", Presentation at the SEA-EU-NET Visitation to NRC of Indonesia, August 27, 2008.

National Research Foundation, Singapore, http://www.nrf.gov.sg/nrf/otherProgrammes.aspx?id=142.

National Science and Technology Policy Committee (NSTPC) (2004), *The National Science and Technology Strategic Plan 2004-2013*.

Nee, V., Opper, S. & Wong (2007), "Developmental State and Corporate Governance in China", Management and Organization Review, Vol. 3, No. 1, pp. 19-53.

Nanyang Technological University (NTU) (2007), *Annual Report 2007*, Singapore.

OECD (2008), "DAC List of ODA Recipients", www.oecd.org/dataoecd/23/34/37954893.pdf, accessed October 10, 2008.

PUSPIPTEK (2008), "Science and Technology Park", Power point presentation, Jarkata.

Posadas, Roger (1999), "The Development of Science and Technology in South-East Asia: Status and Prospects. Science", Technology *& Society*, Vol. 4, No. 1, pp. 115-135.

Rasli, Amran Md. (2005), "Commercialisation of UTM Research Findings: Problems and Challenges", Universiti Teknologi Malaysia, http://www.nia.or.th/innovasia/download/22Sep2005/Commercialization%20of%20UTM%20Research%20Findings%20Bangkok%20paper.doc, accessed October 1, 2008.

Remoe, Svend Otto (2008), "International Co-operation in Science and Technology, Science and Technology in the ASEAN Countries", Background Report.

RISTEK (2006), "R&D Government Research Institutions 2006", Background information to the authors.

Simamora, Manaek and Syahrul Aiman (2006), "Policy Approaches and support mechanisms to promote innovation in SMEs in Indonesia: A case of Iptekda", National Workshop on Sub-national Innovation Systems and Technology Capacity Building Policies to Enhance Compeititiveness of SMEs, October 27-30, 2006, China.

Suttmeier, Richard P. (2008), "State, Self-Organization, And Identity in the Building of Sino-U.S. Cooperation in Science and Technology", *Asian Perspective*, Vol. 32, No. 1, pp. 5-31, http://www.asianperspective.org/articles/v32n1-a.pdf.

Taufik, Tatang A (2007), "Indonesia's Subnational System Policy and Programmes", Presented at the National Workshop on Subnational Innovation Systems and Technology Capacity Building Polices to Enhance Competitiveness of SMEs, 3-4 April 2007, Jakarta. Power Point Presentation: http://www.unescap.org/tid/projects/sisindo_s2_tatang.pdf, accessed October 10, 2008.

UNESCO (2008), *Draft Regional Report on Asia. Study on National Research Systems.* A Meta Review, Paris, France.

Volkmann, Rabea (2008), "Why does ASEAN need a Charter?", *Asien*, Vol. 109, October, pp. 78-87.

Wagner, Caroline S. and Loet Leydesdorff (2004), "Network Structure, Self-Organization and the Growth of International Collboration in Science", Amsterdam School of Communications Research, University of Amsterdam, http://users.fmg.uva.nl/lleydesdorff/cwagner/collabnets.pdf, accessed October 10, 2008.

Wah, Chin Kin (2007), "Introduction: ASEAN – Facing the Fifth Decade", *Contemporary Southeast Asia*, vol. 29, No. 3, pp. 395-405.

Wie, Thee Kian (2006), "Policies Affecting Indonesia's Industrial Policy Development", *ASEAN Economic Bulletin*, Vol. 23, No. 3, pp. 341-59.

Wisconsin Alumni Association Thailand Website, http://waat.org/collabration.html, accessed October 31, 2008.

Wong, Ph Kam (1999), "National Innovation Systems for Rapid Technological Catch-up: An analytical framework and a comparative analysis of Korea, Taiwan and Singapore", DRUID Summer Conference on National Innovation Systems, Industrial Dynamics and Innovation Policy. Denmark, June 9-12.

