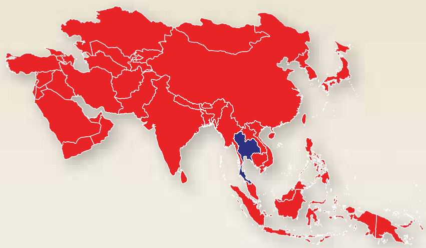
UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT

UNCTAD

Science, Technology & Innovation Policy Review

Thailand



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NOTE

This publication has been edited externally.

Symbols used in some of the tables denote the following:

Two dots (..) indicate that data are not available or are not separately reported.

Use of a dash (–) between dates representing years (e.g. 2008–2010) signifies the full period involved, including the beginning and end years.

Reference to “dollars” ($) means United States dollars, unless otherwise indicated.

Details and percentages in tables do not necessarily add to totals because of rounding.

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PREFACE

The Science, Technology and Innovation Policy (STIP) Reviews prepared by UNCTAD aim to contribute to the development of national capacities in this field in order that national STI plans and programmes better contribute to development strategies and to improve the competitiveness of the productive sectors. These reviews are intended to serve as an analytical instrument which examines a set of proposals from an external and neutral perspective, and to make some suggestions for action. They are not a rating mechanism.

The STIP Review of Thailand has three fundamental goals: to offer an up-to-date assessment of the framework conditions and interactions that characterize Thailand's national innovation system; to provide a number of recommendations for strengthening policies and measures in order to improve national technological capabilities and encourage innovation; and to offer more detailed assessments in two areas critical for Thailand's development, namely supporting innovation in small-scale agriculture and promoting the development of human resources in STI.

The STIP Review of Thailand was conducted in response to a request by the Government of Thailand, and received the support of the Ministry of Science and Technology and of the National Science, Technology and Innovation Policy Office. It was undertaken by a team of experts which carried out two missions in Thailand, in October 2013 and June 2014. It involved more than 70 interviews with representatives of government bodies, research institutions, universities, professional associations and chambers of commerce, business incubators and technology licensing offices, companies and non-governmental organizations. An initial draft of this document was discussed with more than 80 experts and national stakeholders at a workshop held in Bangkok on 12 December 2014. The comments and suggestions made there have been taken into account in the preparation of the final draft.

This Review would not have been possible without the cooperation of the National Science, Technology and Innovation Policy Office and, in particular, H.E. Pichet Durongkaveroj (Secretary-General and, since August 2014, Minister of Science and Technology) and Kanchana Wanichkorn (Director of the Department of International Affairs and national focal person for this Review). A special thanks is owed to Puangrat Asavapisit, Sakarindr Bhumiratana, Naksitte Coovattanachai, Krisda Monthienvichienchai, Thanin Pa-Em, Damri Sukhotanang, Chachanat Thebtaranont, Orapong Thien-Ngern and Kan Trakulhoon, members of the National STIP Review Steering Committee that provided guidance to this project. A special thanks is also owed to Pongthep Akratanakul, Panee Boonyagukul, Nakorn Chantasorn, Akarawit Kanchana-opas, Thaweesak Koanantakool, Chen Namchaisiri, Kitipong Promwong, Piniti Ratananukul, Saowaruj Rattanakhamfu, Morakot Tanticharoen, Carmela Torres and Chaicharn Wongsamun, who also provided substantive inputs and comments to the review. Gratitude is also extended to all participants in the national workshop and to the persons and entities, too numerous to be listed, that generously contributed their comments and ideas.

The assessments, opinions and conclusions expressed in this document are entirely those of the UNCTAD secretariat.

ACKNOWLEDGEMENTS

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ABBREVIATIONS

ARDA	Agriculture Research and Development Agency
ASEAN	Association of South-East Asian Nations
BAAC	Bank for Agriculture and Agricultural Cooperatives
BIOTEC	National Center for Genetic Engineering and Biotechnology
FDI	foreign direct investment
FTE	full-time equivalent
GDP	gross domestic product
GERD	gross expenditure in R&D
GII	Global Innovation Index
GISTDA	Geo-informatics and Space Technology Development Agency
HAII	Hydro and Agro Informatics Institute
HDDI	Hard Disk Drive Institute
HR	human resources
HRD	human resources development
ICT	information and communications technologies
IGOs	inter-governmental organizations
IP	intellectual property
IT	information technology
ITAP	Industrial Technology Assistance Programme
KMUTT	King Mongkut's University of Technology Thonburi
LDD	Land Development Department
M&E	monitoring and evaluation
MOAC	Ministry of Agriculture and Cooperatives
MOST	Ministry of Science and Technology
NANOTEC	National Nanotechnology Center
NESD	National Economic and Social Development (plan)
NGO	non-governmental organization
NIA	National Innovation Agency
NRCT	National Research Council of Thailand
NSTDA	National Science and Technology Development Agency
NSTIPO	National STI Policy Office
OECD	Organisation for Economic Co-operation and Development
OHEC	Office of the Higher Education Commission

OSMEP	Office of SMEs Promotion
OVEC	Office of the Vocational Educational Commission
PISA	Programme of International Student Assessment
PPP$	purchasing power parity in dollars
R&D	research and development
RD&D	research, development and diffusion
RRI	Researchers for Research in Industry
RTO	research and technology organization
S&T	science and technology
SME	small and medium-sized enterprise
STI	science, technology and innovation
TDRI	Thailand Development Research Institute
TIMSS	Trends in International Maths and Science Study
TISTR	Thailand Institute of Scientific and Technological Research
TLO	technology licensing office
TNC	transnational corporation
TRF	Thailand Research Fund
TVET	technical and vocational education and training
UBI	university business incubator
UNESCO	United Nations Educational, Scientific and Cultural Organization

EXECUTIVE SUMMARY

Following a significant increase in per capita income over the past few decades, Thailand is now experiencing a decline in growth as well as productivity. The country is at risk of falling into the “middle-income trap” as it faces increasing difficulty in competing against lower cost locations in less skill-intensive economic activities while still lacking the technological know-how and human capabilities of moving into more sophisticated, higher value-added activities. Other major concerns for Thailand relate to social inclusiveness and environmental sustainability.

To address these challenges, it is imperative for Thailand to make strong efforts to foster innovation. Innovation is much more than research and development (R&D); it also involves the actions taken by economic actors to upgrade their technological level, enhance their organization and production methods, develop new activities and enter new markets. Thailand’s modest performance compared with other economies at a similar level of development is partly due to relative weaknesses in its innovation system. However, the country has significant assets to help it become an innovation-based economy: a number of competitive industries, notably in automotive and electronic components, an agricultural sector that makes it a leading world exporter of several products, and a growing services sector. The country also has a sizeable research infrastructure, a reasonably well-developed higher education system and a large network of vocational schools.

Political instability and a lack of policy continuity have weakened the ability of public institutions to provide an enabling environment for businesses and, equally important, to steer and sustain major reforms over time. In the current context of national reforms, it will be important to adopt strategic policies aimed at supporting a new development trajectory. This Science, Technology and Innovation Policy (STIP) Review proposes three major directions for those efforts: enhancing STI governance and management, stimulating innovation efforts and upgrading the education system.

Enhancing STI governance and management

The organization and functioning of institutions in charge of overseeing and funding Science, Technology and Innovation (STI) policies present a number of problems. Agencies with overlapping responsibilities have proliferated. There are several instances of individual departments being simultaneously responsible for policy setting, financing and implementation, when these should in fact be independent of each other. Advisory committees are not sufficiently inclusive. Lack of clarity regarding institutional roles and responsibilities and a lack of oversight and accountability have resulted in poor management and a less than optimal use of resources in key elements of the innovation system. The following measures are proposed in order to enhance STI governance and management:

- **Establish a clear division of roles and responsibilities and hierarchy among STI institutions.** The National STI Policy Committee should be entrusted with a supervisory role, focusing on strategic issues and establishing broad budget allocations, while implementation should be the responsibility of operational agencies. The Committee should be composed of the Minister of Finance in addition to the key relevant ministers, as well as high-level representatives of business organizations, trade unions, academics and civil society. It should be chaired by the Prime Minister and meet at least once a month. The National STI Policy Office should concentrate on policy advice and, increasingly, on policy monitoring and evaluation.
- **Clarify the respective roles of various R&D bodies.** A clear distinction is needed between those bodies that design the policies and monitor their implementation and those that fund programmes and organizations. The supervising body overseeing the R&D policy, the National Research Council of Thailand (NRCT) should report to the National STIP Committee, and not to the Prime Minister (as it currently does).
- **Rationalize the R&D structure.** Merge organizations that overlap, suppress those that have outlived their usefulness, and establish new ones, as appropriate. An audit of the scientific quality and effectiveness of government research centres – conducted in association with international experts – could guide this rationalization exercise.

- **Decentralize STI policy and infrastructure.** National, overall and STI-specific, investments and resources tend to be directed to the more technologically developed areas, leading to a concentration of activities around the capital, Bangkok. STI offices should be set up throughout the country, serving notably as one-stop shops for innovators and researchers. Branches of key research centres could be set up close to universities. Regional science and technology (S&T) parks should be further upgraded, and local awareness and capacities for developing STI policies encouraged.

Stimulate innovation efforts

Thailand has displayed a modest performance in terms of innovation. Linkages between various actors in the innovation system (e.g. business enterprises, universities, research organizations) are insufficient. The various existing financial and non-financial schemes to improve innovation efforts are too fragmented and uncoordinated, leveraging little R&D and innovation financing from the private sector and supporting only a small number of firms. The following additional measures should be taken to support innovation more effectively:

- **Use matching funds to support collaborative R&D,** subsidizing firms' R&D projects that are undertaken in collaboration with universities or public research entities.
- **Review current tax incentives for R&D and innovation,** particularly their impact on small and medium-sized enterprises (SMEs), before proposing more generous tax incentives.
- **Scale-up bridging schemes** (e.g. the Industrial Technology and Assistance Programme, ITAP) and organizations (e.g. the Hard Disk Drive Institute (HDDI), Thai Automotive Institute (TAI), and the Thai Food Institute) that operate at the interface between sources of knowledge and clients seeking knowledge.
- **Provide incentives for collaboration between industry and research centres and universities.** Require public research organizations to progressively increase the percentage of their budgets funded through contracts. Provide incentives for researchers, teachers and their institutions to collaborate with industry. For example, formally value researchers' collaboration with industry for the advancement of their careers, and in evaluations of universities and research institutions include criteria concerning their ability to collaborate with industry, provide services and transfer technology.
- **Foster awareness about intellectual property (IP) and the potential for commercializing research.** Adopt a clear IP policy for publicly funded research, and support research processes that promote collaboration with industry and social partners.
- **Take full advantage of megaprojects.** Well-designed and implemented national infrastructure projects, because of their size, offer unique opportunities to boost domestic capabilities. The development of trained engineers and of technological competences among local firms through efficient technology transfer from foreign contractors should be an explicit objective of Thailand's railway mega programme, for example. This should be supported through well-defined actions, responsibilities and monitoring systems.

Upgrade the education system

Thailand faces increasing demands for human resources in STI, both at the vocational and higher levels of education. The number of R&D personnel per population, particularly in the private sector, is relatively low. In addition, there are significant skills shortages in certain fields and industries. More importantly, Thailand faces persistent difficulties in training people with the STI-related skills needed by an economy that aspires to grow based on innovation and to compete in higher value-added activities. Substantial efforts are needed to improve the quality of STI education and training at all levels, including the following measures:

- **Improve education budgets.** Budgets should provide sufficient resources for training teachers in STI skills, developing STI teaching materials and upgrading equipment, and supporting linkages with the private sector.
- **Make educational institutions accountable.** Take appropriate measures with regard to underperforming educational institutions and actors identified through the established quality assurance processes. Adjust quality assurance processes to reward institutional collaboration with the private sector. Raise the performance

standards of all higher education institutions over time. Increasingly link budget allocations to performance in a manner that provides adequate incentives for quality enhancement and that takes into account the specific mandates of different educational institutions.

- **Overhaul technical and vocational education and training** (TVET) to make it an important mechanism for training skilled workers. Upgrade teachers' qualifications, teaching methods and resources. Following an independent evaluation, adopt measures to enhance the quality and relevance of non-formal TVET (i.e. skills development training).
- **Reinforce education-business linkages.** Programmes that expose students, teachers and academics to work in the private sector (e.g. internships, dual vocational training, mobility programmes and combined studies) should be reinforced and scaled up. Successful cooperative educational programmes (e.g. the Mechai Pattana School, the pilot work integrated learning, and the engineering practice schools of the King Mongkut's University of Technology Thonburi) should be expanded.

Agricultural innovation and small-scale farming: A test case

This Review also examines in more detail the agricultural innovation system of Thailand from the perspective of small-scale farmers, who produce the bulk of the key energy and food crops and represent a large share of the population whose welfare could improve through innovation-driven growth. Three critical issues arise for policy in respect of agricultural innovation.

First, there is no central policy or institutional mechanism to direct and ensure the effectiveness and cohesion of agricultural R&D and its diffusion. There is limited monitoring and evaluation of the impacts of R&D results on end-users. Secondly, activities to support and promote innovation in agriculture are not adequately linked to long-term planning and to building an effective enabling environment for STI activities at the farm level. Finally, there is a concentration of STI resources in and around Bangkok, and weaknesses in maintaining effective channels for diffusion of the benefits from STI resources to small-scale farmers in the regions. Based on these key issues, the following recommendations are made:

- **Articulate an "innovation roadmap"** to address the four major long-term agricultural challenges: land fragmentation, inadequate water supply and management, poor and deteriorating soil quality, lack of human resources.
- **Develop and implement a long-term soil improvement strategy** that includes a combination of a wide range of technologies, and reverses the increasing use of chemical inputs.
- Following wide stakeholder discussions, **consider resubmitting a national biosafety regime** for parliamentary approval.

In addition, in order to inform the design of STI programmes and policies, further research is required regarding:

- STI awareness and engagement at the provincial, district and *tambon* (sub-district) levels.
- Practices that work in Thailand for establishing local links to improve the participation of farmers and to enhance knowledge and information flows between producers and users of technology.
- The current state of agricultural extension and major barriers to effective technology diffusion.
- Evaluation and monitoring of agricultural R&D undertaken outside the Ministry of Agriculture and Cooperatives (MOAC).

An overall conclusion of this STIP Review is that Thailand has significant assets for innovation-driven economic growth and for inclusive and sustainable development. Most of the needed measures involve fostering discipline and collaboration within the overall innovation system and among the actors concerned. Decisive action and strategic reforms are required to ensure the long-term sustainability of Thailand's social and economic development.

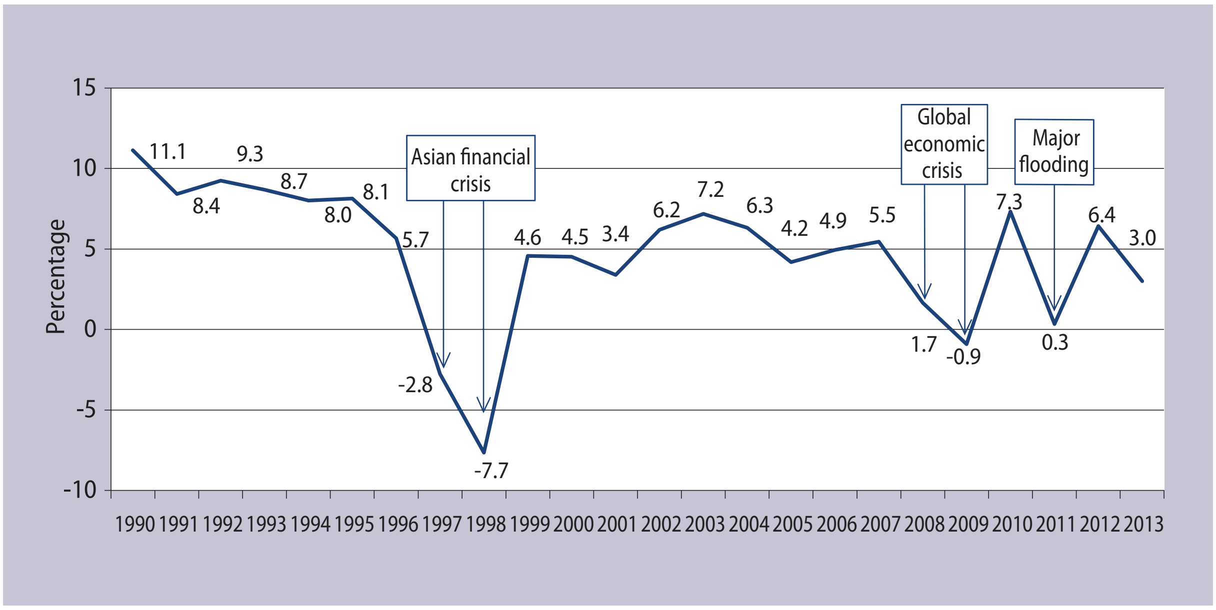
General context of science, technology and innovation in Thailand

A. KEY SOCIO-ECONOMIC TRENDS

Thailand is an upper-middle-income country and the second largest economy in South-East Asia with a gross domestic product (GDP) of $409 billion in 2013 (table 1.1).

Between 1961 and 1996, GDP growth averaged 7.7 per cent, and high export growth rates led to rapid industrialization and diversification and to a significant growth of per capita income. The Asian financial crisis of 1997-1998 resulted in a sharp recession, slowing down economic growth which has not returned to its pre-crisis levels. Nevertheless, since 2002 the economy has experienced an average annual growth rate of 3.8 per cent, despite the huge setbacks resulting from the global economic crisis of 2008–2009 and the major floods of 2011 (figure 1.1). Thailand's rate of economic expansion accelerated to 6.4 per cent in 2012, owing largely to the low base of comparison in the previous, flood-hit year, but this rapid pace of growth was not sustained in 2013. Thailand's political crisis has affected consumer and business confidence, and real GDP growth for 2014 is estimated to be 0.7 per cent.[1]

Figure 1.1 Thailand's real GDP growth rate, 1990–2013 (percentage)



Source: UNCTAD, based on UNCTADstat.

The Thai economy has undergone a structural transformation over the past few decades, with the reallocation of labour and capital from agriculture to manufacturing and services. However, this structural transformation has been only partial, as labour participation in agriculture is still markedly high (table 1.1). Today, Thailand's economic output is dominated by the services sector (including tourism), which accounts for half of its GDP and for 39 per cent of employment, followed by industry (39 per cent of GDP), in which electronics and automobile and auto parts manufacturing dominate, while the share of the textile industry has fallen. Agriculture, which continues to contribute 10 per cent of GDP, remains an important economic sector as it employs around 35 per cent of the labour force and feeds much of the country.

Thailand is a leading exporter of a number of agricultural and agro-based products, including rice, sugar, rubber, cassava and chicken. Indeed food and agricultural raw materials account for nearly 17.7 per cent of Thailand's exports.[2] It is also the second largest exporter of hard-disk drives and a major auto manufacturing hub. Exports accounted for 70 per cent of Thailand's GDP in 2012 (table 1.1), of which 58 per cent comprised manufactures.[3] China has become one of the country's three major trading (export and import) partners, together with Japan and the United States.[4] The United Arab Emirates and Saudi Arabia are Thailand's major import partners, because of its reliance on oil from these countries.

Table 1.1 Key economic indicators, 1990–2013 (Billions of US dollars at current prices and current exchange rates, unless otherwise specified)

	1970	1975	1980	1985	1990	1995	2000	2005	2010	2011	2012	2013
Output												
GDP (billions of dollars)	7	15	33	40	88	169	126	189	338	365	386	409
GDP per capita (dollars)	200	366	707	773	1 561	2 865	2 023	2 877	5 090	5 478	5 775	6 097
Sectoral value added (% of GDP)												
Agriculture, hunting, forestry, fisheries	**26**	**27**	**23**	**16**	**10**	**9**	**9**	**9**	**11**	**11**	**10**	**..**
Industry	**23**	**24**	**29**	**32**	**37**	**38**	**37**	**39**	**40**	**38**	**39**	**..**
Mining, manufacturing, utilities	19	21	24	27	31	30	34	36	37	36	36	..
Manufacturing	16	19	22	22	27	27	29	30	31	30	30	..
Services	**51**	**49**	**48**	**52**	**53**	**53**	**55**	**52**	**49**	**50**	**51**	**..**
Wholesale, retail trade, rest. & hotels	24	25	23	24	23	22	21	18	18	18	18	..
Other activities	21	20	20	21	22	25	25	27	25	26	26	..
Employment												
Agriculture (% of total employment)	..	..	71	..	64	52	49	43	38	39	40	..
Industry (% of total employment)	..	..	10	..	14	20	19	20	21	21	21	..
Services (% of total employment)	..	..	19	..	22	28	32	37	41	41	39	..
Unemployment (% of labour force)	..	..	0.9	3.7	2.2	1.2	2.4	1.3	1.0	0.7	0.7	..
Gini index	..	..	..	..	45	..	43	..	39	..	..	..
FDI - inward flows (billions of dollars)	0.04	0.09	0.19	0.16	2.58	2.07	3.41	8.07	9.15	3.71	10.71	12.95
Gross capital formation (% of GDP)	28	30	29	28	42	43	22	31	26	27	30	..
Trade												
Trade balance (billions of dollars)	..	..	-2.1	-1.1	-6.6	-12.0	10.1	-3.5	19.0	6.4	2.6	10.1
Exports, goods & services (% of GDP)	14	18	23	23	33	42	65	69	67	71	70	..
Imports, goods & services (% of GDP)	19	22	30	25	41	48	57	70	61	70	71	..
Current account (billions of dollars)	..	..	-2.08	-1.54	-7.28	-13.58	9.31	-7.65	9.95	8.92	-1.43	-2.68
(% of GDP)	..	..	-6.2	-3.8	-8.2	-8.0	7.4	-4.1	2.9	2.4	-0.4	-0.7

Source: UNCTADstat, World Bank, World Development Indicators.

In the 1970s, Thailand replaced its import-substitution industrialization strategy with an export-led strategy. This growth strategy has since supported foreign direct investment (FDI) as a vehicle for economic development by attracting new industries to Thailand, primarily in assembly activities (especially electronics and automobiles) and natural-resource-based products. Foreign investors were initially attracted to Thailand because of its lower production costs. FDI inflows boomed during the period 1985–1996 following a combination of sound macroeconomic policies, well-timed regulatory changes and a positive international context (Hoyrup and Simon, 2010). The real exchange rate appreciation in Japan and the Republic of Korea following the Plaza Accord of 1985 gave Thailand's labour cost advantage a further boost and attracted investments by Japanese transnational corporations (TNCs) in assembly industries (electronics and automotive sectors). Today, the country continues to attract greenfield investments in these two sectors (UNCTAD, 2013a), with Japanese firms being the largest investors.

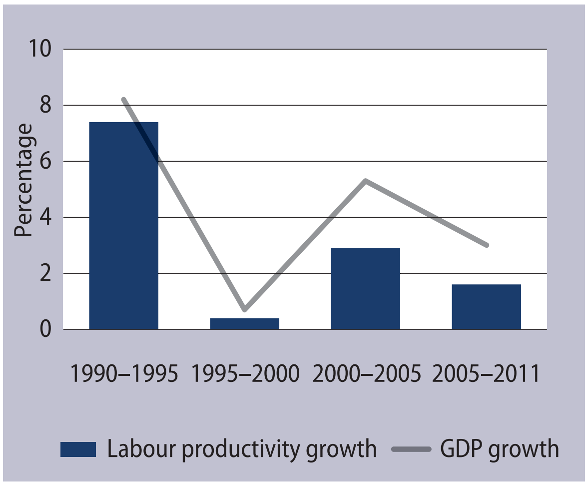
FDI has contributed to employment creation, capital formation and diversification of production. However, while TNCs have transferred technology to their subsidiaries, overall, FDI has made only a moderate contribution to the building of domestic capabilities and the development of a domestic support industry in Thailand, unlike in Malaysia and Singapore.[5] The lack of well-defined, sustained and coherently implemented STI and industrial policies have constrained the development of domestic STI capabilities.

Industrial policies introduced in the 1980s and 1990s promoted general education, infrastructure building and exports, but lacked focus, with virtually no selective policies to support particular industries (Intarakumnerd et al., 2010). Trade policy focused more on maintaining macroeconomic balance than on promoting technological learning. FDI policy aimed at attracting capital and generating employment, but it did not include reciprocal performance-based criteria, such as local value added or technological upgrading targets, that could have encouraged the development of technological capabilities. One exception was the local content requirement in the automobile industry. Tightened public spending also prevented major public investments in strategic projects and industries (Hoyrup and Simon, 2010).

Following the 1997-1998 Asian financial crisis, Thailand introduced industrial restructuring plans (IRPs) to address industrial weaknesses and promote industrial deepening. The master plan of the IRPs identified priority sectors and supported independent technology institutions or *sathabans* (e.g. the Thailand Productivity Institute, the Thai German Institute and the Thai Automotive Institute) to build the technological capacities of SMEs in targeted industries (Suehiro, 2010). However, gradually, and particularly from 2001, industrial policy shifted from the promotion of targeted industries towards the development of general business competitiveness and SME promotion (Suehiro, 2010). Moreover, national competitiveness was to be led by the private sector while the Government would play a coordinating role, and its scope for supporting State projects was reduced (Suehiro, 2010).[6] The adopted cluster policy identified five national strategic industries,[7] but these were not geographically concentrated. As a result, the policy did not help catalyse collective technological learning or the emergence of positive externalities associated with the proximity of actors (Intarakumnerd et al., 2010). Neither the short-lived STI and industrial policies nor the limited monitoring and evaluation (M&E) of policies have been conducive to systematic learning (Intarakumnerd et al., 2010).

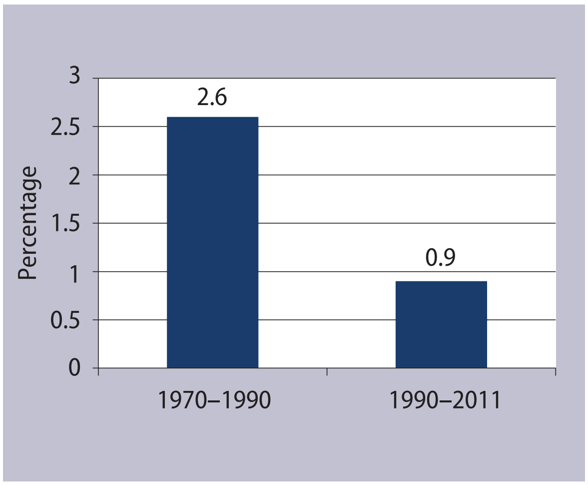
Overall, Thailand's economic growth has resulted more from capital investment and employment reallocation from the agricultural to the manufacturing and services sectors, than from productivity gains. Total factor productivity accounted for only one sixth of the annual growth rate between 1985 and 2005 (World Bank, 2011). Labour productivity growth was fast in the early 1990s. However, GDP as well as productivity growth performances have declined in the past decade (figures 1.2 and 1.3).

Figure 1.2 Trends in GDP and labour productivity growth, Thailand, 1990–2011 (average annual growth rate)



Source: Asian Productivity Organization (APO), 2013
Note: Labour productivity growth: Average annual growth rate of GDP at constant basic prices per hour, at 2005 PPP$

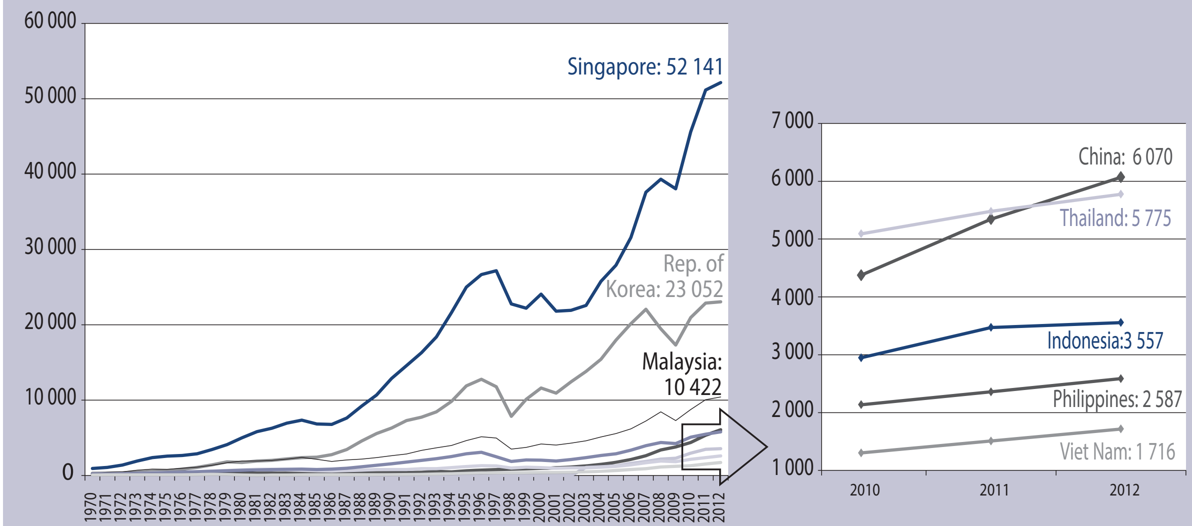
Figure 1.3 Total factor productivity growth, Thailand, 1970–2011 (average annual growth rate)



Source: APO, 2013

Thailand has achieved a significant increase in per capita income in recent decades (figure 1.4). Today, it remains internationally competitive[8] and attractive to FDI because of a generally sound macroeconomic environment together with its market size, a fairly well-developed financial market and relatively reasonable levels of competition (despite a number of barriers to competition in specific sectors) (WEF, 2014). However, it is now experiencing difficulties in making further progress. This has become a source of concern both for its policymakers and business leaders. The country is at risk of falling into the so-called "middle-income trap",[9] whereby it can no longer compete against lower cost neighbouring countries such as Cambodia, Lao People's Democratic Republic and Viet Nam in less skill-intensive activities, while still lacking the STI capabilities and skills base needed to move into higher value-added activities and compete with more industrialized neighbours, such as the Republic of Korea and Singapore.

Figure 1.4 GDP per capita of selected countries, 1970–2012 (dollars at current prices and current exchange rates)



Source: UNCTADstat.

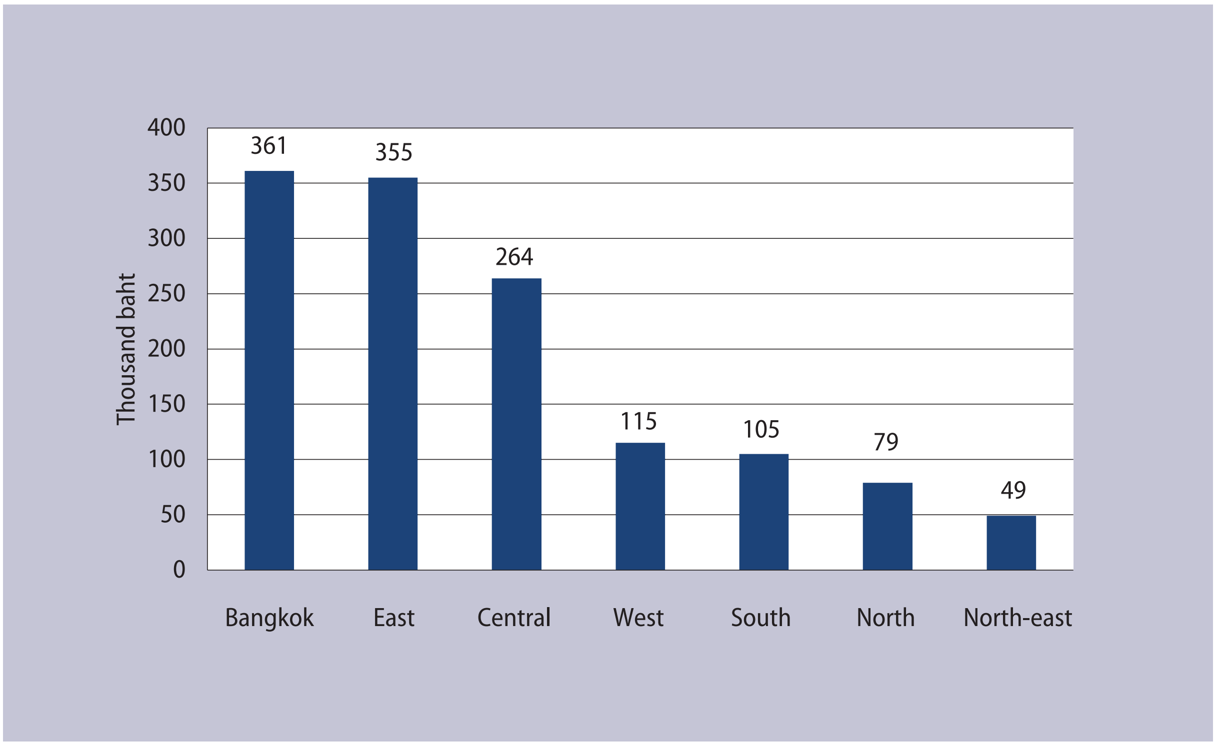
Cumbersome, non-transparent bureaucratic procedures are often cited as factors that adversely affect the quality of the business environment (see, for example, WEF, 2014), including for innovation. Political instability, short-lived governments and the resulting lack of policy continuity have also weakened the ability of public institutions to provide an enabling environment for businesses, and, equally important, to steer and sustain major reforms over time. For the past few years, growing tensions between different elements of Thai society have created divisions along social as well as geographical lines, and added to the political difficulties facing the country. A highly confrontational political system has favoured the development of policies that seek to address the concerns of increasingly divided constituencies, further contributing to policy instability. The growing predominance of politicians and lobbyists (see, for example, Suehiro, 2010) over the professional civil service has also affected the design and implementation of economic policies and long-term development strategies.

Large TNCs (particularly Japanese) State-owned enterprises and family-owned domestic conglomerates are the primary contributors to GDP (OECD, 2013a). These large firms and conglomerates play a major role in the development of STI capabilities in the country, through investments in STI but also through their influence on the design of industrial and economic policies (Suehiro, 2010). SMEs still account for 80 per cent of employment, 37.7 per cent of non-agricultural GDP, and 28.8 per cent of exports (OSMEP, 2013). An important feature of SMEs in Thailand is the relative underrepresentation of medium-sized firms (those employing 51–200 employees), which may constrain productivity and the development of technological capability. This is a common pattern in developing countries, often referred to as the «missing middle» (UNCTAD, 2007).

Another factor that is a major hindrance to Thailand's economic growth is its geographically unequal development. While poverty fell from 42.6 per cent in 2000 to 13.2 per cent in 2011 (UNDP, 2014),[10] widespread inequalities of income and opportunity are taking a toll on Thailand's economic potential. Income inequality, which grew rapidly at the start of the industrialization process (1980s and early 1990s) and somewhat diminished thereafter, partly due to improved social protection and widespread employment opportunities, remains high by international standards (UNDP, 2014). In 2010, the Gini index (a measure of income inequality) was 39 compared with 45 in 1985 (table 1.1).

The spatial dimension is a major factor of income and human development inequality. Economic and political powers are concentrated in Bangkok and the surrounding provinces. Poverty is largely a rural phenomenon (FAO, 2011; UNDP, 2014)[11] and is affecting significantly the north-east region, the border provinces in the northern region and the three southern-most provinces (figure 1.5). There are also significant disparities in terms of access to health, education, employment, housing, family and community life, transport and communication, and political and civil society participation at the provincial level (UNDP, 2014).

Figure 1.5 Gross provincial product per capita, Bangkok and the regions, 2011 (thousands of baht)



Source: UNDP, 2014.

There are major concerns about environmental sustainability in Thailand. Environmental degradation and the deterioration of natural resources have resulted from rapid urbanization, industrialization and increasing intensive farming and fishing activities that have supported and accompanied economic growth. Climate change is also affecting Thailand. The country is experiencing recurring extreme weather events, landslides, floods (notably that of 2011) and droughts that have serious impacts on the lives and livelihoods of its people.

B. SCIENCE, TECHNOLOGY AND INNOVATION PERFORMANCE IN THAILAND

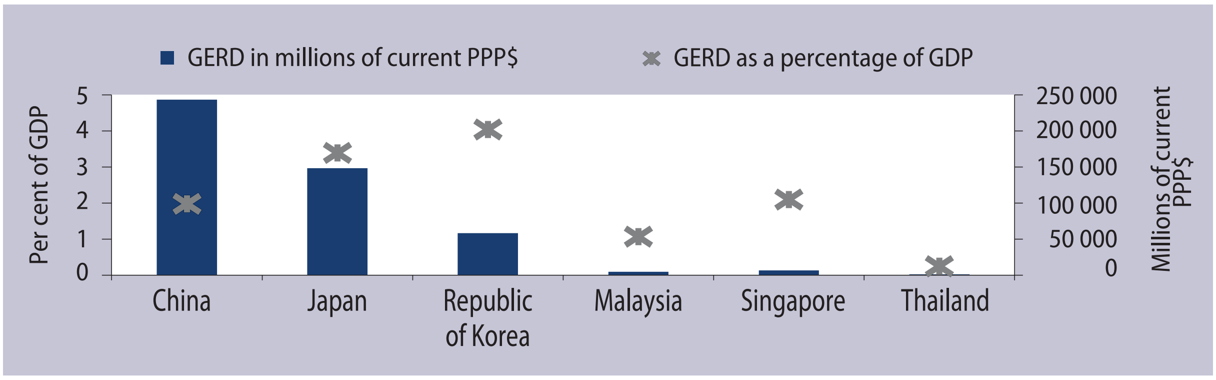
1. STI inputs

Thailand has sizeable financial and human resources devoted to science and technology (S&T), but not sufficient to support broad-based growth and enable innovation-led economic development. R&D investments are mainly from public sources, and most of the R&D work is conducted in public research institutions and universities. Weak access to and use of information and communications technologies (ICTs) in rural areas and periphery regions also constrain the emergence of a broader range of innovation activities and innovative actors.

Investment in R&D

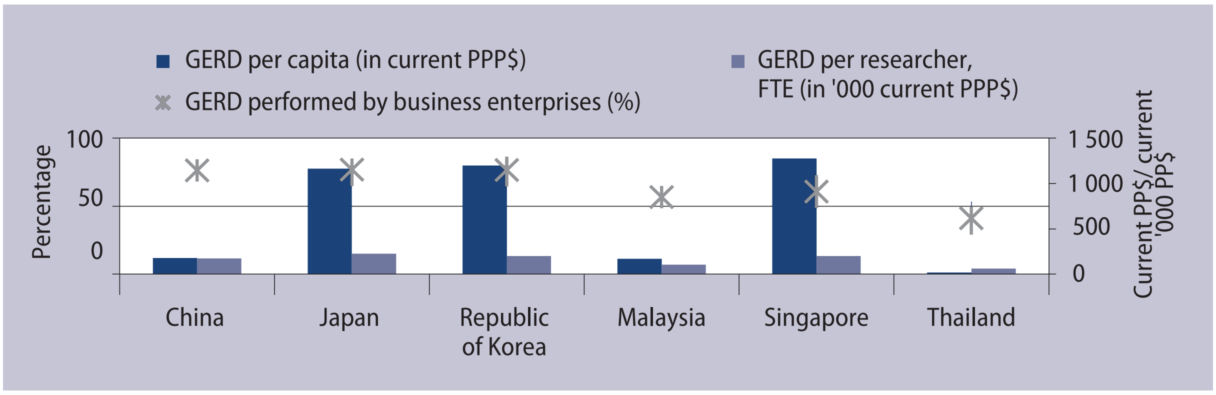
Thailand's financial support for STI, as measured by the proxy, "gross expenditure on R&D" (GERD) indicator, is lower than that of the more advanced economies in the region, in absolute terms and relative to GDP (0.25 per cent), to population and to the number of R&D personnel (figures 1.6 and 1.7). Moreover, R&D investments are largely from public expenditure rather than from the private sector (figure 1.7).

Figure 1.6 Gross expenditure on R&D, selected Asian countries, various years (Millions of current PPP$ and as a percentage of GDP)



Source: Data centre of UNESCO Institute for Statistics (https://stats.uis.unesco.org).
Note: Data for the countries shown refer to different years: China (2012), Japan (2011), Republic of Korea (2011), Malaysia (2011), Singapore (2012), Thailand (2009).

Figure 1.7 Public and private investment in R&D, selected Asian countries, various years

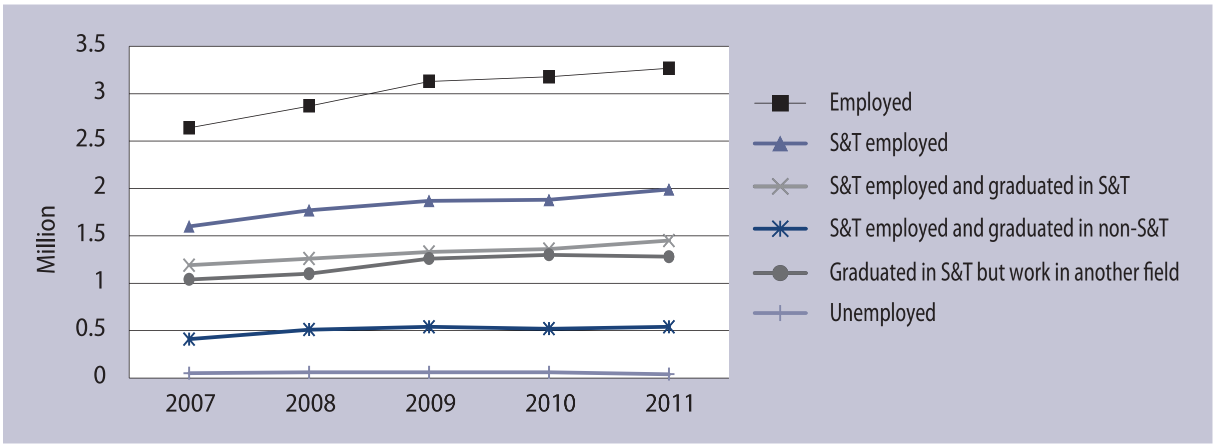


Source: Data centre of UNESCO Institute for Statistics (https://stats.uis.unesco.org).
Note: See note to figure 1.6.

Labour force employed in S&T

The labour force employed in S&T[12] in Thailand has increased constantly to reach 3.31 million persons in 2011 (9 per cent of a total workforce) (figure 1.8). There is limited unemployment among S&T graduates, (unemployment rate is generally low in Thailand (table 1.1)). However, around 40 per cent of S&T graduates work in a different area than S&T (figure 1.8) –which suggests a poor match between educational offer and market needs. In the S&T workforce, 58 per cent have a degree lower than a bachelor's.

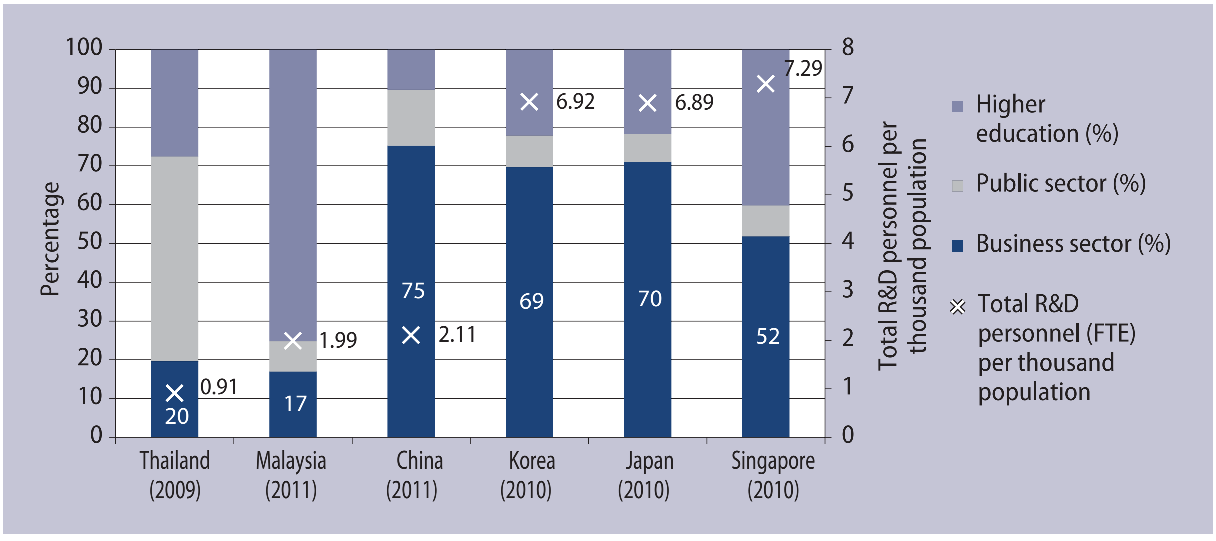
Figure 1.8 Labour force employed in S&T in Thailand, 2007–2011 (Millions of persons)



Employed = Those employed in S&T + graduates in S&T but working in another field.
S&T employed = S&T employed and graduated in S&T + S&T employed and graduated in non-S&T
Source: National STI Policy Office, 2013.

Thailand has over 60,000 persons working in R&D today, following an impressive growth of such personnel over the decade 1999–2009. However, much of that growth has taken place at public and academic institutions, while the proportion of researchers in the private sector has declined steadily (table 4.3). By 2009, only 20 per cent of R&D personnel employed in full-time equivalent (FTE) worked in the private sector. The number of R&D personnel per thousand inhabitants and the ratio of researchers in the private sector in Thailand remains low compared with other countries in the region (figure 1.9).

Figure 1.9 Proportion of R&D personnel in different sectors, selected Asian countries, various years (Percentage)

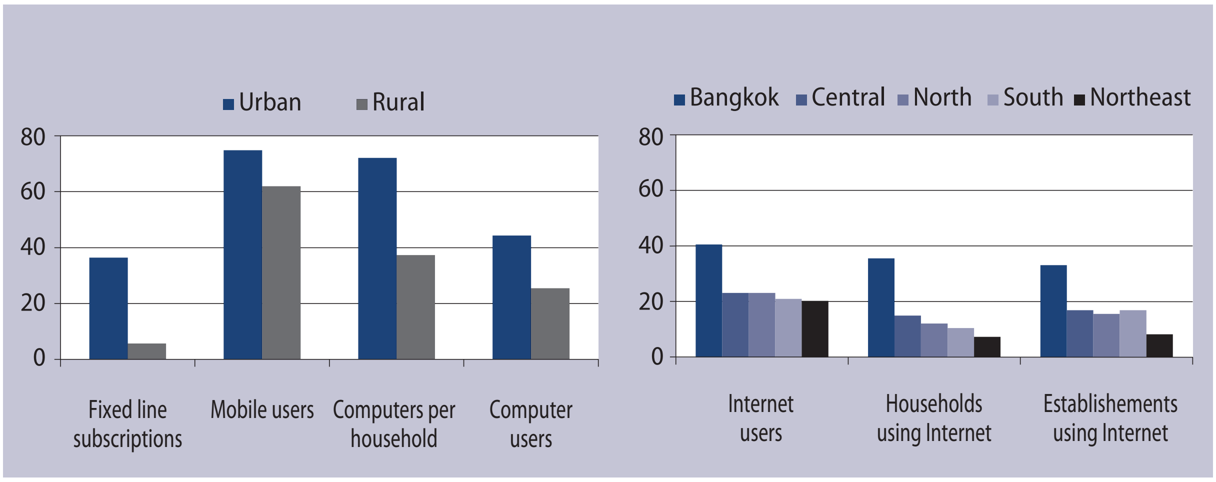


Source: Data centre of UNESCO Institute for Statistics, at https://stats.uis.unesco.org.