World Bank (2008), *World Development Report 2008* Washington, D.C.

Yue, Chia Siow and Jamus Jerome Lim (2003), "Singapre: A Regional Hub in ICT", in: Masuyama, Seiichi and Dolnna Vandenbrink (eds.): *East Asia's Changing Industrial Geography*, Singapore, pp. 259-298.

Youngsuksathaporn, Preeda (2005), "Innovation in Thai Government", http://www.nia.or.th/nis/download/Innovation_in_Thai_Government.pdf, accessed October 10, 2008.

List of interview partners

Indonesia			
Date	**Institution**	**Name**	**Position**
27.8.	The State Ministry of Research and Technology, Republic of Indonesia (RISTEK)	Nada D.S. Marsudi.	Acting Director for International Research, S&T Program
27.8.	RISTEK	Dr. Teguh Rahardjo	Deputy to the State Minister for Science and Technology Program
27.8.	RISTEK	Listyani Wijayanti	Advisor for Food and Health Technology
27.8.	National Research Council of Indonesia (DRN)	Dr. Ir. Tusy A. Adibroto, Msi	Secretary of DRN, Member of Technical Committee on Transportation Technology and Management
27.8.	Agency for the Assessment and Application of Technology (BBBT), Energy Technology Centre	Dr. Gatot Dwianto	Head of Genral Affair Division
27.8.	BBBT, Energy Technology Centre	Ir. M. Syafri Syarief, M.Eng	Head of Technology Services Division
27.8.	BBBT, Energy Technology Centre	Ir. Hari Yurismono, M.Eng	Head of Efficieny Energy Division
27.8.	Center for the Assessment and Application for Biotechnology	Dr. Bambang Marwoto, Apt. M.Eng.	Scientist
27.8.	Biotech Center - BPPT	Dr. Wahyu Purbowasito S.	
27.8.	Eijkman Institute for Molecular Biology	Professor Sangkot Marzuki	Director
27.8.	Universitas Gadjah Mada, Yogyakarta	Drs. Djoko Moerdiyanto, MA	Sekretaris Eksekutif
27.8.	Universitas Gadjah Mada, Yogyakarta	Rachmat Sriwijaya	Doctor of Engineering Department of Mechanical and Industrial Engineering
27.8.	Indonesian Institute of Sciences (LIPI)	Prof. Dr. Endang Sukara	Deputy Chairman for Life Sciences
27.8.	LIPI	Dr. Ir. Neni Sintawardani	Head of Bureau
28.8	Universitas Indonesia (UI), Directorate of Partnership and Business Incubator	Junaidi, M.A	Head Academic Partnership
28.8.	UI, International Office	Raphaella D Dwianto, Ph.D	Head of International Office
28.8.	UI, Directorate of Research and Community Services	Bachtiar, Alam, Ph.D.	Director
28.8.	UI	A.A.A. Ratna Dewi, MSi, Ak.	Asisten Ahli Sub. Direktorat Riset & Lab. Multidisiplin
28.8.	Bogar Agricultural University (IPB?)	Parulian Htuagaol, Ph.D.	Lecturer and Researcher Department of Economics, Faculty of Economics and Management
28.8.	IPB	Prof. Dr. Ir. Ronny R. Noor, M.Rur. Sc	Deputy for Research, Research and Community Services Institution
28.8.	IPB	Dr. Ir. Arif Satria, M.Si	Direktur Riset dan Kajian Strategi ??
28.8.	IPB	Dr. Ir. Anas M. Fauzi, M. Eng	Vice Rector for Research and Collaboration
28.8.	IPB, Center for Costal and Marine Resources Studies (CCMS)	Dr. Ario Damar	Head of Natural Resource and Environment Management Program
	IPB, Surfactant and Bioenergy Research Center (SBAC)	Dr. Dwi Setyaningsih	Researcher
	SBAC	Dr. Endang Warsiki	Researcher
29.8.	Institut Teknologi Bandung, Office of Vice Rector for Research, Innovation and Partnership, Institute of Research and Community Services	Dr.Ir. Edwan Kardena	Deputy Vice Rector for Partnership/Director of Interational Office
29.8.	Institut Teknologi Bandung	Prof. Dr. Edy Soewono	Professor , Department of Mathematics