Access to and use of ICTs in Thailand

Access to and use of ICTs are fundamental for innovation. Thailand's ICT infrastructure and ICT use are significantly lagging behind other Asian economies, partly because of an underdeveloped rural infrastructure for ICTs. For instance, in 2011, only 22 per cent of Thais were using the Internet, compared with one third in China and over 50 per cent in Malaysia (National STI Policy Office, 2013). More importantly, there are wide urban-rural differences in ICT use and access. For instance, the percentage of Internet users in the regions (around 20 per cent) is half that of Bangkok (40.3 per cent) (figure 1.10).

Figure 1.10 Disparities in ICT access and use in Thailand, 2011 (percentage)



Source: Based on National STI Policy Office, 2013.
Note: Fixed line subscriptions (per 100 inhabitants, 2010); mobile phone users (population 6 years of age and over using mobile phones per 100 inhabitants); computers per household (computers per 100 households); Computer users (as a percentage of the population aged 6 years and over using computer); Internet users (population aged 6 years and over using the Internet per 100 inhabitants; households using the Internet (population of households using the Internet per 100 inhabitants); establishments using the Internet (population of establishments using the Internet per 100 inhabitants)

2. STI outputs

Scientific publications

Thailand has a reasonable capacity to publish scientific articles. In 2013, 11,313 articles were indexed in international journals.[13] While Thai researchers publish fewer articles than researchers in the more advanced countries in the region, they show greater international collaboration than researchers in China, Japan, Malaysia and the Republic of Korea and greater publication impact (as measured by the h-index[14]) than Malaysia (table 1.2). Half of the collaborative research is done with researchers from the United States, Japan, the United Kingdom, Australia and China.

Table 1.2 Relative level and impact of published research, selected Asian countries, 2013

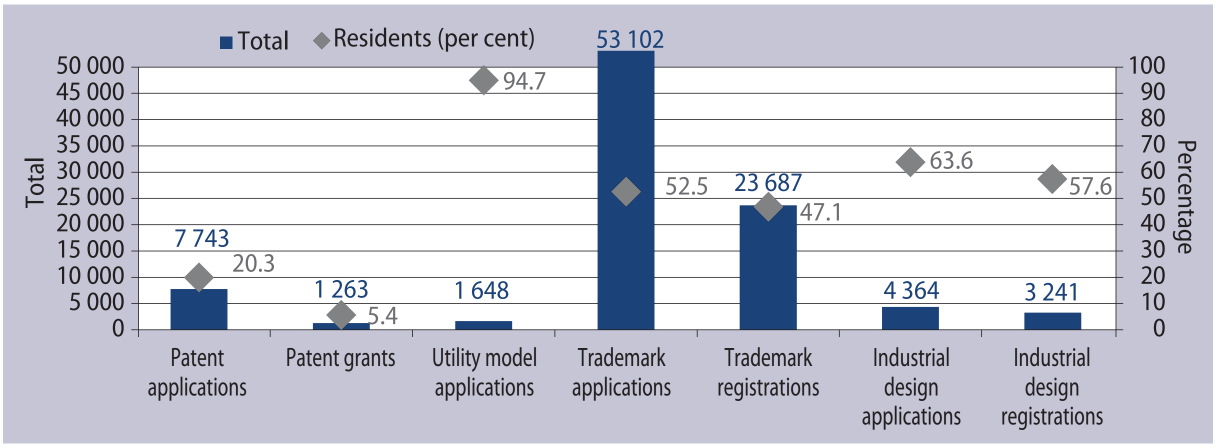
	China	Japan	Malaysia	Rep. of Korea	Singapore	Thailand
Documents published	425 677	121 668	23 190	71 072	17 052	**11 313**
Citations per document published in 2010	4.0	5.9	3.6	6.1	9.5	**5.1**
H-index	436	694	145	375	308	**190**
International collaboration	17	25	34	27	58	**39**

Source: UNCTAD, based on SCImago Journal & Country Rank, at: www.scimagojr.com.

Patents and other intellectual property (IP)

Thailand has a fairly developed IP system, although there are considerable delays in examining patent applications and some uncertainty about protection (WEF, 2014). Patent applications and grants largely involve non-residents. In 2013, of the 1,263 patents granted by Thailand's patent office, only 5 per cent were granted to residents (figure 1.11). Domestic public research institutions and universities accounted for a minor proportion of the total patents granted, particularly relative to their investments in R&D. During the period 2007–2011, less than 3 per cent of patents were granted to each of these two sectors, even though they accounted for 43 per cent and 27 per cent, respectively, of GERD.[15] On the other hand, utility models, trademarks and industrial design are much more relevant for Thai residents, as is to be expected in a country at Thailand's stage of development and technological capabilities. For instance, in 2012 nearly 95 per cent of utility model applications were filed by residents.

Figure 1.11 Intellectual property indicators, 2013

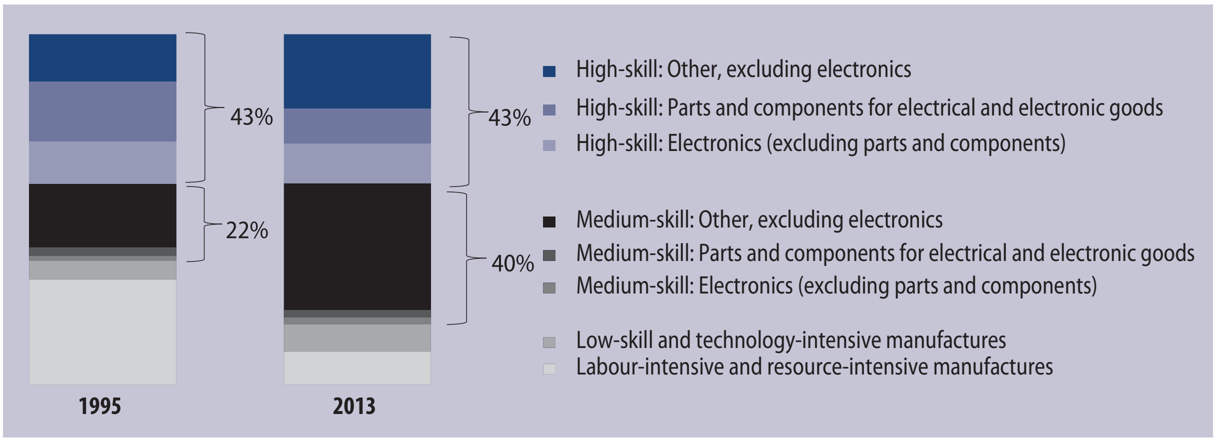


Source: UNCTAD, based on World Intellectual Property Organization (WIPO) Statistical Country Profiles, at: http://www.wipo.int/ipstats/en/statistics/country_profile/

Technology content of exports

Over the past two decades there has been a significant increase in the skill and technology content of Thailand's exports. Products involving high- and medium-skill-intensive technologies account for the bulk of its exports of manufactures, at 43 per cent and 41 per cent respectively (figure 1.12). These are largely from the automobile and electronics industries, which depend on imported technologies.

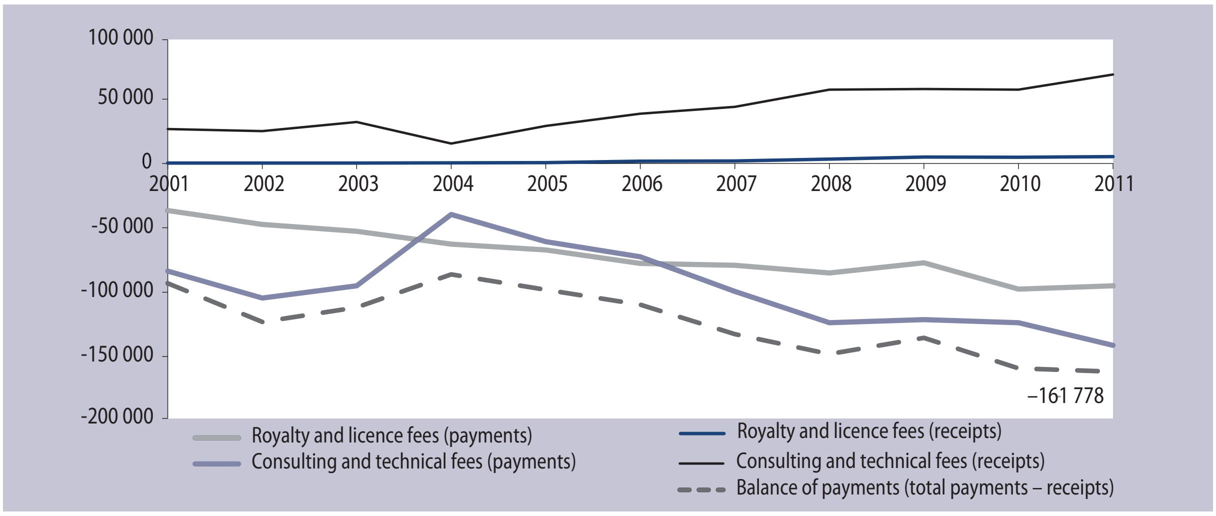
Figure 1.12 Evolution of the technological content of Thailand's exports, 1995–2011 (percentage)



Source: UNCTAD, based on UNCTADstat.

Thailand's deficit in the technology balance of payments[16] rose significantly from 2001 to 2011 (figure 1.13). This was largely due to higher payments, which have been only partially offset by higher receipts from consulting and technical fees. In 2011, the automotive sector accounted for one third of royalty and licence fee payments, and one third of the consulting and technical fees were incurred by the oil and gas sector.[17] This type of imbalance is characteristic of an economy that is pursuing more sophisticated activities but has not yet developed sufficient domestic capabilities to generate revenue from IP.

Figure 1.13 Technology balance of payments, 2001–2011 (millions of baht)



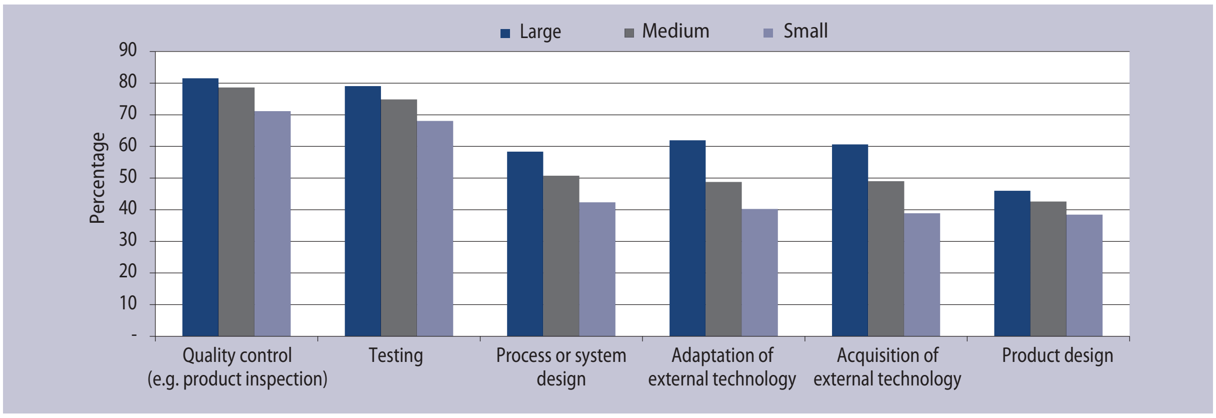
Source: UNCTAD, based on Bank of Thailand data from National STI Policy Office, 2013.

3. Overview of firms' innovation activities

The latest R&D and innovation survey conducted in Thailand, covering activities in 2011, provides some insights into the innovation features of the private sector. As in other countries, smaller firms in Thailand tend to engage less in R&D and innovation activities than larger ones, and when they do so, their activities tend to be less sophisticated.

Conducting quality control or testing activities[18] is fairly common in Thailand. Over two thirds of firms conducted a quality control or testing activity in 2011. However, less than 40 per cent of small firms have acquired or adapted external technologies or designed products or processes (figure 1.14).

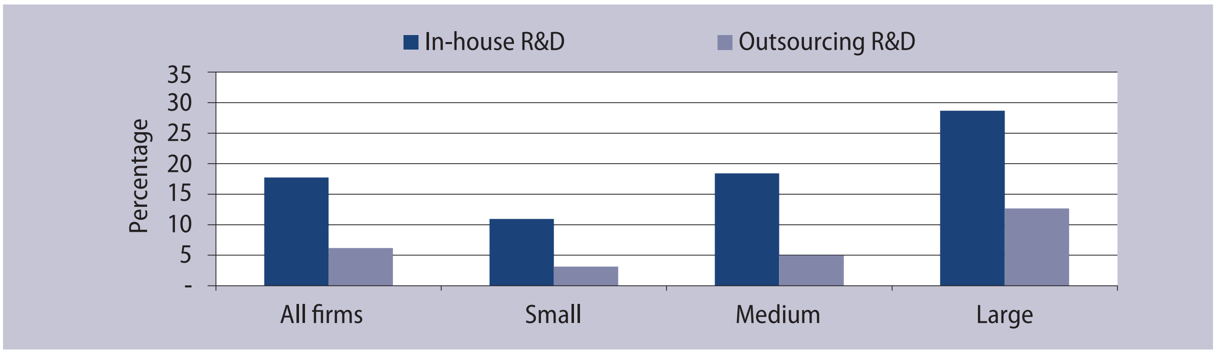
Figure 1.14 Propensity to conduct quality activities, adapt or acquire technology and design new products or processes (Percentage of firms carrying out each of the activities, by firm size)



Source: UNCTAD, based on data from the National R&D and Innovation Survey 2011.

Considerably fewer firms are engaged in the more sophisticated activity of conducting R&D. Over a quarter of large firms conduct R&D in-house compared with only 10 per cent of smaller firms (figure 1.15). The propensity of firms to conduct in-house R&D varies greatly across sectors. Independently of firm size, the largest proportion of firms conducting such R&D consists of those engaged in manufacturing (notably the chemical, electronics, food, rubber, machinery, and oil and gas industries). In-house R&D expenditure is largely devoted to the development of new or improved products (65 per cent) rather than processes (22 per cent). Six per cent of firms outsource R&D activities (figure 1.15). Most outsourced R&D is undertaken by local universities (31 per cent) and foreign private organizations (31 per cent), and to a lesser extent by domestic public research organizations (12 per cent) or foreign universities (12 per cent). Affiliated and parent firms play a minor role in this area.

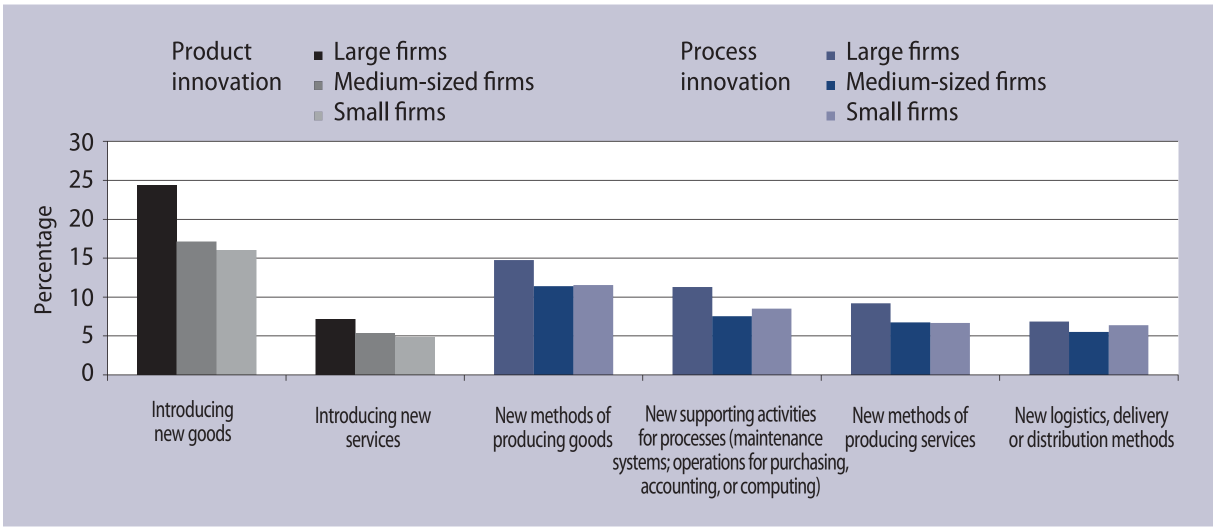
Figure 1.15 Firms conducting in-house R&D and outsourcing R&D, by firm size (percentage)



Source: UNCTAD, based on data from the National R&D and Innovation Survey, 2011.

Reported innovation is greater in goods than in services: whereas nearly one fifth of firms have introduced new goods, only 5 per cent have introduced a new service (figure 1.16).

Figure 1.16 Innovation in goods and services compared, by size of firm (percentage)



Source: UNCTAD, based on data from the National R&D and Innovation Survey, 2011.

According to the results of the National R&D and Innovation Survey 2011, firms, regardless of their size, reported that the main barriers to innovation were the lack of qualified personnel, the cost of innovation and limited access to information on technology and markets. Anecdotally, medium-sized firms tended to report greater difficulties for each of the barriers than smaller and larger firms. Larger firms perceived access to finance as a relatively less important barrier.

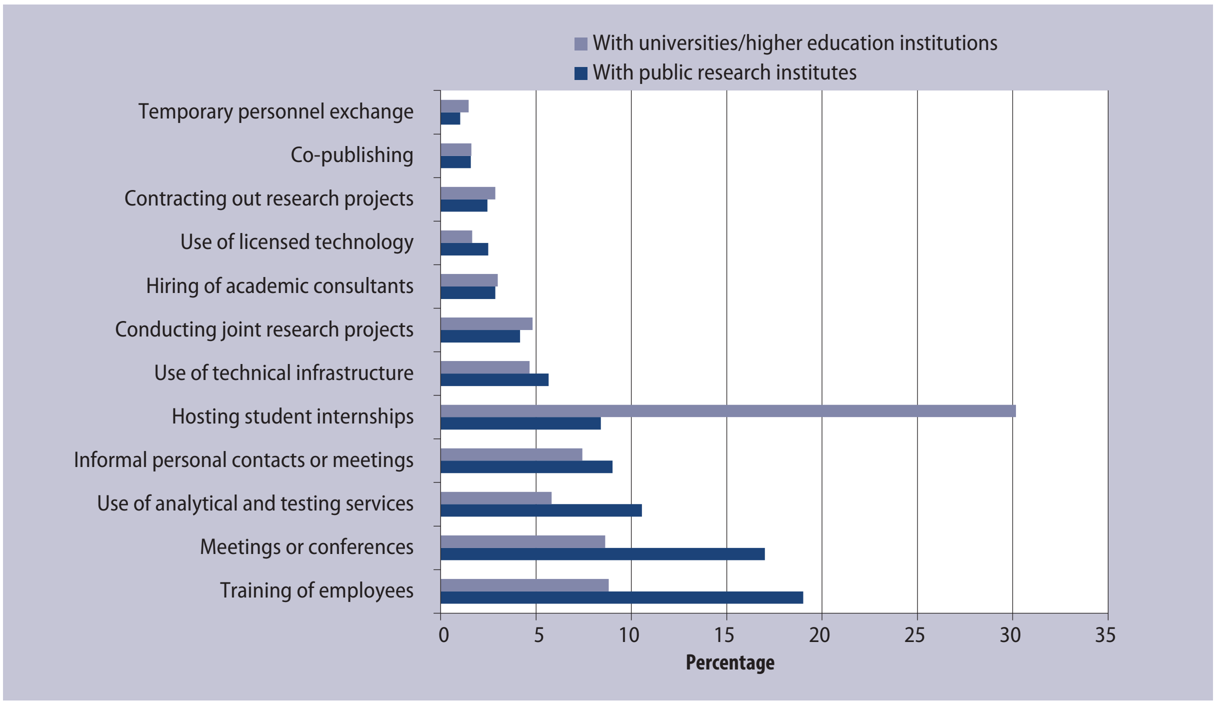
The main sources of information for Thai firms are those persons/entities with which firms interact on a routine basis (e.g. clients, employees, parent firms, local suppliers, competitors) in addition to the Internet. More sophisticated sources of information such as patent disclosures, public research institutions and universities or business service providers are much less important for Thai firms.

To innovate, firms are likely to collaborate more with market actors (e.g. customers, suppliers, parent or associated companies). Next, they collaborate with knowledge-generating institutions (universities and public research institutions) and professional and industry associations. Smaller firms tend to collaborate more with competitors, local suppliers and professional and industry associations than with universities. For example, a third of firms (but only a fifth of small ones) reported some type of collaboration with universities and/or public research institutions.

Firms collaborate with public research institutions primarily for training employees and through meetings or conferences (figure 1.17), and to a lesser extent through the use of analytical and testing services, informal personal contacts and the hosting of students. This pattern of collaboration does not vary with firm size, but there are wide gaps between the proportion of large and small firms undertaking each of the activities. For instance, the proportion of larger firms using analytical and testing services or the technical infrastructure of public research institutes is at least 2.5 times that of smaller firms.

Nearly half of large firms and one fifth of small ones host university student internships (figure 1.17). Businesses also collaborate with universities to train employees through conferences or to use testing services, but much less so with public research institutions. Firm size influences the propensity to collaborate, but not the pattern of firm-university collaboration.

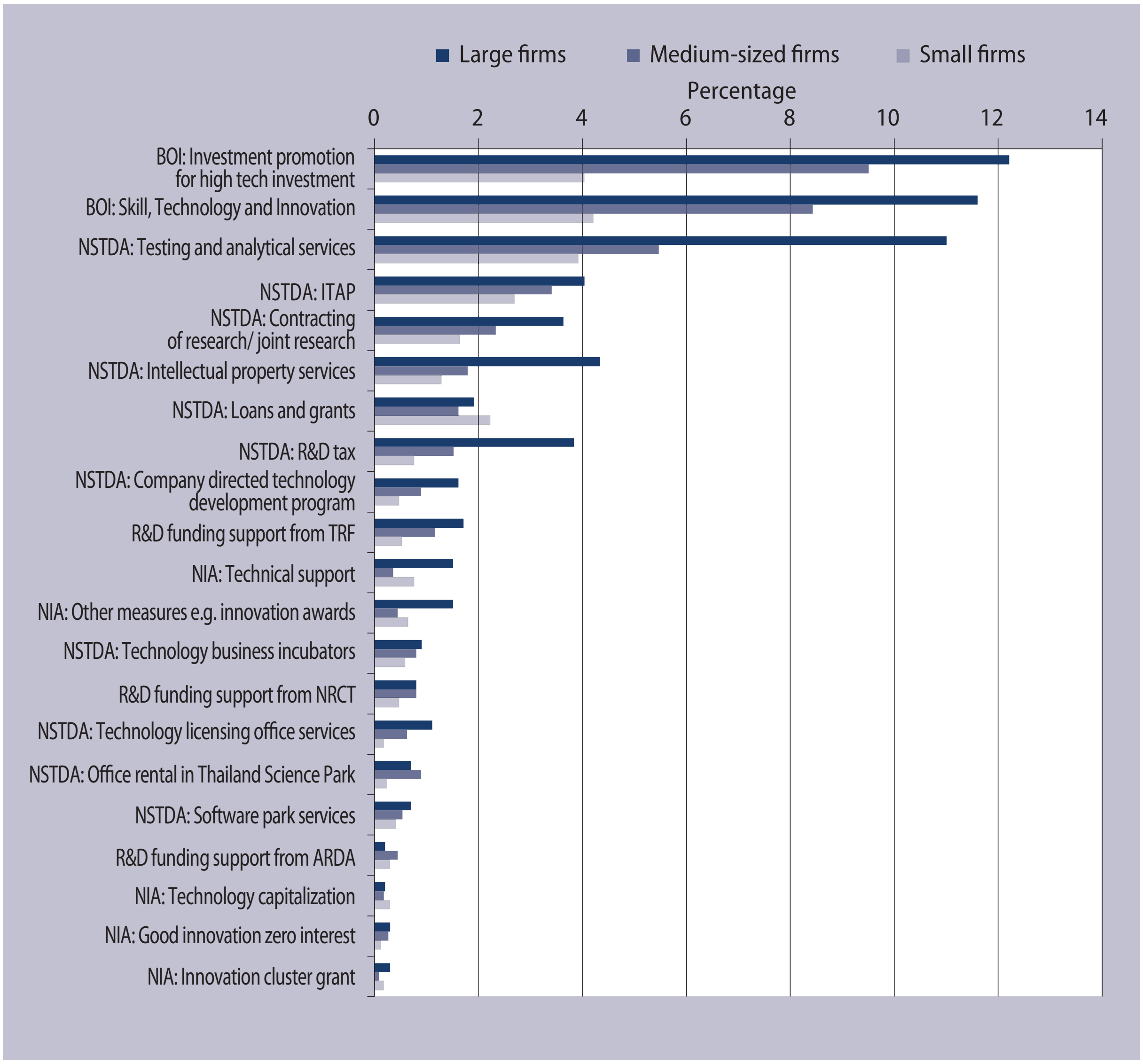
Figure 1.17 Types and extent of collaboration of firms with universities and public research institutions (percentage)



Source: UNCTAD, based on data from the National R&D and Innovation Survey, 2011.

A very small proportion of firms make use of the different public instruments[19] available to support R&D and innovation (figure 1.18). More firms, particularly larger and medium-sized firms, use the Bureau of Investment instruments and the testing and analytical services of the National Science and Technology Development Agency (NSTDA). Over 10 per cent of large firms use them, while around 4 per cent of smaller firms use them. On the other hand, smaller firms make greater use of NSTDA's loans and grants than larger ones. The Industrial Technology Assistance Programme (ITAP) is also relatively important for smaller firms.

Figure 1.18 Public services and incentives used by private firms, 2011 (percentage)



Source: UNCTAD, based on data from the National R&D and Innovation Survey, 2011.

Structure of this STIP Review

Following this introduction of the broader socio-economic conditions that have shaped the development of Thailand's indigenous STI capabilities and skills, chapter 2 identifies key strengths and weaknesses of its national innovation system. The chapter provides policy suggestions on options for reinforcing the national innovation system, which would support the upgrading of the technological and innovation capabilities necessary for Thailand to escape the middle-income trap.

Chapters 3 and 4 provide further insights into two aspects of STI. Chapter 3 examines the agricultural innovation system of Thailand from the perspective of small-scale farmers, who produce the bulk of the key energy and food crops and represent a large share of the population whose welfare could improve through innovation-driven growth. Chapter 4 analyses in more detail Thailand's ability to educate and train the human resources required to support the development of its productive capabilities.

NOTES

1 Source: Economist Intelligence Unit, January 2015.

2 UNCTAD calculations based on UNCTADstat

3 UNCTADstat

4 In 2013, the largest importers from Thailand were China ($27 billion), the United States ($23 billion), Japan ($22 billion), Hong Kong (Special Administrative Region of China) ($13 million) and Malaysia ($13 million); and the largest exporters to Thailand were Japan ($41 billion), China ($38 million), the United Arab Emirates ($17 million), the United States ($15 million) and Malaysia ($13 million) (UNCTADstat).

5 See, for example, Doner et al., 2013; Intarakumnerd et al., 2010.

6 National Competitiveness Plan, 2003.

7 Food, automotive, fashion, tourism and software.

8 In 2014, Thailand advanced its ranking to 31st position in the Global Competitiveness Index (GCI) despite an unstable political environment.

9 See, for example, Felipe, 2012.

10 Defined as the percentage of the population at the national poverty line as opposed to the international poverty lines of $1.25 or $2 (purchasing power parity) per day.

11 See also World Bank, at: www.worldbank.org/en/country/thailand/overview.

12 The S&T labour force comprises all the labour force working in S&T fields (whether or not they have graduated in S&T), plus graduates in S&T working in other fields as well as unemployed S&T graduates.

13 SCImago Journal and Country Rank, at: http://www.scimagojr.com/countryrank.php.

14 The h index is a country's number of articles (h) that have received at least h citations. It quantifies both country scientific productivity and scientific impact.

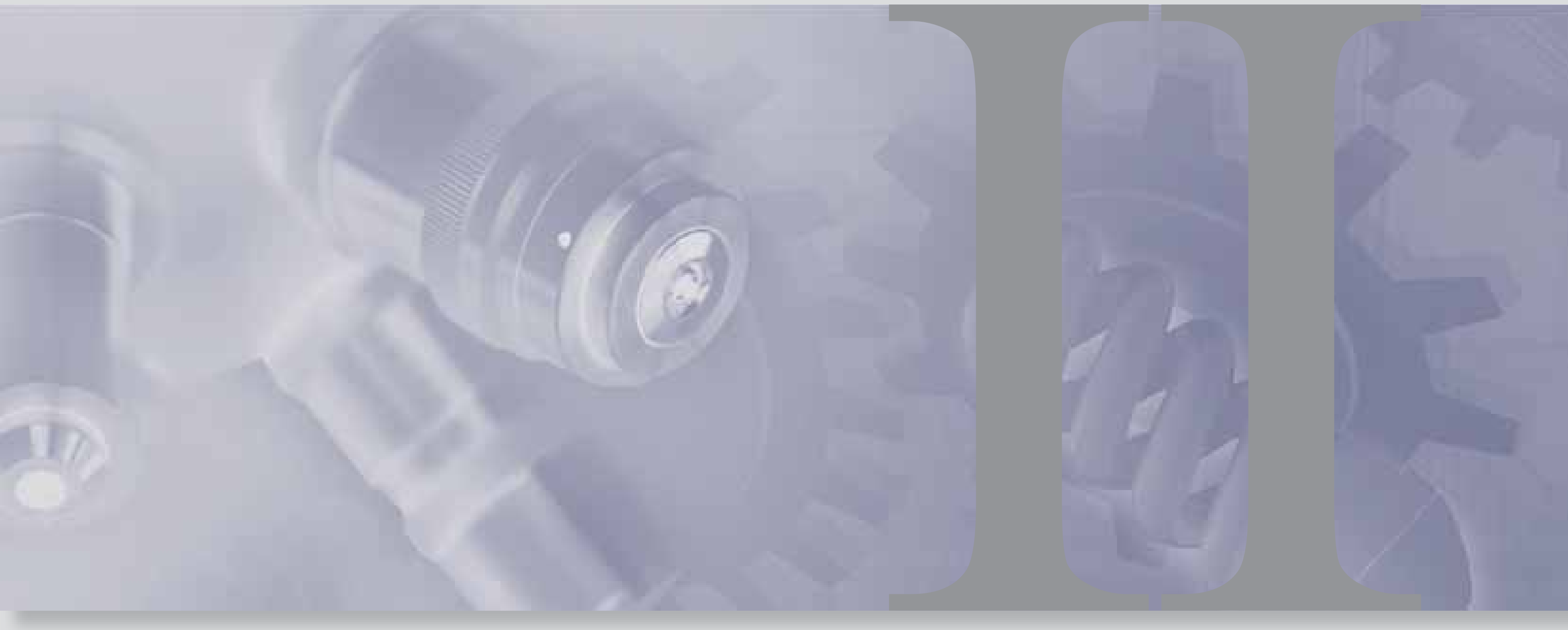
15 Based on National STI Policy Office, 2013 and UNESCO Institute for Statistics

16 The technology balance of payments is the difference between the receipts and payments of Royalty and licence fees plus consulting and technical fees.

17 Based on data published in National STI Policy Office, 2013.

18 Quality control and testing activities, while they may require technology, are not innovation activities (except when a quality control or testing process is first introduced by a firm).

19 These statistics should be interpreted with caution. The 2011 survey did not cover a number of public services and incentives available at the tim e (e.g. those provided by the Ministry of Industry and the Thailand Institute of Scientific and Technological Research, or TISTR) or the newer innovation coupon (see Chapter 2).



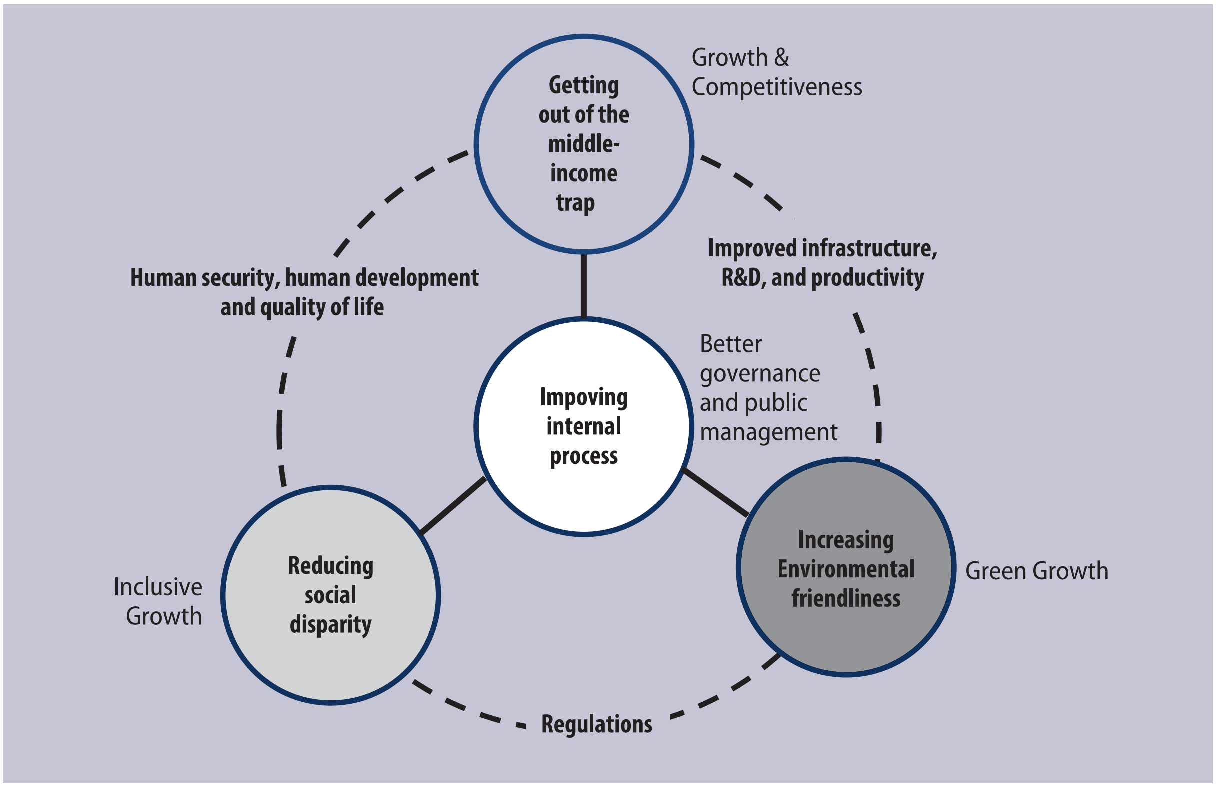
Thailand’s innovation system: Critical observations and policy recommendations

A. THE RATIONALE FOR FOSTERING INNOVATION

Thailand has seen a significant increase in per capita income over recent decades (figure 1.4), but is now experiencing a slowdown in GDP and total factor productivity growth (figures 1.2 and 1.3). The country risks falling into the so-called "middle-income trap"[1] and it will find it increasingly difficult to compete against lower cost locations in less skill-intensive economic activities, while still lacking the technological know-how and human capacity to progress into more sophisticated higher value-added activities.

At the same time, Thailand faces major problems relating to social inclusiveness and environmental sustainability. These combined economic, social and environmental concerns and the challenge of governance and public management are considered in the 11th National Economic and Social Development Plan 2012–2016 (NESDB, 2011) (figure 2.1).

Figure 2.1 Thailand's long-term development strategy



Source: Wanichkorn, 2013.

To tackle these multiple challenges, it is imperative that efforts be made to improve the country's innovation capabilities. Innovation refers to the actions taken by economic actors to upgrade their technological level, enhance their organization and production methods, develop new activities and enter new markets. Innovation is much more than R&D; it also encompasses the adoption and dissemination of known technologies, as well as the development of new ones. For instance, in agriculture, innovation may mean farmers' use of available mechanization processes, but also, at the other end of the "sophistication spectrum", it could refer to the development of entirely new technologies, such as biofuels based on biomass, that require long-term R&D and large-scale experimentation.

Innovation activities are carried out primarily by firms, but within a broader system comprising public and private agents (e.g. research centres, academic and training institutions, public ministries and funding agencies) that generate and intermediate knowledge and technology flows, and this is commonly referred to as an innovation system.[2]

As innovation is much more than R&D alone, innovation policies go far beyond research policies or S&T policies; they also involve policies concerning entrepreneurship promotion, industrial reform, market competition and skills development. Thus, the promotion of innovation requires governance structures that accord innovation policy the stature and cross-ministerial reach needed to place innovation at the forefront of policy efforts and ensure policy coordination.

The relative weakness of Thailand's innovation system is reflected in several international benchmarking exercises which show its modest performance compared with other Asian countries of similar size and development level. For example, according to the Global Innovation Index, Thailand trails far behind the Republic of Korea and Singapore (top world performers), but it is also behind Malaysia, while Viet Nam is rapidly catching up (table 2.1). The traditional indicator of investment in R&D as a percentage of GDP is remarkably low for a country at a relatively advanced stage of development: 0.25 per cent (figure 1.6). Industry surveys also show limited sophistication of innovation, particularly among Thailand's SMEs (see chapter 1).

Table 2.1 Innovation performance according to the Global Innovation Index 2014, selected Asian countries

	Singapore	Rep. of Korea	Malaysia	Thailand	Viet Nam	Indonesia	Philippines
Global Innovation Index (A+B/2)	59.2	55.3	45.6	**39.3**	34.9	31.8	29.9
Innovation output sub-index (A)	44.9	48.4	38.7	**33.8**	34	31.2	26.8
Innovation input sub-index (B)	73.6	62.2	52.5	**44.7**	35.8	32.4	32.9
Innovation efficiency ratio (A/B)	0.61	0.78	0.74	**0.76**	0.95	1	0.8

Source: Cornell University et al., 2014.

However, Thailand has significant assets to enable it to become an innovative economy: a number of competitive industries, notably in automotive and electronic components, an agricultural sector that makes it a leading world exporter of several products (e.g. rice, rubber, sugar and chicken), and a growing services sector. The country also possesses a sizeable research infrastructure, a reasonably developed higher education system and a large network of vocational schools.

Innovation systems are not static; they can be influenced by policy actions. STI policies stimulate technological learning by building the capabilities of the different agents and by fostering interactions among them through an enabling environment and appropriate incentives. Since the 1960s, successive Thai governments have launched policy initiatives in different fields (R&D, education and industry) that have contributed to improving national innovation capabilities.

This chapter looks at the opportunities for policy to enhance Thailand's national innovation system. First, it discusses the current innovation climate, looking at the capabilities of key actors – businesses, research and technology organizations and educational establishments – and their interactions, especially pointing out obstacles to innovation. Second, it reviews government actions in key policy domains that have had an impact on its innovation performance, identifying strengths but also shortcomings. Based on this analysis, the final section offers a set of policy recommendations. Many of these are relevant, not only for national policymakers, but also for other national stakeholders, and will require their participation in policy design and implementation.

B. THE INNOVATION CLIMATE: TRENDS AND ISSUES

The capabilities and organization of an innovation system are inherently influenced by the general conditions in which an economy operates and society functions. Thus, to better understand the capabilities and behaviour of innovation actors, this section first briefly presents these conditions.

1. Framework conditions

The overall political and institutional framework in Thailand is challenging for the business environment and for innovation activity (WEF, 2013; Cornell University et al., 2014; EIU, 2014). Political instability, short-lived governments and the resulting lack of continuity of policies have weakened the ability of public institutions to provide an enabling environment for businesses, and, equally important, to steer and sustain major reforms over time. Cumbersome and non-transparent bureaucratic procedures and a challenging regulatory environment (in particular law enforcement) are also hampering innovation efforts by constraining the design and implementation of effective long-term development strategies, and by obstructing and making innovation by firms more costly.

Thailand's overall economic situation, which is characterized by sound, though uneven, economic growth rates and by very low levels of unemployment, has not been conducive to innovation. Conformism among business leaders and policymakers has discouraged the implementation of strategic reforms and technological upgrading efforts by the private sector. In the absence of strong pressure for change and with solid confidence in the country's ability to recover from serious economic downturns (e.g. the Asian financial crisis of 1997-1998), Thai leaders are inclined to operate in their comfort zone.

A third major problem is the general level of education.[3] The steady and substantial increase in student participation at all levels has not been accompanied by significant improvements in learning performance. Basic education performance is weak, according to international assessments, such as the Programme of International Student Assessment (PISA) and the Trends in International Maths and Science Study (TIMSS) of the Organisation for Economic Co-operation and Development (OECD). Thailand is trailing behind most East Asian countries in these assessments. A large segment of the population lacks basic reading, writing, and science and math skills, even though the education budget accounts for 20.6 per cent of the total government budget. While Thailand's S&T education at the tertiary level has notably expanded (see chapter 4), it is not adequate in terms of quality or quantity to meet the requirements of the economy, and this is hampering technological upgrading. An important gap also exists in intermediary technological competences, such as those provided by professional and technical schools.

A fourth issue is the insufficient development and use of the ICT infrastructure. ICTs are the backbone of a knowledge-based economy, just as roads and railways are for industrialization. However, Thailand ranks poorly in global benchmarking indicators, such as ICT access and use, with less than 30 per cent of the population using the Internet (WEF, 2013). This is largely because the poor rural ICT infrastructure limits ICT access and use by a large segment of the population, as noted in chapter 1.

On the positive side, Thailand offers very good conditions for innovation in several areas. It has an open economy with a high proportion of high-tech imports and exports, and a substantial and competitive industrial sector,[4] which, despite being dominated by TNCs, provides substantial technological learning opportunities. The business environment is also conducive to innovation. In 2014, Thailand ranked 18th (out of 189 countries) in the Business Index (World Bank, 2013) and 31st (out of 148 countries) in the Global Competitiveness Index (WEF, 2014).

The higher education and research infrastructure, including a dozen high quality universities, provides a significant scientific base. The number of scientific publications has increased tenfold, from about 1,200 in 1996 to more than 11,300 in 2013, when 40 per cent of the papers were co-authored with foreign authors.[5]

Finally, Thailand's public administration has competent officials with sufficient access to information and exposure to international practices to be able to formulate coherent STI policies and programmes. The country also has well-informed think tanks as well as proactive business associations such as the Federation of Thai Industries and the Thai Chamber of Commerce.

2. The productive sector

The majority of private sector firms are not oriented towards innovative activity. The proportion of firms engaged in innovation is relatively small: less than 30 per cent of manufacturing and services firms – compared to 50 per cent or more in OECD countries – are considered to be innovative (table 2.2). Nevertheless, there has been progress over time, with the proportion of innovative firms doubling between 2008 and 2011. The most innovative manufacturing firms are in the chemical, electronics, food, rubber, machinery, and oil and gas industries.[6] In the services sector, apart from the firms dedicated to R&D, the most in-house R&D is conducted by firms engaged in wholesale and retail trade, and computer services.

Table 2.2 Percentage of innovative firms in manufacturing and services, 2003–2011

	2003	2008	2011
Total	**7.16**	**13.70**	**28.50**
Large firms	11.84	22.63	34.59
Medium-sized firms	7.21	11.69	27.41
Small firms	2.75	5.87	25.67

Source: R&D and Innovation Surveys conducted by NSTDA (2003 and 2008); National STI Policy Office, 2014
Note: The 2003 survey had 2,583 respondents, the 2008 survey had 3,533 and the 2011 survey had 4,252. Results of 2011 are not fully comparable with those of 2003 and 2008, as in 2011 the sample covered was both widened (to include the trading sector) and deepened (to cover four digit industries).

In some respects Thailand has a dynamic SME sector.[7] Compared with countries at a similar stage of economic development, it has a high rate of entrepreneurial activity. Individuals become entrepreneurs because they see opportunities rather than out of necessity, and women participate in business ventures to the same extent as men (GEM et al., 2012). However, the SME sector is not particularly technology-intensive or innovative, and consists mainly of consumer-oriented businesses (GEM et al., 2012) with limited exposure to international trade.[8] SMEs play a smaller role than larger ones in the country's exports.[9] Moreover, they tend to be followers, providing the same products as existing businesses. The drive for entrepreneurship is hindered by a fear of failure and by the ample opportunities available to access salaried jobs. The Thai Office of SMEs Promotion (OSMEP) notes difficulties in achieving greater ratios of exporting SMEs, enhancing the total factor productivity and labour productivity of manufacturing SMEs and expanding the weight, creativity and competences of SMEs in the services sector.

Larger firms tend to engage more in innovation, but their level of involvement varies depending on their sector of operation and on their financial resources. Large food processing groups, under pressure from domestic demand and foreign competition, are investing increasingly in R&D so as to diversify their products and increase their export capabilities. The State enterprise PTT, Thailand's largest and leading petrochemical company, has invested in various technology fields (e.g. deep water exploration, biogas, bioplastics), and has launched significant innovative institutions, including several of public interest (e.g. an energy academy for public information, a research university and a leadership institute) with an S&T budget three times larger than that of the Ministry of Science and Technology (MOST).

Foreign investors, which constitute the backbone of Thai industry, have contributed significantly to improve the qualifications of the labour force, but they have played a limited role in technology transfer and in strengthening the technology capabilities of domestic firms. Technological improvements have generally been achieved through the acquisition of imported equipment in the context of production and export agreements with TNCs. Technology transfer is limited to the operational level, as TNCs tend to train workers to produce goods efficiently rather than equipping them with engineering and design skills (OECD, 2013a: 270). However, a number of TNCs have started to develop R&D facilities in the country. For example, the Toyota Technical Development Center Asia Pacific (Thailand) specializes in materials development, vehicle testing and design to meet regional needs.