29.08 .08	Institut Teknologi Bandung	Dr. Armi Susandi	Lecturer, Department of Meteorology
29.8.	Institut Teknologi Bandung, School of Life Sciences and Technology, Bandung	Dr. Ir. Robert Manurung, M.Eng	Associate Professor
29.8.	Indonesian Institute of Sciences (LIPI), Research Center for Geotechnology	Dr. Ir. Iskandar Zulkarnain	Director
29.8.	National Institute for Aeronautics and Space (LAPAN), Center for Application of Atmospheric Science and Climate, Bandung	Dr. Thomas Djamaluddin	Head of Center, Research on Astronomy and Astrophisics
Malaysia			
Date	**Institution**	**Interview partner Name**	**Interview partner Depart./ Function/Position (?)**
21.8.	Ministry of Science, Technology and Innovation (MOSTI)	Wan Ashbi Lehman	International Division, ASEAN Unit, Principle Assistant Secretary
21.8.	MOSTI	Dr. Cheong Weng Chung	National Biotechnology Division, Assistant Director
21.8.	MOSTI	Radzman Abd Rahim	International Division Assistant Director
21.8.	MOSTI	Radin Zulhazimi Bin Radin Abdul Halim	Industry Division Principal Assistant Secretary
21.08 .08	MOSTI	Kamaruhzaman B. Mat Zin	Principle Assistant Director, S&T Indicator & Forecasting Unit
21.08 .08	Universiti Putra Malaysia (UPM)	Prof. Dato' Dr. Mohamed Shariff Mohamed Din	Professor, Faculty of Veterinary Medicine
21.8.	Malaysian Agricultural Research & Development Institute (MARDI)	Hasimah Hafiz Ahmad	Deputy Director (Food Processing & Product Development Programme)
22.8.	Malaysian Industry-Government Group for High Technology (MIGHT)	Norida Abd Rahman	Vice President, Technology Nurturing
22.8.	MIGHT	Asmadi Md. Said	Vice President, Special Projects & Business Development
22.8.	MIGHT	Zulazuan Pilus	Acting General Manager Corporate Services Division
22.8.	MIGHT	Maj (R) Ir Kandiah Padmanathan	General Manager, Industrial Technology
22.8.	MIGHT	Mohd Kamaruzaman Abdullah	Assistant Manager, Special Projects & Business Development
22.8.	MIGHT	Noriah Ismail	Manager, Corporate Affairs, Admin & Human Resource
22.08 .08	MIGHT	Shamsul Kamar Abu Samah	Manager, Intelligence & Research
22.8.	UPM	Dr. Goh Yong-Meng	Senior Lecturer, Labaratory Coordinator, Faculty of Venterinary Medicine
22.8.	UPM	Prof. Dr. Raja Noor Zaliha Raja Abd. Rahman	Deputy Dean (Research & Graduate Students), Faculty of Biotechnology and Biomolecular Sciences
22.8.	UPM	Tengku Aizan Hamid (Ph.D)	Assoc. Prof./Director Institute of Gerontology
22.8.	UPM	Abdul Karim Bin Noh Shah	Senior Deputy Registrar Corporate Planing Division
22.8.	UPM	Dr. Mohd Adzir Mahdi	SMIEEE, MOSA, MSPIE Associate Professor, Photonics Devices, Optical Fiber Comm., RFID, Dep. Of Computer and Comm., Faculty of Engineering
	Standard and Industrial Research Institute of Malaysia (SIRIM Berhad)	Goay Peck Sim	General Manager, Techno-Economy and Commercialisation Centre (TECC)
	World Association of Industrial and Technological Research Organizations (WAITRO)	Dr. Rohani Hashim	Secretary General
	WAITRO	Mair Nesrul Zainal Abidin	Finance Officer
	WAITRO	Zulkefli Mohd. Nani	Project Officer
Singapore			
Date	**Institution**	**Name**	**Position**
24.8.	A*STAR, Institute of Chemical and Engineering Sciences	Dr. Keith Carpenter	Executive Director