A number of new technology-based firms have emerged, but, apart from some emblematic examples (e.g. FlexoResearch, see box 4.8), few have succeeded in capturing new markets or expanding in size. Several reasons explain the limited development of such firms:

- The pool of potential entrepreneurs is relatively small – SME density is below the OECD average (OECD, 2011: 28) and the rate of enterprise creation per population is relatively low[10] – and scientists, engineers or managers prefer to work in public agencies or large businesses.
- The competitive climate is not very open; for instance, some public procurement markets, such as for vaccines and blood testing, continue to be reserved for importers of foreign products.[11]
- The venture capital market is insufficiently developed, and the banking and credit system is reluctant to invest in risky businesses (Cornell University et al., 2014; Wonglimpiyarat, 2013).

- Support provided to entrepreneurs is inadequate; for instance, there are some 60 incubators operating throughout the country, but only about a dozen are considered effective.[12]

Despite Thailand's structural transformation, the agriculture sector still employs 35 per cent of the labour force. It is largely characterized by labour-intensive farming on smallholdings and rain-fed crop production. A number of factors have prevented greater innovation in the farming sector. First, the lack of pressure to upgrade, as the export of crops has remained easy due to their good quality and low production costs or because of subsidies for certain producers (e.g. for rice, sugar and cassava). Second, weaknesses persist in maintaining effective channels for the diffusion of benefits from STI resources (which tend to be concentrated in and around Bangkok) to farmers and a lack of feedback of information to planners and researchers about farmers' needs and experiences. Third, there is an absence of strategic mechanisms to ensure the effectiveness and cohesion of agricultural R&D. Lastly, there is inadequate long-term planning and lack of cohesion in multi-stakeholder efforts for agricultural innovation. These challenges are discussed in detail in chapter 3.

3. Public research and technology organizations

The public research structure is well developed, but it also presents various weaknesses. Over the years a number of public bodies have been established, reporting to different ministries and agencies (table 2.3). There are public research institutes involved in basic research (including mega-sciences such as space and nuclear), four centers devoted to high technologies and established in the Thailand Science Park near Bangkok, and a series of sector-specific technology organisations, notably for industrial purposes. Most of these organisations suffer from two syndromes: they are too thin in terms of budget; and they tend to be inward oriented (that is, they focus mostly on knowledge accumulation activities and pay little attention to technology transfer) – a trait confirmed by the very low level of contract funding in their budget. University research structures also suffer from these insufficiencies.

Table 2.3 Main public research and technology organizations

	Budget (millions of baht)	Personnel
Major science institutes (supported by the Ministry of Science and Technology)		
National Science Museum	777	..
National Institute of Metrology Thailand	approx. 200 govt. funding + approx. 30 revenue (2014)	135 specialists + 65 support staff (2014)
Thailand Institute of Nuclear Technology	..	..
Hydro and Agro Informatics Institute	..	3 R&D staff, 38 support staff
National Synchrotron Light Research Institute	..	..
Thailand Centre of Excellence for Life Sciences	..	..
Geo-informatics and Space Technology Development Agency	Operating budget approx. $20 million (govt. funding + revenue)	360 (10 R&D staff)
National Astronomical Research Institute of Thailand	178.2 (2011)	90 staff
Office of Atoms for Peace	..	..
National Innovation Agency	429 (2012)	..
Thailand Institute of Scientific and Technological Research (R&D and industrial services)	approx. 1 000 government budget + approx. 200 revenue (2013)	1 100 (800 researchers, 200 services staff)
Dept. of Science Services (testing, accreditation)	493 (2014)	..

Table 2.3 Main public research and technology organizations *(continued)*

	Budget (millions of baht)	Personnel
High-tech research centres (under NSTDA)	**3 400 (2009)**	**2 663 staff (1 784 R&D staff)**
National Center for Genetic Engineering and Biotechnology (BIOTEC)	772.7 (2012)	472 R&D staff, 98 others (2012)
National Nanotechnology Center	approx. 15 non-direct income (2011)	103 R&D staff, 51 others (2011)
National Metals and Materials Technology Center	641 govt. funding; 14.8 technological services (2013)	323 R&D staff , 186 others (2013)
National Electronics and Computer Technology Center	..	..
Sector-related technology organisations **Ministry of Industry**		
Thailand Productivity Institute	..	..
Thai-German Institute	..	..
National Food Institute	Self-financed	180 staff (50 training, 50 lab/testing, 30 data services, 50 others) (2014)
Thailand Textile Institute	..	80
Management System Certification Institute	..	..
Thailand Automotive Institute (testing services and policy advice)	Self-financed	approx. 182 staff (91 testing, 91 policy and training) (2009)
Electrical and Electronics Institute	..	..
Institute for SME Development	..	..
Iron and Steel Institute of Thailand	..	..
Ministry of Agriculture		
Department of Agriculture	..	..
Department of Rice (Bureau of Rice Research & Development, 27 Rice Research Stations)	..	..
Department of Land Development	..	..

Source: UNCTAD secretariat, based on (Durongkaveroj, 2014a); Chunhavuthiyanon and Intarakumnerd, 2014, BIOTEC, 2013; MTEC, 2014; Ohno, 2011; SEA-EU-NET, Songsivilai, 2011, as well as information provided by the STI Policy Office and interviews held during field missions in October 2013 and June 2014.

The research and technology organizations (RTOs) listed in table 2.3, and particularly those operating under the NSTDA, perform the bulk of industrial research in Thailand. They tend to support the development of S&T knowledge and capabilities *on behalf of* firms rather than supporting the accumulation of technological and innovative capabilities *within* firms (Intarakumnerd, 2011). Based on a linear perception of the innovation process, Thai RTOs are more entities for knowledge accumulation than channels for knowledge transfer and upgrading, as their staff members are generally more interested in publishing their work than in its application. Mechanisms for technology transfer to industry are limited. Government sources provide most of the funding, and scarcely any funding comes from the private sector. As firms have little involvement in R&D activities, these RTOs do not help build strong R&D capabilities in the business sector. Although RTOs under the Ministry of Industry may have developed closer links with businesses, they operate at lower technology levels, focus their activities on the provision of training and industrial services, and conduct limited R&D (Brimble and Doner, 2007).

The RTOs that build technological and innovative capabilities *within* firms, such as the Industrial Technology Research Institute (ITRI) of Taiwan Province of China (box 2.1), function on different principles: strong efforts aimed at technology transfer and assistance to firms, systematic scouting of technologies from abroad, joint public-private R&D programmes and greater attention to the potential use and impact of R&D.

Box 2.1 Building technological and innovative capabilities within firms: The case of the Industrial Technology Research Institute (ITRI), Taiwan Province of China

Established in 1973, ITRI's main aim has been to support Taiwan's industrial development. It has played a decisive role in improving the competitive capabilities of Taiwanese industry using a strategy of foreign technology assimilation and transfer to local firms through spin-offs. It has promoted technology transfer through joint efforts and mutual and continuous learning. The nature of its support has varied in response to the needs and capabilities of domestic firms. From the 1970s to the early 1990s, ITRI focused on diffusing leading foreign technologies and helping firms to develop their capacity to assimilate and upgrade those technologies. It generated spin-offs from its R&D and used R&D consortia to design prototypes that were subsequently developed into commercial products by participating firms. Since the late 1990s, when domestic firms had mastered design and engineering technologies and started to carry out in-house R&D, ITRI has supported local firms in developing R&D capabilities and leading-edge products. For instance, it provides incubation services for technology start-ups and has an "open lab" that allows SMEs to use ITRI's R&D laboratory.

The Institute has specialized in high-tech industries (e.g. optoelectronics, semiconductors and ICTs) by progressively investing in its successful R&D departments and closing down its unsuccessful ones. Its management understands the needs and technological learning processes of firms, as several of its board directors and executives have had extensive experience working in the private sector. ITRI is the industrial technology development arm of the Ministry of Economic Affairs, and there is a strong link between policy formulation, implementation and evaluation. Its funding has come increasingly from the private sector and from competitive bidding projects.

Source: Intarakumnerd, 2011; UNCTAD, 2014.

Converting Thai RTOs, such as NDSTA research centres, into ITRI-type institutions that promote R&D *within* firms will be challenging. It would require strong and sustained policy efforts, especially policy measures that encourage greater participation of the private sector in R&D financing. In addition, it would be necessary to ensure that RTOs' staff members (through training or renewal) are interested and able to work with firms, that R&D capabilities are developed which respond to the needs of Thai industries,[13] and that industry is given a prominent role in the management and development of these centres.

Metrology, standards and certification services are provided by several organizations, including the Department of Science Services and the National Institute of Metrology Thailand. However, the division of responsibilities among them is not clear, notably concerning certification tasks. Even more critical are the apparent shortage of resources and staff, and the limited availability of testing and laboratory facilities outside the central region of Bangkok.[14]

The Thailand Institute of Scientific and Technological Research (TISTR) – a State enterprise attached to MOST – pursues innovation-oriented R&D projects and also engages in commercialization activities. It has a large workforce of 1,100 employees (including 600 researchers), and a significant budget of 1.2 billion baht (including 200 million baht from the private sector, of which 60 million baht are from PTT PCL.[15] The institute files an average of 26 patents a year (in the domestic system), 30 enterprises are incubated, and 500 persons participate in its training programmes. An evaluation of its activities showed that 500 baht invested in it would bring a return of 6,000 baht in three years for the economy – which appears to be quite high.[16] However, the rationale for having a public institution engage in certain commercialization activities that compete, to some extent, with the private sector is not clear. Synergies and complementarities with the private sector need to be demonstrated. TISTR's indiscriminate provision of services also increases the risk of dispersion and underinvestment.

4. Educational and training establishments[17]

Thailand counts more than 150 tertiary educational establishments,[18] which encompass a wide range of institutions[19] with different purposes and varying levels of teaching quality and research activity. Nine research universities account for the bulk of Thai publications in international peer reviewed journals,[20] and their scientific productivity is moderate. The problem is that most of the universities, including those doing research, have very few links with industry. Of greater concern is that they produce graduates who very often lack the skills required by the economy. Nevertheless, there are some striking exceptions that demonstrate that it is possible to provide quality education and have strong linkages with Thai industry. The King Mongkut's University of Technology Thonburi (KMUTT) is a striking example of this (box 2.2).

Box 2.2 King Mongkut's University of Technology Thonburi (KMUTT)

King Mongkut's University of Technology Thonburi (KMUTT) has its origins in the Thonburi Technology Institute, a technical college founded in 1960. In 1998 the Institute became a university and in 2009 it was distinguished as a national research university. In 2014, it became the first Thai university to be included in the Times Higher Education World University Rankings (309th out of 400).

The university has 18,000 students (35 per cent post-graduates and 4 per cent PhD students), and over 2,000 staff members (860 academic and 1,290 non-academic staff). Its annual budget is 3 billion baht, 50 per cent from central government sources and the rest from fees and contracts with the business sector and other clients (for technical services). KMUTT has based its development on technical excellence and high impact research. Its main fields of specialization include agriculture, food, biotechnology, pharmaceuticals and life sciences, which are supported by 100 research units and laboratories.

The university has developed strong linkages with industry through the promotion of cooperative education – education programmes that include some training in firms – and the provision of services to firms. KMUTT has been a pioneer in the implementation of engineering practice schools in the chemical and food industries at the graduate level (box 4.6). To serve industry needs, it has established several major facilities. The Pilot Plant Development and Training Institute (with a staff of 500, including 140 teachers and researchers) provides testing facilities for the biotechnology industry and serves as a practice school. The National Biopharmaceutical Facility, launched in 2014 with an investment of 1 billion baht, aims to play a key role in the development of vaccines for the regional market of the Association of South-East Asian Nations (ASEAN).

One major problem is the limited entrepreneurial activity directly generated by KMUTT. So far, its techno-entrepreneur programme has generated limited interest among students, and few spin-offs have emerged from the university and its industry-related facilities. Furthermore, there is little activity in the industrial campus built around the university.

Source: UNCTAD, based on field interviews in October 2013 (see: www.kmutt.ac.th).

The vocational school system in Thailand is extensively developed through private and public networks. TNCs' need for a qualified workforce has contributed to this development. A considerable number of firms participate in the provision of formal training (through both TVET and skills development courses). However, today, the TVET system is not performing satisfactorily and is unable to provide an adequate supply of technical professionals. Teachers' qualifications, the teaching methods and curriculum contents are ill-adapted to industry needs.[21]

The overall performance of basic education is unsatisfactory, with weak national results in maths and science. Educational approaches that promote analytical thinking and entrepreneurship skills are not widely used. Government initiatives to replace traditional teaching methods based on rote learning with methods that foster analytical and critical thinking have been insufficient so far. Civil society has launched some bold initiatives. For example, the Mechai Pattana School emphasizes entrepreneurial, social and environmental activities along with teaching maths, science, English and other basic cognitive skills (box 4.5). However, these initiatives remain isolated cases.

5. Intermediary organizations

Intermediary organizations[22] play a central role in innovation systems. They act as a bridge between knowledge generating institutions, large and small firms, users and other innovation actors, facilitating processes of knowledge brokering and transfer. In Thailand, intermediary organizations, except for the Hard Disk Drive Institute (HDDI) (box 2.3), have played a limited role in promoting technological development. Public research and technology organizations have tended to focus more on their own research than on playing any intermediary role. Private sector associations have traditionally focused on lobbying for specific policies and protection rather than on promoting the technological development of their industry.[23] Farmer cooperatives mostly focus on providing farmers with access to finance; while they disseminate information to individual farmers, they have not been a channel for technology diffusion.[24]

Box 2.3 The Hard Disk Drive Institute

Thailand has become a global centre for the manufacture of hard disk drives. The industry represented 41 per cent of the global market and employed around 200,000 workers in 2010. Four TNCs dominate production (Seagate Technology, Western Digital, Hitachi Global Storage Technology and Fujitsu), and over 60 first-tier to third-tier suppliers operate in Thailand.

In the late 1990s, Seagate Technology organized a loose consortium with five universities, including Suranaree University of Technology (SUT), to train engineers capable of managing the firm's highly automated production facilities. Seagate also established joint R&D centres with two universities (Khon Kaen and SUT) located in the north-east, close to its major production facilities. The organization, officially renamed in 2005 as the Hard Disk Drive Institute (HDDI), has supported the technological upgrading of the whole industry in Thailand, including improving training in engineering and developing visual inspection software. Most of the programmes implemented promote academic-industry consortia.

In 2006, three leading universities were selected and funded by HDDI as industry/university cooperative research centres specialized in teaching and research in critical fields of hard disk drive technologies. HDDI funded research proposed by these three research centres only if that research was jointly proposed with private companies which would agree to jointly fund that research with HDDI.

Under NSTDA, HDDI functioned well as a resource provider and a broker. However, NSTDA considered that the development of the internal capabilities of firms was secondary to its own research. As a result, HDDI's budget has been cut.

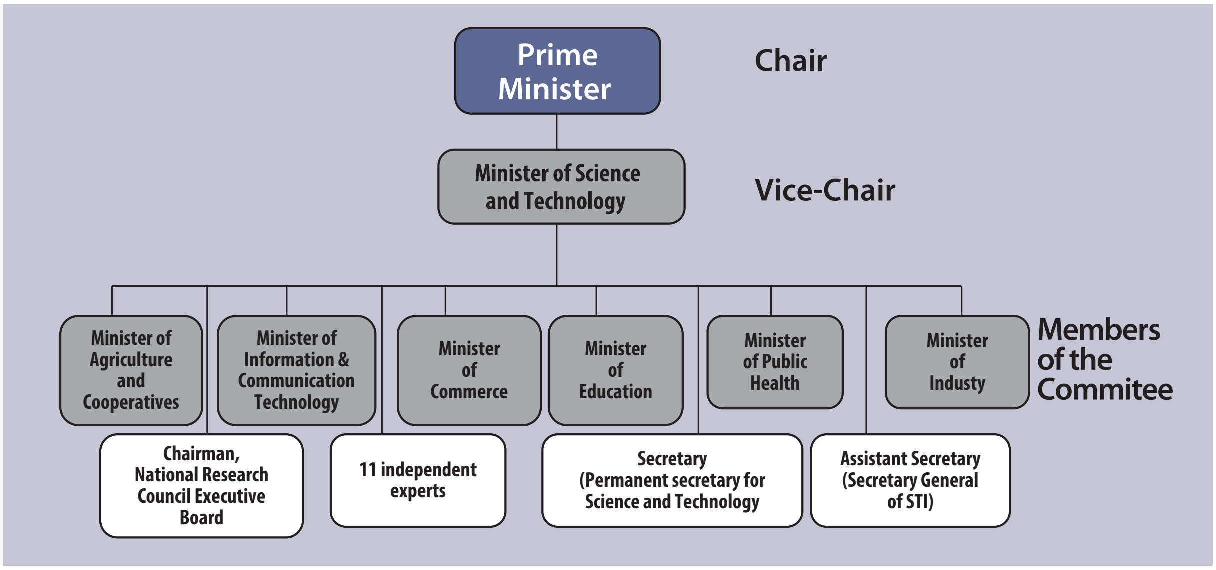
Source: Doner et al., 2013; Intarakumnerd and Chaoroenporn, 2013.

C. GOVERNMENT POLICIES: INITIATIVES AND SHORTCOMINGS

1. Institutional arrangements and national STI plans

A number of ministries and agencies, operating in a context of loose cooperation and coordination, are involved in developing policies related to STI. The Ministry of Science and Technology, established in 1979, is the main entity, but a number of its initial responsibilities have been gradually given to other ministries or to independent agencies and councils. Several other ministries are involved in STI policymaking, including the Ministries of Education, ICT, Industry, Commerce, Agriculture and Health. Their ministers are members of a National STI Policy Committee, nominally chaired by the Prime Minister, and assisted by a number of independent experts and high-level civil servants (figure 2.2).

Figure 2.2 Thailand's National Science, Technology and Innovation Policy Committee



Source: (Durongkaveroj, 2014a).

The Ministry's National Science Technology and Innovation Policy Office (NSTIPO), established in 2005, has elaborated a 10-year STI strategy[25] that conforms to the three pillars identified in the national development plan: economic competitiveness, social inclusion and environmental sustainability. The STI strategy is very comprehensive, aiming to fulfil multiple goals and to include numerous actors (annex 2). Ambitious objectives have been fixed in terms of national R&D expenditures, R&D personnel and private R&D efforts (table 2.4).

Table 2.4 Strategic objectives of the National STI Policy and Plan 2012–2021

	R&D as a percentage of GDP	R&D personnel per 10 000 population	Private vs. public funding
2012	0.24	9	38/62
2016	1.00	15	
2021	2.00	25	70/30

Source: National STI Policy and Plan 2012-2021.

Past experiences in Thailand indicate, however, that policies, which are often well designed, encounter serious obstacles in their implementation. A weak and fragmented governance structure and the absence of a strategic driver have been two major stumbling blocks to the implementation of the National STI Policy.

The next section discusses in more detail the main governance issues that affect the overall functioning of the STI system and key STI-related policies.

2. Governance issues

The institutional structure in which the STI policy system operates is rather fragmented, and much more complex than suggested by the organization of the National STI Policy Committee (figure 2.2). The organization chart (annex 1) describes the main flows of authority and funding, distinguishing between policymaking bodies, funding agencies and implementing organizations. This review identifies six governance issues.

The first, and main, governance issue is the absence of a strategic driver of STI policy. This situation is partly due to the ineffective functioning of the National STI Policy Committee. The Committee, which was established in 2008, comprises the key ministers involved in STI and is chaired by the Prime Minister. However, since the Prime Minister rarely chairs the Committee meetings,[26] they are chaired by the Minister of Science and Technology (Vice-Chairman of the Committee). This undermines any sense of ownership among other ministers – a typical but highly undesirable situation given the cross-departmental nature of STI policies. As another body (the National Research Council of Thailand) reporting also to the Prime Minister has been particularly active (see below), the National STI Policy Committee has not been fully operational. Moreover, there is a lack of understanding and awareness about innovation among policymakers and decision makers. Although innovation encompasses R&D, science and technology, and intellectual property, innovation policy is restricted to R&D or science and technology, or is viewed as a component of research policy and not the opposite. The predominant role provided to MOST under the National STI Policy Committee, and the fact that the Committee's secretariat (the National STI Policy Office) is under the administration of MOST, has perpetuated the perception that innovation is mainly about S&T research.

A second major problem is the proliferation of bodies in charge of R&D funding and management. At least six bodies are involved in its funding, with tasks and responsibilities that partly overlap (table 2.5). Even more problematic for the governance of STI is that some agencies combine functions of policy guidance, funding and even management of research, leading to conflicts of interest and preventing accountability. For example, NSTDA combines functions of funding and managing research. This unusual situation generates numerous problems: duplication, lack of a critical mass, competition for funding and responsibilities, and lack of accountability. To partly address some of these issues, the six bodies have recently joined together in meetings, led by the NRCT, to harmonize their decisions and interventions. As they meet regularly with the Prime Minister, the group has become the *de facto* organ managing R&D policy, superseding, to a certain extent, the job of the ineffective National STIP Committee. This tends to have the negative consequence of reducing STI policy to a research policy.

Table 2.5 Main government bodies in charge of financing R&D in Thailand

	Main responsibilities	R&D budget share (broad estimates)
National Research Council of Thailand	Oversees the national R&D policy, reports directly to the Prime Minister.	50 per cent
Thailand Research Fund	Main body in charge of non-institutional research budget and scholarships, the Talent Mobility Program and the Golden Jubilee PhD Program.	10 per cent (mostly contract funding)
National Science and Technology Development Agency	In charge of research institutes operating under MOST, including the four high-tech centres (Nanotec, Biotec, Mtec, Nectec).	20 per cent (mostly institutional)
Agriculture Research and Development Agency	Responsible for agriculture research funding and related public research structures. Allocates 30 per cent of its budget to enhance the research capacity of MOAC.	10 per cent (institutional and contract funding)
Health System Research Fund	In charge of health research funding and related public research structures.	5 per cent (institutional and contract funding)
Office of the Higher Education Commission	Responsible for research in universities	5 per cent (institutional and contract funding)

Source: UNCTAD, based interviews in October 2013, and on rough budget estimates given by stakeholders. No official data are available.

A third problem is the process of budget allocations to the R&D and innovation system and insufficient monitoring, control and evaluation of programmes. The Bureau of the Budget (Ministry of Finance) allocates the budget on a yearly basis. It is supposed to evaluate the budget requests of ministries and agencies (in principle, examined and approved by the National STIP committee) to ensure these are justified and that the concerned organizations have the capabilities to carry out the proposed work. But the Bureau lacks the competences and resources to seriously undertake such evaluations. Generally, budgets increase every year for most items by a fixed percentage,[27] and final allocations tend to be substantially less than the initial demands. A tactic often used to secure a budget increase is to propose the creation of a new centre or programme. This practice has encouraged the expansion of new structures/ programmes without reviewing/eliminating existing ones.

A fourth problem is the tendency to elaborate plans consisting of extensive lists of actions, without prioritization, that are not implemented. Often, this is because there are too many actions to implement or the modalities for their implementation have not been sufficiently specified (e.g. R&D fields may be identified and budgeted but no organization designated to carry out the R&D). This approach, which derives from a concern to have “everyone on board”, prevents prioritizing action and an efficient use of the limited resources available.

A fifth problem is that the business sector is not sufficiently involved in the policy elaboration process and in making strategic decisions. Its representative organs, such as the Federation of Thai Industries and the Thai Chamber of Commerce, are not adequately consulted. For instance, they are not officially represented at the top level of the National STI Policy Committee (as is the case in other countries such as Finland – box 2.4). The involvement of the business sector in STI policy design or R&D programme design is largely ad hoc and based on personal connections.

A sixth governance issue is the proliferation of government bodies and entry points in the innovation system that creates confusion, opacity and misunderstanding among stakeholders (see section 3 below). This impacts the business sector, which is less familiar with the government machinery, and particularly SMEs, which have fewer resources to understand and navigate the system. Consequently, personal connections play a critical role for gaining access to decision makers, sources of financing and various kinds of support, thus increasing the possibilities of distorted competition and privilege-based allocations.

Box 2.4 Finland's innovation policy: Key features

Finland is generally recognized as an innovation leader, which it owes largely to an efficient government policy. Building on a solid R&D infrastructure, a high quality education system and a dynamic business sector, a national innovation policy was first deployed in the 1990s and has been refined since then. Key elements include a powerful coordinating mechanism, a strong lead agency and an effective training instrument for national leaders, combined with significant regional and local decentralisation of policy implementation.

The main coordination mechanism is the Research and Innovation Council, established in 1987 as the Science and Technology Policy Council, to coordinate S&T policy and stimulate the overall innovation effort at a time when the country was experiencing a serious slowdown with the collapse of the Soviet Union, its main trading partner. The Research and Innovation Council, under the chairmanship of the Prime Minister, comprises concerned ministers, including the ministers in charge of education, industry, trade, science and, most importantly, the Minister of Finance in charge of the State budget. The Council also includes high-level representatives of the science community, the business sector, the trade unions and civil society. The Council meets twice a month, under the effective chairmanship of the Prime Minister, to discuss and decide on strategic issues, budget allocations and institutional questions.

A second major instrument, established also in the early 1990s, is the Finnish Innovation Agency, known as TEKES. Positioned at the core of the innovation system and entirely funded by the Government, its main role is to promote all forms of R&D and innovation efforts based on cooperation between universities, and the public and private sectors, thereby facilitating the mobilization of all actors engaged in promising technological developments, from academic researchers to venture capitalists. To accomplish its mission, TEKES uses a diversified set of instruments, notably matching funding schemes with private sector financial engagement. In 2012, TEKES supported firms and RTOs with 570 million euros in funds. Of this total, 350 million euros were allocated to company projects, with 68 per cent targeting SMEs. On average, TEKES has an estimated impact factor of 21 - that is, one euro from TEKES to firms provides 21 euros in annual turnover.

The third major instrument – though not directly concerning innovation policy per se, but which has played a major role in creating a climate favourable to reforms – is a training programme for parliamentarians, business leaders, civil servants and trade unionists established in the 1970s by SITRA, the R&D financing arm of the Finish Parliament. The objective is to inform key legislators, policymakers and opinion leaders about, and involve them in, major macroeconomic issues and fundamental policy questions, including those relating to STI. Thousands of persons have attended these high-level training and discussion sessions, which have been instrumental in facilitating reform processes in Finland and the economy's adaptation to global opportunities and external shocks and pressures.

Finally, Finland's innovation policy has always had a vibrant regional and local dimension. Innovation policy is built on a model of decentralized implementation, although financial resources are relatively centralized. National agencies have regional branches which enlist local authorities (municipalities, provinces) in pilot programmes. Local technology forums convene firms, universities and other actors to identify opportunities to develop internationally competitive clusters.

Source: UNCTAD, based on Dahlman et al., 2006; World Bank, 2014; www.sitra.fi/en/about-sitra/training.

3. Innovation promotion schemes

Major efforts have been made to introduce programmes that provide public financial support for innovation activities by private firms. More than 20 schemes promote innovation in the business sector. Managed by half a dozen ministries (and a dozen agencies operating under ministries), they address various issues faced by innovators, and provide support in the form of subsidies (reimbursable in case of success) and grants (for small investments).[28] As a whole, however, the schemes are too fragmented and uncoordinated. They have a limited impact on innovation, leveraging little R&D and private sector funding for innovation, and involving a relatively small number of companies. The major schemes are described below.

The National Innovation Agency (NIA), established in 2003, supports the development and commercialization of new products and processes proposed by individual inventors and firms through a system of grants (which have to be repaid if the project is successful), funding up to 75 per cent of project costs. NIA provides funding averaging $20,000 per project to about 100 projects annually since 2008. About 30 per cent of those projects have reached the commercialization stage. In addition to its 40 staff, NIA also seeks specialized advice from experts. It has no regional offices. Its current budget of 300 million baht supports three priority programmes and the Innovation Coupon programme. This latter programme, launched recently, gives potential innovators vouchers for research and technological services (e.g. feasibility studies, testing, prototypes) to be performed by university or government laboratories. Coupons cover funds of up to 100,000 baht for feasibility studies, 400,000 baht for project development and 90 per cent of project costs. This programme, which benefited about 280 firms over the period 2011-2012, has stimulated interest in innovation and helped build linkages between the industrial and academic worlds. The Government intends to scale it up considerably.

The Industrial Technology Assistance Program (ITAP), administered by NSTDA, assists enterprises in technology development projects. Modelled on the Canadian Industrial Research Assistance Program and established 17 years ago, it provides enterprises with technological expertise, links them to competent sources, including from overseas, supports R&D activities, organizes training and funds projects on a 50/50 basis. It has 10 regional nodes located in universities and science parks. Since its inception, the programme has benefited over 3,000 enterprises at a total cost of $60 million. The number of firms served annually has increased steadily, reaching 883 in 2011. Thai business leaders and innovation experts consider the programme to be highly useful.[29] The Ministry of Industry has led training programmes for firms on intellectual knowledge infrastructure and productivity management which have reached some 95,000 employees directly or indirectly.[30]

The Government has established several funds to promote venture capital totalling more than 6 billion baht, while venture capital from the private sector has amounted to less than 1 billion baht (Wonglimpiyarat, 2013). The impact of those public funds has been limited; for instance, the Venture Capital fund administered by the Office of SMEs Promotion with 1 billion baht capital has supported 60 enterprises over the period 2004–2009, but they have created less than 5,000 jobs (Wonglimpiyarat, 2013). There is a lack of potentially profitable, good innovative projects, and of competent business angels and coaches to help develop new ventures, and only a small private equity financing market.[31]

4. Tax Incentives[32]

The Revenue Department offers a substantial tax incentive for R&D: a 200 per cent deduction of R&D expenses from taxable income (with a 40 per cent allowance for machinery and equipment depreciation). Over the period 2002–2010, this scheme benefited 872 projects of a total value of 2.7 billion baht, with an approval rate of 77 per cent. Small firms, in particular, have shown interest in this scheme accounting for 39.8 per cent of the applications for the R&D tax incentive. Despite its generosity, the use of the scheme as a whole has been modest in terms of both the number of firms that have taken advantage of it and the value of the projects developed.[33]

The Board of Investment, responsible for both foreign and domestic industrial investors, has offered a tax incentive scheme since 2006 to encourage investment in training, R&D and university-industry collaboration in selected industries: fashion, automotives and ICT. There are certain minimal requirements of this scheme, known as the Skills, Technology and Innovation Program, depending on the industrial zones in which the various firms are located. For example, R&D expenses should represent more than 1 or 5 per cent of annual sales. More than 60 per cent of the beneficiaries of this scheme are Japanese firms, and almost 40 per cent of the beneficiaries are in the auto industry. The incentive has been moderately used. Only 43 projects, valued at 6.4 billion baht, have been approved since the establishment of the programme. The administrative procedure to determine the incentives to be offered requires a thorough investigation, is rather cumbersome for the firms, requiring at least six months for approval, and it is very costly to administer. This might have discouraged potential investors from taking advantage of it.

The Thai Government may wish to consider reviewing the use and, more importantly, the impact of current tax schemes to promote R&D and innovation. It may be advisable to pay particular attention to their use among, and impact on, SMEs, which often benefit less from these schemes. By nature, SMEs find it more difficult to finance R&D and innovation in advance and to deal with the bureaucratic procedures involved. Simplifying administrative procedures would be a step in the right direction.

5. R&D programmes

Various public research institutions have launched a significant number of R&D programmes. For example, NIA hosts three innovation-oriented programmes, in bioplastics (box 2.6), organic agriculture and manufacturing design; NCRT has initiated R&D programmes in new “niches” (e.g. medical equipment and tourism) to be supported with matching funds from the private sector; the Thailand Research Fund (TRF) has launched international research programmes (e.g. in chicken bacteria); and NSTDA supports agriculture R&D programmes (e.g. in agricultural genetics). Some programmes have resulted in the creation of new R&D centres, jointly operated with industry. For example, the Center of Excellence for Shrimp Molecular Biology and Biotechnology,[34] established by Mahidol University with the support of BIOTEC and in conjunction with a shrimp industry consortium, has developed virus testing kits and diagnostic training, which have resulted in fewer losses for the shrimp industry from viruses (box 2.5).

Box 2.5 Centex Shrimp: An example of effective R&D collaboration

The shrimp industry is a major Thai success story. After Taiwan's shrimp industry collapsed in the late 1980s, Thailand became the world's largest producer of cultivated (farmed) shrimp by the mid-1990s. Thai agro-industry groups, especially Charoen Phokpand, along with Japanese trading companies employing Taiwanese technicians, were critical to the transfer of shrimp farming technology to Thailand. The industry's establishment and growth owe much to public policy (subsidized financing, property rights adjustments and supporting infrastructure) and to highly institutionalized and effective university-industry linkages.

These linkages have been crucial in fighting the diseases endemic to the industry. Thai educational institutions, especially Mahidol University, helped reduce losses from viruses by developing DNA diagnostic probes. This effort was undertaken in conjunction with an industry consortium, the Shrimp Culture Research and Development Company, and has become well institutionalized.

In 2001, Mahidol University, supported by BIOTEC, established Centex Shrimp (Center of Excellence for Shrimp Molecular Biology and Biotechnology) – a multidisciplinary laboratory that amalgamated research from a number of the university's departments. In 2000, BIOTEC also helped establish the Shrimp Biotechnology Business Unit to commercialize R&D results (e.g. virus test kits and diagnostic training). Revenues from this unit are invested in further research by BIOTEC and Centex Shrimp.

Several factors specific to the shrimp industry have contributed to successful university-industry linkages. First, an organized private sector, led by a powerful business group, was able to agree on a clearly identified set of problems. Second, a cadre of laboratory scientists found those problems to be interesting challenges intellectually, but also in terms of contributing to their career objectives. Third, there was significant public sector interest in promoting a sector that demonstrated ample potential to generate export revenues. Fourth, intra-industry collective action did not pose a problem, given the relatively weak position of small shrimp farmers (in contrast to recurrent conflicts between sugar growers and millers). Finally, a helpful quasi-public facilitator, BIOTEC, provided strategic financing and coordination.

Source: Based on Brimble and Doner, 2007.

The elaboration and implementation of R&D programmes involve, in general, various concerned stakeholders (RTOs, researchers, funders, private sector, relevant ministries), but in conditions that remain rather opaque and not well-structured and formalized. There is no evidence of clear and structured stakeholder involvement in programme monitoring and evaluation. Another problem is that the resources invested in each programme are rather small. Greater prioritization of research activities and a sustained focus on fewer research areas will be necessary to develop a critical mass. As practically no evaluations of programmes' achievements were made available to the UNCTAD team,[35] there is not a sufficient basis to provide more specific suggestions on how to rationalize R&D programmes. More open and systematic monitoring and impact evaluation of R&D programmes and wider access to monitoring and evaluation results will be necessary in order to enhance the strategic contribution of R&D programmes.

Box 2.6 Comprehensive support for the development of the bioplastics industry in Thailand

Thailand has a number of competitive advantages to develop a bioplastics industry. It is endowed with abundant raw materials (e.g. cassava) that can be used for bioplastics production; a well-established plastics industry, with over 3,000 firms, plus multiple firms involved in many steps of the value chain; and a solid research base to support the development of new plant varieties and bioplastic products.

Box 2.6 Comprehensive support for the development of the bioplastics industry in Thailand *(continued)*

The development of a bioplastics industry has been on the Government's agenda since 2006, supported by NIA. The 2008 roadmap for the development of the bioplastics industry focused on four broad strategies: developing a sufficient supply of raw materials as bioplastic feedstock; developing new technologies; attracting and developing new businesses in the sector; and setting up a supportive infrastructure. To implement this, the Government allocated 1.8 billion baht and designated NIA to manage and monitor implementation. As part of the roadmap, an R&D programme has financed 20 research projects. The Bureau of Investment has provided special incentives to firms investing in bioplastics, and approved 7 projects for a total investment of 21 billion baht. Technical and financial support has been provided to Thai firms innovating in bioplastics. New compounding technology and products have been developed and commercialized and a Thai Bioplastics Industry Association has been created. A Thai Industrial standard for the specification of compostable plastics was published and three local testing laboratories for compostable bioplastics were certified internationally.

The second phase of the roadmap (2011–2015) focuses on the construction of a bioplastic resin pilot plant through public-private co-investment (30:70) and further supporting actions in the above-mentioned areas.

Source: UNCTAD, based on information provided by Thailand's National Innovation Agency.

6. Science parks

The Government has built or initiated work on several science parks. The Thailand Science Park (TSP), launched in 1996 in the northern suburb of Bangkok, is the most advanced. It hosts four national high-tech research centres (Nanotec, Biotec, Mtec, Nectec) where 1,800 researchers (including 480 with PhDs) work. It has 60 tenant enterprises with about 500 staff members (of which 60 per cent are R&D personnel). Tenant firms are largely working in R&D fields related to the activities of the four national research centres located in the park. Around one third of the tenants are electronics and computer firms, 28 per cent are biotechnology firms and 27 per cent are in the metals and materials industry. The park also has a Business Incubator Centre to facilitate the growth of small innovative businesses. This centre has incubated 74 start-ups and supported R&D projects in a number of established firms (see chapter 4 for further details). In addition, the science park offers innovation-related services (e.g. IP management and technological services) and is host to three universities and one medical school. Phase II of the park opened in 2014, but there are difficulties in attracting firms to locate there, as they prefer more central locations in Bangkok. TSP has been highly successful in providing Thailand with a well-developed physical R&D infrastructure, but less successful in supporting and attracting private R&D efforts and in incubating R&D firms.[36]

There are plans to establish three science parks with some degree of technological specialization in three other regions of the country, close to universities and colleges. During a first phase, services that connect university and industry activities (business incubator, technological and consulting services, product design centre, IP management) have been established.[37] After three years, an assessment will determine whether universities would be ready to launch a science park. At present both Khon Kaen University and Prince of Songla Universities have passed the assessment criteria and are in the transition period to start work on science parks in the north-east and southern regions respectively. For each regional science park, 3 billion baht have been approved. However, their development, after an initial pilot phase, has slowed down, apparently due to a reorganization of national agencies (the programme, initially under the NSTDA, is now the responsibility of the agency in charge of industrial zones operating under the Prime Minister). Various stakeholders (from the public administration and public universities) interviewed in Bangkok and in the north-east region expressed their continued interest in supporting the development of regional science parks. However, private sector interest and the level of public support are uncertain. Plans for other science parks (e.g. Krenovation Park of GISTDA, Food Innopolis of Kasetsart University) are currently being developed. In addition, a private science park, AMATA Science City, will be launched in 2015 at the Amata Nakorn industrial estate in the eastern region.

7. Human resources, education and culture[38]

Thailand has considerably expanded its educational system, substantially increasing participation rates in primary, secondary and tertiary education through proactive education policies (Mounier and Tangchuang, 2010). Now, policy should aim to increase the quality and relevance of education at all levels, and particularly beyond Bangkok. There are significant shortages of qualified S&T graduates and trained technicians, as well as inadequate promotion of the entrepreneurial and innovation skills required by an innovative economy.

At the level of higher education, a major problem is the inability of institutions to produce S&T graduates with the skills and quality needed by the private sector. There is a shortage of S&T graduates in most disciplines, notably engineering.[39] Thai industries often call upon foreign graduates to fill qualified S&T positions. Making higher education more responsive to the requirements of industry is inhibited by the poor linkages between universities and industry.[40] Policy orientations[41] to enhance the quality and relevance of higher education have not sufficiently influenced university structures and behaviour, partly because of inadequate coordination between research, education and industrial policies. Other reasons include institutional reluctance to change, including among faculty and university managers, increased autonomy granted to academic establishments – both public and private – and quasi-automatic budget allocations provided with limited government oversight.

Consequently, the Government has focused its attention on introducing a series of schemes to fill the gaps in advanced S&T skills and to raise the quality of research personnel. These include, for example, the Royal Golden Jubilee PhD Program, which provides 300 fellowships annually for post-graduate studies; the recently established Talent Mobility Scheme to facilitate the mobility of researchers from higher education institutions and public laboratories to the industrial sector; and the Thai Advanced Institute of S&T (THAIST), which connects Thai education and research institutions with foreign academic and research institutions and firms. The potential impact of some of these schemes is limited by their lack of institutionalization. For instance, universities have no particular incentives to participate in the Talent Mobility scheme.

Technical vocational education and training (TVET) tends to be weak for several reasons: the private sector demands higher levels of education to compensate for the inadequate skills of vocational graduates; access to higher levels of education has been facilitated by policies supporting its rapid expansion; and limited resources are provided for vocational education. Reform of the existing system is being broadly considered, but the possible direction and support required is uncertain so far. The renewal of teachers (40,000 of whom will retire by 2018) is the Government's main concern. It rightly wants to use this opportunity to boost TVET. The recruitment of adequate teachers has become an uphill task as the status of teachers is not valued much and teacher training structures are underdeveloped. Two other areas requiring urgent attention are improving teaching methods and equipment. A number of policies and programmes have been put in place since the mid-1990s to promote the training of science and maths teachers, but improving S&T teaching requires still further action, in particular updating curricula, training materials and learning opportunities that promote more practical learning and problem-solving, and that keep pace with the requirements of industry.

The promotion of a scientific and technological culture has received significant attention. Thailand has a science museum (established in 1992) with regional branches and an ambitious media programme, including a 24-hour TV channel (currently under development). The overall promotion programme has attracted 2.5 million visitors annually.

Private endeavours are increasingly contributing to the development of STI human resources (box 4.1). For instance, the PPT Group, Thailand's State-owned oil and gas firm, is setting up an academy and a research and training institute.

Chapter 4 discusses each of these issues in greater details and offers specific policy proposals.

8. Patents and licences

Thailand has signed all the major patent-related international treaties[42] and has a well-established intellectual property (IP) administration body. However, a number of issues affect Thailand's ability to generate IP rights and, more notably, to commercialize IP. The latter is mostly due to the limited commercial value of the IP created by Thai research institutions and universities (see chapter 4).

One problem is the considerable delay in examining patents deposited by national and foreign entities. Currently, there is a backlog of 30,000 requests. A large recruitment process for specialists has been launched and 30 examiners should be operational soon to reduce this backlog.[43] The enforcement of IP rights in case of infringement, which requires an efficient judicial system, is also an issue. The cost of filing patents, particularly in the patent offices in Europe, Japan and the United States, is a significant barrier for universities and smaller firms.

Another issue relates to the confusing and restrictive IP regime of patents relating to publicly funded research. There are plans to introduce a scheme – pending parliamentary approval – that would facilitate the exploitation of such patents by researchers and universities in line with the Bayh-Dole Act in the United States.

9. Conclusions

A number of general conclusions can be drawn from this review of government institutions and actions to enhance Thailand's STI system.

Many of the plans are generally suitable and commendable. Some initiatives (for instance, at the tertiary level of education) are creatively addressing core issues. However, there is a lack of clarity regarding institutional roles and responsibilities, a lack of clear and strategic orientations and a dispersion of resources on multiple, uncoordinated projects, with an insufficient critical mass. These initiatives are unlikely to make an impact on the scale that is needed to resolve the core challenges facing the Thai innovation system.

The overall STI system tends to be dominated by a science-supply approach, a linear concept that perceives innovation as deriving directly from research. The policymaking process is overwhelmed by research bodies. Users – representatives of business, consumers and farmers – are not adequately involved in the design of STI policies and programmes. Financial mechanisms to involve firms in innovation activities, such as matching funds, are scarcely used. In this context, programmes working at the interface between knowledge structures and businesses are much needed, and have been well appreciated when efficiently implemented. Significant measures have been put in place for developing human resources at the tertiary and post-graduate levels in response to fundamental needs. Most of these, however, continue to follow a supply-driven approach, and it would be important that programmes be redesigned with stronger inputs from users and producers.

Overall investments, currently coming mostly from government sources, are insufficient to turn Thailand into an innovation-driven economy. Public resources should be increased, provided they are matched by more resources from a wider spectrum of the private sector (and not only from State enterprises with sizeable assets). The generous R&D tax incentives have yet to prove their ability to attract more private resources into innovation activities. Key mechanisms, such as public procurement and public-private partnerships, for stimulating the development of collective goods (e.g. transport, utilities) while promoting the technological capabilities of domestic firms are not much used in Thailand. If well managed, they could significantly increase the financial resources available in the system and promote the development of domestic technological capabilities.

The next section addresses the weaknesses of the STI system and offers a number of policy suggestions.

D. POLICY RECOMMENDATIONS: TEN STRATEGIC THRUSTS FOR CHANGE

The critical review of the Thai innovation system suggests that its efficient functioning is inhibited by attitudinal and behavioural issues that permeate the whole system and concern all actors. These are induced by the overall context in which the actors operate – economic, political, institutional and financial – and the incentives provided. The bulk of the recommendations address these issues.

Changes in mentality and behaviour and deep transformations do not occur overnight. Nevertheless, there are a number of actions that could serve short-term economic and social needs, while stimulating the attitudinal changes required for a long-term improvement of the innovation system.

1. Moving leaders and institutions out of their comfort zone

Probably the main reason for Thai decision makers not being more innovative is that they do not feel the need for it. The risk of being trapped in a state of economic stagnation is not tangible enough. Thailand's emergence from the 1997–1998 Asian financial crisis and its resilience vis-à-vis the 2008-2009 global economic crisis has created a sense of confidence and complacency. The economy is performing well for the time being, and operating at near to full employment. The business sector, particularly the SME segment, feels little pressure to innovate. On the public sector side, accountability does not seem of particular concern: organizations often receive higher budgets without careful monitoring and evaluation of their performance.

In this situation, convincing leaders of the need to focus more on STI for future economic growth is challenging. The first step should be to sensitize key actors, and the public at large, about the threats to the economy and its competitiveness. The media could be mobilized to support this process. Success stories should be widely publicized to create positive dynamics and promote confidence in the country's abilities to innovate.

Pressure for change could be achieved by increasing accountability, mainly through the introduction of effective monitoring and evaluation systems and through performance-related funding (see section 5) for all entities concerned with the public interest (e.g. public STI agencies, RTOs, universities and schools).

2. Mobilizing stakeholders for common goals and aspirations

To truly engage actors and obtain clear commitments, it is necessary for leaders and agents of change at various levels to gain a clear understanding of what is at stake, what innovation is all about and its relevance for economic development. Only then can they develop the types of policies, programmes and institutions that can promote a more innovative economy. Finland's long-standing leadership training (box 2.4) is a good example of a mechanism that has created powerful dynamics and facilitated reform processes. Well-organized consultation processes during the design of national projects that include the participation of society at large through representative bodies (e.g. parliament, unions, chambers of commerce) are also required in order to build and sustain consensus on the goals to be achieved and the investments to be made. Thailand faces strong political divisions which hamper the adoption and execution of policies. Inclusive deliberations that consider the needs and capabilities of different sectors of society as well as discussions based on evidence can help provide the consensus required. For this, policymakers must be provided with timely, clear and reliable STI data.