25.8.	A*STAR Experimental Therapeutics Centre	Dr. Michael Entzeroth	Senior Vice President, Drug Discovery
25.8.	A*STAR Bioinformatics Institute	Dr. Chandra Verma	Principal Investigator/Divisional Head Biomolecular Modelling and Design
25.8.	A*STAR Bioinformatics Institute	Dr. Frank Eisenhaber	Director
25.8.	A*STAR Biomedical Research Council	Prof. Ren Ee Chee	Director, Graduate Affairs
25.8.	A*STAR Immunology Network	Prof. Paola Castagnoli	Scientific Director, Singapore Immunology Network (SIgN)
26.8.	A*STAR Genome Institute of Singapore	Martin L. Hibberd (Ph.D)	Senior Group Leader/Associate Director Infectious Disease
	A*STAR Institute of Molecular and Cell Biology	Jean Paul Thiery	Principal Investigator
25.8.	National Research Foundation (NRF)	Dr. Michael Khor	Director, Projects Prime Minister's Office
25.8.	NRF	Simon Liew Boh Shan	Head, Planning & Policy Prime Minister's Office
25.8.	Nanyang Technological University (NTU)	Tony Mayer	Senior Science Officer Associate Registrar, President's Office
25.8.	National University of Singapore (NUS)	Professor Andrew Wee	Director, Surface Science Laboratory, Co-Director, NUS Nanoscience & Nanotechnology (NUSNNI)
26.8.	Glaxo Smith Kline Glaxo Wellcome Manufacturing Pte Ltd., Neurology CEDO R&D Centre Biopolis	Dr. Neil D. Miller	Director of Medicinal Chemistry, Neurology CEDD, Cognition & Neurodegeneration Centre
	British High Commission Singapore	Yeo Wee Cheng	Science and Innovation Officer
Thailand			
Date	**Institution**	**Name**	**Position**
1.9.	National Science and Technology Development Agency (NSTDA)	Prof. Sirirug Songsvilai	Nanotech (National Naotechnology Center) Excecutive Director
1.9.	NSTDA, International Cooperation Department	Simon Grimley	Consultant, International Cooperation Department
1.9.	NSDTA, International Cooperation Department	Supaporn Hempongsopa	Coordinator, International Cooperation Department
	NSDTA, International Cooperation Department	Siritham Naranong	International Cooperation officer, Internat.. Cooperation Department
1.9.	NSTDA, Biotec	Prof. Dr. Yongyuth Yuthavong	Senior Researcher, National Center for Genetic Engineering and Biotechnology
	NSTDA, Biotec	Virisara Ketprom	International Relations Officer
1.9.	NSTDA, Biotec	Chairat Uthaipibull, Ph.D.	Researcher, National Center for Genetic Biotechnology
1.9.	NSTDA, National Metal and Materials Technology Center (MTEC)	Assoc. Prof. Siriluck Nivitchanyong	Assistant Executive Director in Research and Development
1.9.	NSTDA, MTEC	Nuwong Chollacoop, PhD	Senior Researcher
1.9.	Asian Institute of Technology	Peter Haddawy, Ph.D.	Vice President for Academic Affairs, Professor of Computer Science and Information Management
1.9.	Ministry of Science and Technology (MOST)	Somchai Tiamboonprasert	Director, Office of International Collaboration, Depart. of the Permanent Secretary
1.9.	MOST	Churdchan Juangbhanich	Director, International Cooperation Division, Office of International Cooperation
1.9.	MOST	Kamolrat Thongprapai	Foreign Relations Officer
	National Innovation Agency (NIA)	Sirapapha Rungpry	Project Manager, IP Management Unit
2.9.	Delegation of the European Commission	Andrew Jacobs	Head of Operations
2.9.	Delegation of the European Commission	Nopmanee Somboonsub	Programme Officer