An innovation-focused National Economic and Social Development Plan (box 2.7), as suggested by NSTIPO (Durongkaveroj, 2014b), could be a good starting point for mobilizing stakeholders and resources for the achievement of common goals, provided it is generated with a real sense of ownership by a broad spectrum of Thai society. As part of broader discussions for national reform, a set of recommendations is being made to the National Reform Council for STI reform to support innovation-based development (box 2.7) based on three pillars: an innovation-based development plan, a review of STI governance, and budgeting for STI. The three pillars reflect key priorities identified in this Review (see, for example, recommendations 3, 4 and 5 below). It will be crucial that the specific development of each of the three pillars adequately addresses key concerns, such as ensuring a broad sense of ownership by stakeholders, clear leadership for STI policy design and evaluation, a clear division of functions and hierarchy among STI institutions with specific responsibilities and accountability lines, strong monitoring and evaluation and linking of budgetary allocations to performance.

Box 2.7 Ongoing discussions for reform of STI in Thailand

As part of broader discussions for national reform, a set of recommendations for STI reform to support innovation-based development are being proposed to the National Reform Council. Such reform would be based on three pillars:

1. An innovation-based development plan. The National STI Plan for the next five years will sustain the 12th National Economic and Social Development (NESD) Plan. The NESD plan should emphasize innovation-based development (covering the economic, social, environment and quality of life dimensions) with the aim of enhancing competitiveness, inclusiveness and sustainable development. The NESD Board and the STI Policy Office should generate a technology and innovation roadmap for strategic industries as part of the 12th NESD Plan.

2. Governance of innovation. The Prime Minister should further engage in STI policy by heading two new committees: the Science Technology Research and Innovation Policy Committee (a policymaking body) and the Chief Scientific Advisory Committee (an advisory body to the Prime Minister). The STI Policy Office (currently under MOST) should become the Science, Technology, Research and Innovation Policy Office (STRIPO), a statutory agency operating as a unit within the Office of the Prime Minister. It should serve as a coordinator of committees and ministries on matters of STI policy. The role of STI-related agencies (including funding and operational agencies) should be reviewed in order to reduce duplications and gaps, and increase efficiency.

Box 2.7 Ongoing discussions for reform of STI in Thailand *(continued)*

3. Budgeting for STI. A new STI budget linked to the 10-year National STI Policy and Plan should be introduced. The new budget should provide for allocations for five years (instead of annually), and should be more consistent with national objectives. Its allocations to public agencies and State-owned enterprises should be assessed by the NESD Board, the Bureau of the Budget and STRIPO. Furthermore, the budget should be more inclusive and further decentralized to regional and local governments, local enterprises and industries.

Source: Based on a briefing by the National STI Policy Office (February 2015)

3. Balancing social, environmental and economic objectives

To address economic and social inequalities, strategies should be designed to counteract current trends of increasing concentration of economic activity and power in larger firms and in Bangkok. As smaller firms, farmers and citizens outside Bangkok become more marginalized, Thai society risks becoming increasingly polarized. More inclusive innovation policies and programmes, along with other complementary policies (e.g. fiscal, educational, health and social policies), can play a key role in reversing inequalities. Inclusive innovation programmes are those that support innovation both for and by marginal groups (Foster and Heeks, 2013). For instance, such programmes could finance scientific and technological research, particularly translational research, in areas of interest to low-income groups (e.g. small-scale farmers, informal producers, small firms), or they could improve the absorptive capacities of small-scale farmers. Other areas that require greater efforts include promotion of innovation in SMEs through financial schemes that specifically target SMEs (e.g. matching grants), expanding business, technological and testing services beyond Bangkok, developing locally-based sectoral innovation centres/actors that support SMEs and providing assistance for conducting or subcontracting R&D.

On the environment front, a major problem for Thailand is climate change and its effects. Bangkok has been ranked the 7th most vulnerable port city in the world (Nicholls et al., 2008) to the negative effects of climate change. Indeed, the 2011 floods had a devastating economic and human impact. The Thailand Technology Needs Assessment reports for climate change (National STI Policy Office and UNEP, 2012 and 2012b) provide the basis for determining the kinds of policy efforts needed. Those reports identify priority technologies and actions needed to build the capabilities as well as the financial and regulatory conditions necessary for the appropriation of those technologies. As in other countries, those policy actions need to be combined with the adoption and enforcement of regulations in other areas (e.g. anti-pollution measures, reduction of traffic congestion), including through the provision of appropriate financial incentives.

4. Strengthening STI governance and management

The organization and functioning of institutions in charge of overseeing and funding STI policies is inefficient. Agencies with overlapping responsibilities have proliferated. Individual departments carry out the incompatible roles of policy setting, funding and implementation. There is only a narrow representation of Thai society on advisory committees. Institutional confusion and a lack of oversight and accountability are resulting in poor management of bodies and of resources. This Review offers suggestions on how to enhance STI governance and management based on widely accepted principles (box 2.8).

Box 2.8 Basic principles to guide STI policy design, governance and evaluation in Thailand

Basic and widely accepted principles for the effective design, implementation and evaluation of STI policy should underpin STI policy in Thailand, in particular:

Principles for the design of policy instruments

- Identify specific innovation gaps and needs; determine innovation policy objectives (in many instances through political processes); and adopt a mix of policy instruments to achieve them (e.g. competitive collaborative funds to foster industry-academia collaboration or multidisciplinary research).

Box 2.8 Basic principles to guide STI policy design, governance and evaluation in Thailand *(continued)*

- The policy mix should address all types and sources of innovation, not only R&D.
- Schemes should be simple to administer, making them more appealing and reducing opportunities for corruption.
- The policy mix should target all firms, not only larger ones.
- Financial schemes should stimulate additionality, i.e. incentives should be designed to increase private investment beyond what firms would have invested in R&D and innovation without them.

Principles for institutions

- Separate the functions of policy design, funding and implementation. A clear distinction of roles and responsibilities allows more effective supervision and accountability.
- Institutional reporting lines should be established according to a well-defined hierarchy.
- Evaluation and management functions should be separated to avoid conflicts of interest.

Principles for monitoring and evaluation (M&E)

- M&E activities should measure not only inputs, but also outputs and impacts (e.g. innovations, jobs, firm creation).
- M&E activities should be planned and budgeted for in the early stages of programme design.
- Evaluations should be understood and used as a learning exercise, and not only as a compliance exercise. Learning derived from M&E activities should inform ongoing and future planning.
- Evaluations should be performed by independent evaluators. International experts should participate in the evaluation of scientific activities. Stakeholders (including final users) should participate in M&E activities.
- The results of evaluations should be published.

Source: UNCTAD.

There is need for a clear division of functions and hierarchy among institutions. The National STI Policy Committee should be entrusted with a supervisory role, focusing on strategic issues and broad budget allocations, but should not be involved in the implementation of measures; that should be the responsibility of operational agencies. The Prime Minister's regular and active participation as chairperson of the Committee should be ensured through various measures,[44] and the Committee should meet at least once a month. The Committee should comprise the key relevant ministers,[45] including, imperatively, the Minister of Finance, and should be enlarged to include high-level representatives of business organizations, trade unions, academics and civil society. The National STI Policy Office (NSTIPO) should continue in its role as the secretariat of the Committee, and focus on providing policy advice and, increasingly, policy monitoring and evaluation. Ideally, it should not be involved in the implementation of STI programmes. To reinforce the cross-ministerial policy reach of the National STI Policy Committee, NSTIPO, currently administratively located under MOST, could be moved out of that Ministry once broad high-level support for STI policies has been built. In the meantime, NSTIPO could remain under MOST, where it is broadly supported and from where wider high-level support for STI policies could be built.

Among the bodies in charge of R&D, a clear distinction should be established between those that design the policies and monitor their implementation, and those that fund programmes and organizations. Grouping and merging should help rationalize the structure. The supervising body overseeing the R&D policy, which would be the NRCT – possibly enlarged or reshuffled to represent all of the various R&D funding or managing agencies – should report to the National STIP Committee (duly strengthened as indicated above), and not to the Prime Minister (as it currently does).

Rationalization of the whole R&D structure should be considered by merging some entities (agencies, research centres and departments) whose functions overlap, suppressing the small ineffective entities – or those that have outlived their usefulness – and establishing new entities, as appropriate. The strengths and weaknesses of the research system in Thailand should be assessed through an audit of the scientific quality and effectiveness of its public research centres. This audit should be conducted with the participation of international experts.

5. Improving resource management

Thailand's overall investment in STI is inadequate. Expenditure on R&D as a percentage of GDP is markedly low, and most of it comes from the public sector. As indicated in the National STI Policy and Plan, Thailand should aim at increasing investments in R&D and innovation, particularly private sector investments. The country could also achieve more from taxpayers' money through better management of its resources. Various ways to increase investment in STI and make more effective use of it are discussed below.

The tendency to spread resources among many different projects and organizations – resulting partially from a proclivity for bureaucratic tendency to overlook underperformance and largely from a lack of evaluation and oversight– needs to be reviewed. A more cohesive approach that seeks to create critical mass as a matter of priority would be preferable.

A good mechanism for expanding private sector engagement in R&D and innovation efforts is the use of matching funds, whereby an enterprise benefiting from government financial support for innovation contributes an equivalent sum of money. Generally this mechanism is used in projects to stimulate enterprise collaboration with universities or public research centres. While matching funds to promote private sector innovation are commonly used in many countries, in Thailand there is reluctance to use public money for sponsoring the business sector because of corruption concerns. Such concerns could be allayed by creating solid safeguards to prevent the misuse of such financial support. Current tax incentives for R&D and innovation should be carefully reviewed, particularly their impact on SMEs, before proposing more generous tax incentives.[46]

An efficient use of public procurement can provide a good vehicle for increasing the technological capabilities of domestic firms, as demonstrated by many countries, including developing ones. Box 2.9 illustrates how Sri Lanka's public procurement effectively expanded the domestic IT services sector. The use of public procurement for promoting domestic innovation capabilities is particularly relevant for large-scale programmes, such as Thailand's railway infrastructure project.

The effective management of government resources for R&D and innovation requires sound mechanisms for monitoring and evaluation of the outputs and achievements of projects benefiting from government spending. Outputs and impacts should be reported and made public in a systematic manner.[47]

Finally, budget allocations, rather than being quasi-automatically renewed annually, should be conditional upon compliance with policies and instructions set by the supervising authorities – a practice that may help adjust the behaviour of, for instance, universities. On the other hand, recipients of government funds should be able to feel more confident that their funding will be stable over time, particularly for larger projects, when these are implemented in accordance with stated objectives.

Box 2.9 How Sri Lanka's public procurement effectively expanded the domestic information technology (IT) services sector

The Government of Sri Lanka used the e-Sri Lanka initiative, a large project of $32 million involving a critical mass of IT-related procurement, as an opportunity to promote the domestic IT services sector.

The Information and Communication Technology Agency (ICTA), the national agency responsible for large e-government programmes, played a leading role in promoting the development and internationalization of local IT services firms. As manager of large e-government projects and with a broad mandate, ICTA was able to undertake a coordinated set of actions to promote the domestic IT sector through public procurement. As a result, of a sample of 13 key e-services procured by ICTA, all but one included a local firm in the winning bid.

The public administration adopted transparent and open procurement practices to enable fair competition and facilitate the participation of smaller firms. It also developed a close understanding of the local IT services industry and coordinated with the IT sector to design appropriate support measures. Different instruments were deployed to increase the participation of domestic firms. For example, the allocation of preferential marks to domestic bidders promoted joint ventures between international and local firms, which, over time, have encouraged knowledge transfer and technological learning by local firms. It also established a modular e-government architecture, which resulted in invitations for smaller tenders, which are more suitable for SMEs and local firms. In addition, training on public procurement was provided for local bidders.

Box 2.9 How Sri Lanka's public procurement effectively expanded the domestic information technology (IT) services sector *(continued)*

Experience from Sri Lanka and other developing countries indicates that leveraging public procurement for domestic sector development is a complex policy instrument and its successful application requires a certain level of capabilities (in the public and private sector) as well as good procurement practices. This necessitates the following strategic actions:

- Ensuring certain fundamental conditions, including a critical mass of public projects.
- Creating a strong institutional framework with a lead agency.
- Providing targeted preferential treatment for local suppliers (without jeopardizing the quality of the services provided).
- Increasing the options for SMEs to present bids, for example by allowing them the tendering of smaller projects.
- Promoting awareness and capacity-building among local firms and in relevant public authorities.

Source: Adapted from UNCTAD, 2013b.

6. Linking innovation actors

A serious weakness of the Thai innovation system is its fragmentation. Actors operate in silos and do not interact with each other, which obstructs opportunities to learn, to address each other's needs and concerns, and to generate synergies.

Despite good examples of collaboration (e.g. in the hard-disk drive and shrimp industries), relationships between universities, public research organizations and industry are particularly weak (see, for example, Doner et al., 2013; Brimble and Doner, 2007; Intarakumnerd and Schiller, 2009). Academics and part of the public administration believe that innovation can be pushed by research; that is, that research may eventually trickle down to provide solutions for industry, society and consumers. On the other hand, the business sector often behaves as if the research system only needs to respond to market demands. Both viewpoints are erroneous. Innovation takes places in a system as a result of interactions among multiple actors. Greater awareness about the systemic nature of innovation can be built through campaigns and training (as suggested earlier). However, awareness is not enough; proactive policies to stimulate linkages and incentives to support their development are also needed urgently.

The need to strengthen the linkages between actors is abundantly demonstrated by the success of those schemes (e.g. ITAP) and organizations (e.g. HDDI, TAI, Thai Food Institute) that operate at the interface between sources of knowledge and clients seeking knowledge. It is advisable to scale up those schemes significantly, and possibly make ITAP autonomous from NSTDA to minimize bureaucracy and allow it to become more agile. Promoting suitable intermediary organizations for specific sectors and upgrading their capabilities to provide training in critical skills and initiate R&D programmes is also desirable.[48]

Linkages have also partly been discouraged by the absence of incentives for researchers, teachers and their institutions to collaborate with industry. Researchers' participation in industrial research and in the provision of advisory services to firms should be formally recognized and valued as a means of advancing their careers. For instance, the Talent Mobility Program should be strengthened by adjusting incentives to encourage universities and researchers to take part in the scheme. Equally, in their performance assessments, universities and research institutions should be evaluated on their ability to collaborate with industry, provide services and transfer technology. More specifically, it is recommended to progressively impose on public research organizations the obligation to have a significant percentage of their budgets funded through contracts with clients (i.e. private or public sector), possibly to the tune of between 20 and 40 per cent, depending on the nature of the research in which the organization is engaged (smaller for organizations mostly engaged in basic research and higher for those engaged in technological or industrial research). In this regard, the policy changes introduced by the Indian Centre for Scientific and Industrial Research to transform its inward-oriented culture to one of collaboration with industry could serve as an inspiration. Finally, a clear IP policy for publicly funded research should provide incentives, or at least facilitate, industry-RTO collaboration. Researchers' mobility should also be facilitated. First, restrictions on mobility in current public scholarship programmes should be relaxed (i.e. by easing researchers' mobility within public research institutions and reducing the obligatory number of years that beneficiaries of public scholarships must spend in a public research institution). Second, support should be given to mobility programmes for researchers (e.g. Researchers for Research in Industry or the Talent Mobility Program) and incentives for researchers' mobility adjusted. Universities could also take the initiative to provide training that combines the qualifications and competences needed for innovation by offering, for instance, combined engineering and entrepreneurship courses. KMUTT's experience in this regard is a good example.

Programmes that expose students, teachers and academics to working conditions in the business sector, such as dual vocational training, mobility programmes for researchers and combined studies, should be strengthened and expanded significantly.[49] Successful cooperative education programmes, such as the Mechai Pattana School (box 4.5), the pilot work integrated learning, or the engineering practice schools at KMUTT (box 4.6), should be expanded to reach a critical mass of beneficiaries. Mainstream dual vocational training requires a major overhaul, including the upgrading of teachers' qualifications, teaching methods and resources (see discussion in chapter 4).

Thailand's current capacity to promote entrepreneurship and spin-offs in universities and research institutions is insufficient to stimulate the emergence of a solid base of technology and knowledge-based firms.[50] To overcome this weakness, three complementary actions are recommended: providing universities and RTOs with stronger mandates to promote entrepreneurship; more focused initiatives (i.e. reducing the number of university business incubators (UBIs) and concentrating resources in strategic sectors), and the professionalization of UBIs (e.g. by encouraging them to adopt more business-like approaches and structures, and hiring staff with strong experience in the private sector).

Commercialization of research and IP management is also underdeveloped in Thai universities.[51] At present, as universities have limited research that can be patented, commercialized or transferred (largely because research is conducted in isolation from industry), and IP regulations regarding government-funded research are unclear, the main priorities in this area should be to create greater awareness about IP and the commercialization of research; promote clear and coherent institutional IP policies among research institutions; agree on and approve legislation regarding ownership of IP resulting from research financed by public funds; and encourage research processes that promote collaboration with industry and social partners from the outset and thus enable the emergence of research with greater commercial potential. Translational R&D funds and common scale-up facilities should be expanded.

More generally, it is recommended that mechanisms, such as multi-stakeholder committees or mixed evaluation teams, be established that formally involve users (e.g. business, farmers, consumers' representatives) in the design, implementation and evaluation of R&D and innovation programmes.

7. Supporting decentralization

Overall national and STI-specific investments and resources tend to go to more technologically developed areas, leading to a concentration of activities around Bangkok and other big cities. Infrastructure works, such as the railway megaproject, help link peripheral areas to the economic centre of the country. However, further investments in knowledge and technology infrastructure are required to support the economic development of peripheral areas. STI offices should be established throughout the country, serving as one-stop shops for innovators and researchers. Branches of important research centres can be set up close to universities. Technology services (e.g. testing and demonstration) should be developed also at the local level, in line with demand. Regional S&T parks should be extended beyond the pilot phase, provided they have good development prospects. On the education front, primary, secondary and vocational schools should progressively be reformed, inspired by innovative approaches such as the Mechai Pattana School. This requires major reform as well as high-level support and substantial resources. In the field of agriculture, links between central offices and regional/provincial/district and *tambon* (sub-district) levels should be strengthened. Mechanisms for agricultural extension could also be reinforced following internal dialogue in the MoAC about main barriers to, and best mechanisms for, effective technology diffusion (see chapter 3). Centres providing information, training and advisory services have been set up by different ministries at the local level, but with little communication among them. The review of these centres currently being carried out by NSTIPO could be valuable in helping to rationalize their organization and encouraging more user-oriented (e.g. one-stop centres), rather than ministry-directed centres.

Most policymaking, notably STI policy, is concentrated in Bangkok. Efforts to decentralize STI policy by nominating deputy regional governors as chief regional scientist officers have not worked. For the effective development of STI policies at the regional level, it will be necessary to develop local awareness and capacity-building for STI policymaking (based on a survey of STI awareness and policy activities at the local level). In addition, a mandate on STI should eventually be provided to regional governments. The establishment of regional STI councils composed of stakeholders from local administration, industry and academia/training institutions could help develop awareness of local STI needs. Some middle-income countries, such as Peru, have built STI policymaking capabilities at the regional level, which offer lessons for Thailand (box 2.10).

Box 2.10 Promoting regional STI policies and programmes: The case of Peru

Peru's regional STI councils, decentralized versions of the national STI council, are formulating STI policies at the regional level, supporting the creation of regional STI agendas and promoting new sources of financing for STI.

These organs of the regional governments – composed of government representatives, and representatives of sectoral R&D institutes, universities, companies and civil society – help create a consensus and empower the regions in STI matters. They have contributed to the development of STI capacities at the regional level by generating awareness among regional policymakers on the relevance of STI, promoting linkages among actors at the regional level, providing access to schemes that promote STI (e.g. innovation funds, training and research groups) and stimulating the creation and functioning of technology parks.

Source: UNCTAD

8. Expanding international connections

Thailand has developed multiple international connections to support the development of domestic technological capabilities, but at times these are contradictory or insufficient. On the one hand, Thailand has collaborated actively with foreign sources of knowledge (e.g. when designing tertiary education schemes) and has financed the training abroad of future public administration officials and researchers, which have enabled greater learning opportunities, access to international networks of knowledge and the building of domestic capabilities. On the other hand, as foreign companies, mainly TNC, are seen as the main sources of new technology, policies have often focused on attracting FDI to the detriment of developing the technological capabilities of domestic firms, thereby perpetuating an unsustainable situation of technological dependency.[52] Thailand's future cannot depend on external drivers; its indigenous capabilities – which also condition the country's absorptive capacity for increasingly sophisticated foreign technologies – should be gradually strengthened. Measures for fostering those capabilities, as described earlier, can be complemented with policy measures that promote technology transfer from foreign investors through the fostering of linkages between foreign and domestic businesses. Some countries, such as Ireland and Malaysia, offer examples of business linkage programmes that have worked well. Key actions include careful selection of local firms that could benefit from such programmes through rigorous assessment of their capabilities, and clear TNC engagement to support part of the programmes' costs. Business linkage programmes should have well-defined objectives. Generally, they should include technical assistance, training and certification services, and should be given high visibility.[53]

In Thailand, there is a marked absence of foreign evaluators in government-funded scientific programmes, except, of course, in bilateral and multilateral programmes. Thailand should continue to strengthen its participation in international scientific networks through the expansion of programmes that specifically support research networks in areas of national interest, such as the Golden Jubilee PhD Program (box 4.3), which seems to be useful but currently benefits only a relatively small number of people.

9. Taking advantage of megaprojects

National infrastructure projects, because of their size, offer unique opportunities to boost domestic innovative capabilities, if they are well designed and implemented. Thailand's railway megaproject can generate technology spillovers and support the development of trained engineers as well as the acquisition of technological competences among local firms.

An open, transparent, large-scale consultation process would ensure that the development of human resources and the generation of technology spillovers are an integral part of the programme. For this, it may be necessary to create greater awareness among actors of the potential that public procurement offers for generating technological externalities. Human resources development (HRD) and the building of domestic capabilities through efficient technology transfer from foreign contractors should be an explicit objective of the railway programme and should be accompanied by well-defined actions, responsibilities and monitoring mechanisms. This will be key to successfully developing Thailand as a transport services hub for South East Asia.

10. Prioritizing the agenda: Short-term perspectives and long-term developments

The policy proposals presented earlier aim at overcoming several tensions or biases affecting the Thai innovation system, such as: remaining in the comfort zone even while aiming to escape the middle-income trap; the tendency to create additional institutions instead of rationalizing existing structures; providing autonomy while maintaining control; moving on from a linear understanding of innovation towards more systemic approaches; and exploiting more internal drivers, in addition to external ones, to achieve productivity gains. An additional tension is the desire for visible results in the short term in an area that requires long-term investments and persistent action. Smart approaches to strategic reform in change-resistant countries generally consist of gradual processes in which quick-win initiatives create a climate more open to change and help prepare the ground for greater reforms. Given the specific context of Thailand, three complementary lines of actions should be implemented without delay.

First, quick-win initiatives could be taken to demonstrate the innovation capabilities of Thai society as well as the Government's commitment to making STI central to its national development strategy. Awareness campaigns could be launched to showcase promising innovations supported by ITAP and NIA, as well as significant ideas and technologies emerging from Thailand's R&D networks. Such campaigns should also highlight initiatives by industries (e.g. PTT), universities (e.g. KMUTT) and schools (e.g. Mechai Pattana) that illustrate creativity and dynamism. Leadership courses on STI and national development could be organized to encourage the mobilization of private and public sector leaders around common goals. In addition, a few straightforward measures (such as reviewing institutional key performance indicators and research careers, and clarifying IP policy for publicly funded research) could rapidly help enhance much-needed collaboration among actors. In parallel, the Government should pledge support to STI at its highest levels, and take specific measures to demonstrate its commitment, including addressing the functioning of the National STI Committee, using more inclusive consultation processes and conducting an independent evaluation of STI institutions.