2.9.	Delegation of the European Commission	Sutthiya Chantawarangul	Programme Officer
2.9.	National Research Council (NRCT)	Dr. Ahnond Bunyaratvey	Secretary General
2.9.	NRCT	Choosri Keedumrongkool	Director, Office of International Affairs
2.9.	Chulalongkorn University, Center for European Studies	Charit Tingasbadh, Ph.D.	Director
2.9.	Chulalongkorn University, Department of Chemistry	Supawan Tantayanon, Ph.D.	Professor of Chemistry, Director of Technopreneurship and Innovation Management
2.9.	Chulalongkorn University, Department of Industrial Engineering	Natcha Thawesaengskulthai, Ph.D.	Lecturer, Technopreneurship and Innovation Management Program (TIP), Graduate College
2.9.	GTZ	Jim Tomecko	Director,Business and Financial Services
2.9.	GTZ	Wyn Ellis	Senior Programme Advisor
2.9.	Noviscape Consulting Group	Dr. Pun-Arj Chairatana	Principal
Viet Nam			
Date	**Institution**	**Name**	**Position**
3.9.	Vietnamese Academy of Science and Technology (VAST)	Nguyen Gia Lap	Deputy Director, International Cooperation Department
3.9.	VAST, Institute for Scientific Information	Dr. Nguyen Tien Dat	Director
3.9.	VAST, Institute of Bitotechnology (IBT)	Nong Van Hai, Ph.D.	Associate Professor, Deputy Director, National Key Lab for Gene Technology, Acting Director
3.9.	VAST, Institute of Materials Science	Professor Dr. Sc. Nguyen Xuan Phuc	Director
3.9.	VAST, Institute of Environmental Technology (IET)	Nguyen Minh Son	Deputy Director
4.9.	Ministry of Science and Technology MOST, National Institute for Science and Technology Policy and Strategy (NISTPASS)	Tran Ngoc Ca, Ph.D.	Deputy Director
4.9	Vietnam National University Hanoi	Prof. Vu Minh Giang, D.Sc.	Vice-President
4.9.	Vietnam National University Hanoi	Assoc. Prof. Dr. Pham Hong Tung	Deputy Director, Department of R&D
4.9.	Vietnam National University Hanoi	Dinh Duc Long	Vice Director, International Relations Department
4.9	Hanoi Agricultural University, Sustainable Agricultural Development & Research Center	Do Nguyen Hai, Ph.D.	Director
4.9.	Hanoi Agricultural University, Center for Agricultural Research and Ecological Studies	Nguyen Dinh Tien, B.Sc.	Research Fellow
4.9.	Institute of Meteorology and Hydrology	Le Ngugen Tuong	Chief of Science Education and International Cooperation Department
		Nguyen Hong Khanh	Spouse of Deputy Prime Minister and Minister for Foreign Affairs
	Ministry of Science and Technology, National Center for Scientific & Technological Information	Dr. Le Xuan Dinh	Deputy Head of International Cooperation
	Hanoi School of Public Health	Tran Huu Bich MD, PhD	Vice Dean
	Hanoi School of Public Health	Bui Thi Thu Ha MD, PhD	Vice Dean, Head of the Department of Reproductive Health
	Hanoi University of Mining and Geology	Prof. Dr. Tran Dinh Kien	Assoc. Rector
	Vietnamese Academy of Social Sciences	Trinh Duy Luan, PhD	Director, Institute of Sociology; Editor in Chief „Sociological Review“