Second, Thailand could expand the impact of its innovation efforts by replicating existing effective programmes and scaling up useful pilot projects. For example, it could consider replicating successful cooperative education models, expanding the ITAP model and developing four fully-fledged incubation programmes outside Bangkok. These initiatives demand substantial efforts at a high level, but offer greater prospects of accomplishing broader and longer lasting change.

Third, to support strategic and durable advancement, it would be vital to work on a new law that provides a well-defined framework for the whole STI policy with a long-term perspective. It should include firm engagements on budget allocations, well-designed reorganizations of institutions in charge of STI and R&D policies and programmes, the introduction of new policy instruments (e.g. matching funds, public procurement), and robust monitoring and evaluation mechanisms combined with various rewards and sanctions. The overall objective is to adjust behavioural patterns to make the whole STI system more efficient and capable of managing the challenges faced by Thailand. Another pressing goal should be to build support for much-needed educational reform. Such reform should focus on, among others, promoting critical thinking skills and innovation-friendly attitudes, and building stronger linkages between educational institutions and the economy.

Box 2.11 provides an overview of the key strategic thrusts, and the suggested lines of action for achieving them. A number of the actions suggested are discussed in chapters 3 and 4.

Box 2.11 Recommendations: Strategic thrusts and suggested actions

Strategic thrust 1: Move leaders and institutions out of their comfort zone

1.1. Increase awareness on the danger of staying in the comfort zone and the systemic nature of innovation

- Launch awareness campaign showcasing innovative initiatives
- Build commitment for STI education and training reform (particularly VTET, innovation skills & industry linkages)

1.2. Increase accountability through effective evaluation and conditional budget allocation
(see actions 5.4, 5.5)

Strategic thrust 2: Mobilize for common goals and aspirations

2.1 Provide training for policymakers and other stakeholders

- Deliver first training courses for policymakers
- Establish an STI policy training institute

2.2 Strengthen STI consultation processes

- Include high-level representatives of business organizations, trade unions, academia and civil society in the National STI Policy Committee
- Enhance the timely provision of clear and reliable STI data and make that data public

2.3 Agree on a common agenda for reform of STI education and training

- Launch national reform of existing TVET
- Launch a national initiative (comprehensive set of policies and programmes) to promote entrepreneurship
- Agree on a set of actions to encourage industry linkages with research, education and training institutions *(see thrust 6)*
- Expand business and farmers' associations' mandates to include the promotion of technological upgrading

2.4 Develop a long-term vision for agriculture

- Articulate an innovation roadmap to address: land-holding fragmentation, water supply, soil quality and human resources
- Develop a long-term soil improvement strategy, including actions to reduce chemical inputs and encourage precision farming
- Promote adoption of a national biosafety regime, following multi-stakeholder discussions

Strategic thrust 3: Balance social, environmental and economic objectives

3.1 Design STI incentives to benefit disadvantaged groups (smaller firms, farmers, regions outside Bangkok)

- Set an inclusive innovation agenda to promote innovation by and for local communities (e.g. social enterprises)
- Expand the use of financial instruments for supporting SME innovation, including matching funds
- Develop locally based sectoral innovation centres/actors that support SMEs
- Increase the percentage of funds for translational research
- Expand businesses, technological and testing services beyond Bangkok *(see action 7.1)*

3.2 Follow up on the actions suggested in Thailand's climate change technology needs assessment reports

- Set up a national, cross-ministerial committee to take the actions forward

3.3 Develop a strategy for STI in agriculture that focuses on the poor

- Strengthen extension services (or other means of technological knowledge transfer to/from farmers)
- Encourage linkages between central and regional/local actors *(see action 6.6)*
- Ensure that agriculture-related R&D investments help small-scale farmers *(see action 5.6)*

Strategic thrust 4: Strengthen STI governance and management

4.1. Strengthen the role of the National STI Policy Committee

- Consider measures to ensure the Prime Minister's regular and effective participation in the Committee
- Expand the Committee to include the Minister of Finance, and high-level representatives of business organizations, trade unions, academia and civil society.
- The NRCT should report to the Committee

4.2. Separate policy advice from programme implementation

- Review mandates of NSTDA (to focus on carrying out research), NSTIPO (to focus on innovation policy design and evaluation) and NRCT (to focus on R&D policy)

4.3. Rationalize the structures of R&D institutions, following an independent evaluation of STI institutions

- Conduct an independent evaluation of STI institutions to guide rationalization efforts
- Based on the evaluation, rationalize the structure of R&D institutions

4.4 Enhance coordination between research, education and industry

- Set up a formal coordination mechanism (for example, under the National STI Policy Committee)
- Develop a robust labour market information system

4.5 Review educational quality assurance and quality enhancement systems

- Strengthen measures to address underperforming educational institutions
- Over time, raise the performance standards of all higher education institutions
- Progressively link budgets to performance
- Review the quality and relevance of skills development training, and take measures to improve them

Strategic thrust 5: Improve resource management

5.1 Prioritize resources: Build a critical mass

5.2 Update the mix of financing instruments for supporting innovation

- Promote the use of matching innovation funds
- Review the impact of current tax incentives for R&D and innovation before proposing more generous tax incentives

5.3 Use public procurement to develop technological capabilities of domestic firms *(see thrust 9)*

5.4 Introduce effective monitoring and evaluation systems

- Provide the National STI Policy Office with a strong mandate for monitoring and evaluating STI policies
- Develop strong M&E guidelines that encourage the measuring of outputs and impact, institutional learning, engaging of independent evaluators, stakeholder participation in M&E activities and publication of the findings of M&E activities
- Provide training on M&E to STI policymakers and programme managers

5.5 Budget allocation processes to be transparent, based on performance

- Link STI budget allocations to performance
- Review budgeting processes to increase confidence in the availability and distribution of funds for multi-year programmes that perform according to plan

5.6 Strengthen the impact of R&D programmes on raising opportunities for, and productivity of, small-scale farmers

- Review the impact of past R&D programmes
- Review the process of decision-making on research topics and for assigning grants

Strategic thrust 6: Link innovation actors

6.1 Expand schemes at the interface between the sources and the demand for knowledge

- Expand ITAP and consider making it autonomous from NSTDA.
- Upgrade the capabilities of intermediate organizations to offer training in critical skills and to start R&D programmes
- Build support for the three regional science parks (in the north, north-east and south)

6.2 Review incentives for mobility and collaboration

- Review institutional key performance indicators to evaluate university and research institutions on their ability to collaborate with industry, provide services and transfer technology
- Progressively increase the proportion of research organizations' budgets to be funded from contracts
- Formally value public researchers' participation in industrial research and in providing advisory services to firms
- Adopt a clear IP policy for publicly funded research
- Relax restrictions on mobility in public scholarship programmes
- Support researchers' mobility programmes (e.g. Researchers for Research in Industry, Talent Mobility) by adjusting incentives to mobility

6.3 Promote cooperative education

- Expand successful cooperative education models (e.g. Mechai Pattana, work integrated learning, KMUTT practice schools)
- Overhaul mainstream TVET: upgrade teachers' qualifications, teaching methods and resources
- Conduct an independent evaluation of non-formal TVET (skills development programmes) and take measures to enhance the quality of the training

6.4 Strengthen business incubation programmes and support research spin-offs and commercialization

- Establish four fully-fledged incubation programmes outside Bangkok
- Strengthen mandates for entrepreneurship and technology transfer in universities and RTOs
- Professionalize university business incubators and technology licensing offices (promote business-like approaches and appoint staff with extensive private-sector experience to lead them), and provide further training on technology transfer to managers and researchers
- Support commercialization of research: expand translational R&D funds and common scale-up facilities

6.5 Strengthen formal participation of a wider range of stakeholders in programme design, implementation and evaluation

- Train researchers and their managers on how to include users in the design of R&D programmes
- Support research processes that promote collaboration with industry and social partners (expand the use of collaborative matching grants, provide support and matching services to facilitate joint research)
- Establish mechanisms (e.g. multi-stakeholder management committees and evaluation teams) to formally involve users in R&D and innovation programme design, implementation and evaluation

6.6 Strengthen linkages in agriculture

- Review incentives for collaboration between MOAC central research deptartments and other publicly funded research institutions
- Strengthen linkages between central offices and regional/ provincial/district/sub-district levels based on a study of best practices
- Strengthen the mechanisms for agriculture extension, following MOAC internal dialogue
- Develop mechanisms to solicit inputs to decision-making from agricultural coops, and local and provincial authorities
- Increasingly support access to and use of e-government and agriculture

Strategic thrust 7: Support decentralization

7.1. Expand STI infrastructure and networks in the regions

- Establish more one-stop STI offices
- Offer increasing technological services in the regions (in line with demand)
- Build support for the three regional science parks (in the north, north-east and south)

7.2. Develop STI policymaking capacities at the regional level

- Conduct a survey of STI awareness and policy activities at the local level
- Set up regional STI policy councils
- As local capacities develop, increase regional mandates for STI policies

7.3. Expand school models that promote innovation and local development

- Support adoption of the Mechai Pattana School model in other districts

7.4. Reinforce agricultural extension services

- Devise a strategy and earmark funds to strengthen local agricultural STI capacities and enable farmer-driven innovation

Strategic thrust 8: Expand international connections

8.1 Build business linkages between TNCs and local firms

- Establish a programme/unit to support business linkages between TNCs and local firms

8.2 Engage international experts on STI policies and programme design and evaluation

- Engage international experts in the evaluation of STI institutions

8.3 Maximize international collaboration and mobility

- Continue supporting international research and training networks, particularly on topics of national interest
- Facilitate work permits for highly skilled labour (reviewing employment restrictions)
- Continue supporting language skills to further Thailand's integration in teaching and research networks
- Consider a programme to attract foreign experts to fill specific skills gaps, and enlarge international connections

Strategic thrust 9: Take advantage of megaprojects

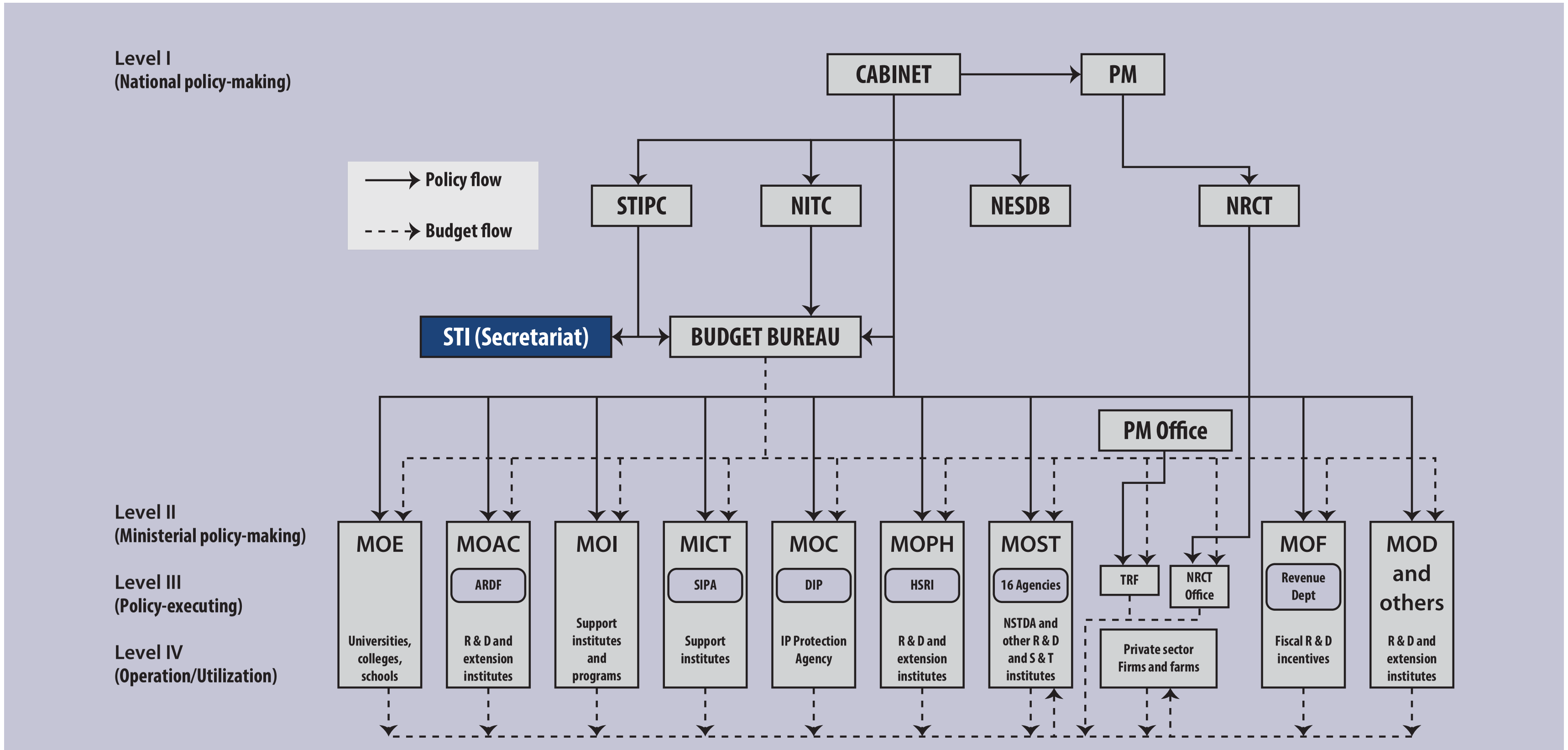
9.1 Ensure that human resources development (HRD) and the generation of technology spillovers are an integral part of the railway project

- Set specific aims and objectives for HRD and technology spillovers in the main railway project plan
- Set a specific budget allocation for HRD (for example, 1 per cent of total project budget)
- Make a more detailed assessment of HRD needs and identify domestic industrial areas with development potential

9.2 Make technology transfer an explicit objective of public procurement for the railway project

- Inform policymakers and firms of the opportunities for technology transfer offered by public procurement
- Include technology transfer considerations in public procurement (e.g. local content provisions that favour joint ventures with local firms; requirements for the training of local engineers and technicians)

Annex 1. Organizational structure of the science, technology and innovation policy system of Thailand



STI	= National Science Technology and Innovation Policy Office
PM	= Prime Minister
STIPC	= National Science Technology and Innovation Policy Committee
NESDB	= National Economic and Social Development Board
NRCT	= National Research Council of Thailand
NITC	= National Information Technology Committee
MOE	= Ministry of Education
MOAC	= Ministry of Agriculture and Cooperatives
MOI	= Ministry of Industry
MICT	= Ministry of Information and Communication Technology
MOC	= Ministry of Commerce
MOST	= Ministry of Science and Technology
MOF	= Ministry of Finance
MOPH	= Ministry of Public Health
MOD	= Ministry of Defense
NSTDA	= National Science and Technology Development Agency
SIPA	= Software Industry Promotion Agency
TRF	= Thailand Research Fund
HSRI	= Health Systems Research Fund
ARDF	= Agricultural Research and Development Fund
DIP	= department of Intellectual Property

Source: (Durongkaveroj, 2014a).

Annex 2. Excerpt from the National STI Policy and Plan (2013–2021)

Mission and objectives

1. Development of science, technology and innovation for building a quality society that is immune to changes
   - To promote public health and well-being
   - To support the development of a knowledge-based society
   - To strengthen local communities through capacity development, thus reinforcing an effort to promote decentralization and inclusive growth
2. Development of science, technology and innovation for improving the quality and stability of economic growth with connectivity to regional and global economy
   - To increase productivity and value added to manufacturing and service sectors
   - To support the green and value creation of products and services
   - To support the improvement of standards of products and services to overcome trade barriers
3. Development of science, technology and innovation for confronting climate change
   - To develop models for natural resource and environmental forecasting
   - To adapt to and mitigate climate change
   - To support balanced management of natural resources and environment
4. Development of science, technology and innovation human resources to confront demographic changes
   - To support the reform of science education and technical education
   - To raise the number and capacity of scientific and technical workforce that meets the needs of the economy and society
5. Development of STI infrastructure and enabling factors to enhance national competitiveness
   - To build and decentralize STI infrastructure
   - To create fiscal and financial tools, market, law and regulations, and an effective management system to support the development and deployment of STI.

Social targets

1. Prevention and treatment of existing and emerging diseases with less dependency on foreign medical technologies.
2. Local communities are capable of using science and technology to enhance local traditional knowledge for value creation and value addition to local products and services as well as for better livelihood.
3. The quality of community products and services is improved and standardized with at least 3% productivity growth on a yearly basis.

Economic targets

1. Farmers and businesses utilize STI to achieve at least 3% productivity growth on a yearly basis.
2. Farmers and businesses utilize STI to achieve at least 5% increase in value added on a yearly basis.
3. Increase the utilization of STI to take the advantage of Free Trade Agreements so that the proportion of export growth due to STI utilization is no less than the total export growth.

Energy and environmental targets

1. STI can prevent the loss of life and reduce the damage due to natural disasters up to 1% of the GDP.
2. STI can increase the proportion of alternative energy utilization to 20-25% and achieve 5% reduction of waste and pollution on a yearly basis.
3. STI can help decrease consumption that affects the ecosystem 10% annually.

Human resource development targets

1. The proportion of graduates in science and technical fields is to increase to at least 60%.
2. Labor productivity for science and technical graduates grows at least 5% on a yearly basis.
3. The ratio of R&D personnel is to increase to 25 per 10,000 population, 60% of which work in the private sector.

Infrastructure and enabling factor development targets

1. The competitiveness ranking of Thailand is within the world's Top 25 according to IMD.
2. Gross expenditure on research & development reaches 2% of the GDP.
3. The private sector contributes to 60% of gross expenditure on R&D.

NOTES

1 See, for example, Felipe, 2012

2 See, for example, Freeman, 1987; Lundvall, 1992; Nelson, 1993; see also UNCTAD (2011) for a description of the systemic approach to innovation that underpins the STIP Review process.

3 Human resources issues are discussed in detail in chapter 4.

4 The industrial sector represents 42 per cent of the value added of the economy (World Bank, World Development Indicators)

5 Based on data from Scimago Journal and Country (SCJ) rankings (http://www.scimagojr.com).

6 These industries have the largest share of firms conducting R&D in-house (National STI Policy Office, 2014).

7 The Thai SME Promotion Act (2000) classifies SMEs depending on their sector. Small firms are those with less than 50 employees or less than 50 million baht in fixed assets, and medium firms those with 51–200 employees or between 50 and 200 million baht in fixed assets. However, these parameters are different for wholesaler and retailer firms (OECD, 2011).

8 According to GEM et al. (2012), 87 per cent of early-stage entrepreneurs and 92 per cent of established business owners exclusively serve the domestic market.

9 SMEs' exports, by value accounted for only 49 per cent of their GDP, compared with Thailand's overall exports, which accounted for 62 per cent of the national GDP (OSMEP, 2013)

10 On this indicator Thailand ranking is 66 as opposed to 48 in the overall Global Innovation Index.

11 Information provided by field interviews during the UNCTAD mission in October 2013.

12 Based on field interviews during the UNCTAD missions (Oct. 2013 and June 2014) and a round table discussion with business incubators in February 2014.

13 See, for example, Chunhavuthiyanon and Intarakumnerd (2014) for a discussion on the need to update the role of the National Food Institute to adequately respond to the new strategies and capability requirements of Thai food exporters.

14 As reported during field interviews in October 2013.

15 As reported during field interviews in October 2013.

16 Oral communication with TISTR's management.

17 See chapter 4 for a more detailed analysis of Thailand's education system.

18 Based on data provided by the STI Policy Office

19 They comprise: 15 public universities, 16 autonomous universities, 2 open admission universities, 40 Rajabhat universities (upgraded teacher training colleges), 9 Rajamangala (technical and commercial colleges) and 70 private colleges and universities.

20 In 2011, the five institutions that published the most scientific and technological papers were: Mahidol University (1,317 papers), Chulalongkorn University (1,252 papers), Chiang Mai University (700), Kasetsart University (473 papers) and Prince of Songkla University (461), with a citation ratio averaging 0.5–0.7 per publication (National STI Policy Office, 2013).

21 As noted in interviews with the private sector, and confirmed by the Office of the Vocational Educational Commission (OVEC).

22 Intermediary organisations may perform a plethora of functions including: foresight, information scanning and processing, knowledge processing and combination, brokering, testing and training, accreditation, regulation, IP, commercialization, technology assessment (Howells, 2006)

23 See, for example, Brimble and Doner, 2007; and Chunhavuthiyanon and Intarakumnerd, 2014.

24 For further details see chapter 3.

25 The National Science Technology and Innovation Policy and Plan 2012-2021.

26 At the time of the interviews (October 2013) the Prime Minister had not chaired any of its meetings for two years

27 Interviews by UNCTAD's STIP Review team point to an increase of 10 per cent.

28 For a detailed description and analysis of some existing schemes, see Intarakumnerd et al., 2011.

29 As reported in interviews in October 2013.

30 Information provided by the Ministry of Industry.

31 The private equity market in Thailand in 2010 amounted to $52 million compared with $3,000 million in Singapore (see Wonglimpiyarat, 2013)

32 The data on tax incentives presented in this section are drawn from Intarakumnerd et al., 2011.

33 By way of comparison, the French tax incentive, the largest among OECD countries, amounts to a total of 6 billion euros/year (OECD, 2014b)

34 See: www.sc.mahidol.ac.th/research/shrimp.htm.

35 This is mainly because often such evaluations are not available, but also because there is widespread reluctance to share the results of evaluation studies.

36 Based on interviews with stakeholders in October 2013 and on NSTDA evaluation's executive summary (2002–2008).

37 For instance, the North Eastern Science Park does not yet have a dedicated infrastructure. The Park has a staff of 15 that support business incubation services, technology consulting services (through ITAP, and a technology licensing office), and a product design centre. A 500-million-baht proposal for building infrastructure for a science park (including space for 15–20 firms, laboratories and a pilot plant for food and pharmaceuticals) has been submitted to MOST. The private sector is not participating in this proposal.

38 See chapter 4 for a detailed analysis of STI-related human resources.

39 As pointed out in OECD, 2013b.

40 See chapter 4 for more details on university-industry linkages.

41 For instance, the National Education Act of 1999 and the National STI Policy and Plan 2012–2021

42 The Berne Convention (in force since 1931), the Agreement on Trade-related Aspects of Intellectual Property Rights (TRIPS, 1994), the Paris Convention (August 2008), the Patent Cooperation Treaty (December 2009) and the WIPO Convention (1989), and is preparing to sign up to the Madrid protocol.

43 As reported during field interviews in October 2013.

44 For example, generating support through high-level briefings to the Prime Minister.

45 Additional ministers may be invited on an ad hoc basis. For example, the Minister of Labour should be invited when issues of international mobility of high-skilled labour and labour permits are to be discussed.

46 In December 2014, a more generous tax deduction rate of 300 per cent of R&D costs was being considered.

47 The scarcity of basic statistics relating to institutional budgets, human resources, activities, outputs and impacts for the elaboration of this report is a worrying indication of the lack of sound and transparent monitoring and evaluation systems.

48 For detailed discussions on the role of intermediary organizations in Thailand and suggestions for policy actions to strengthen them, see Intarakumnerd and Chaoroenporn, 2013.

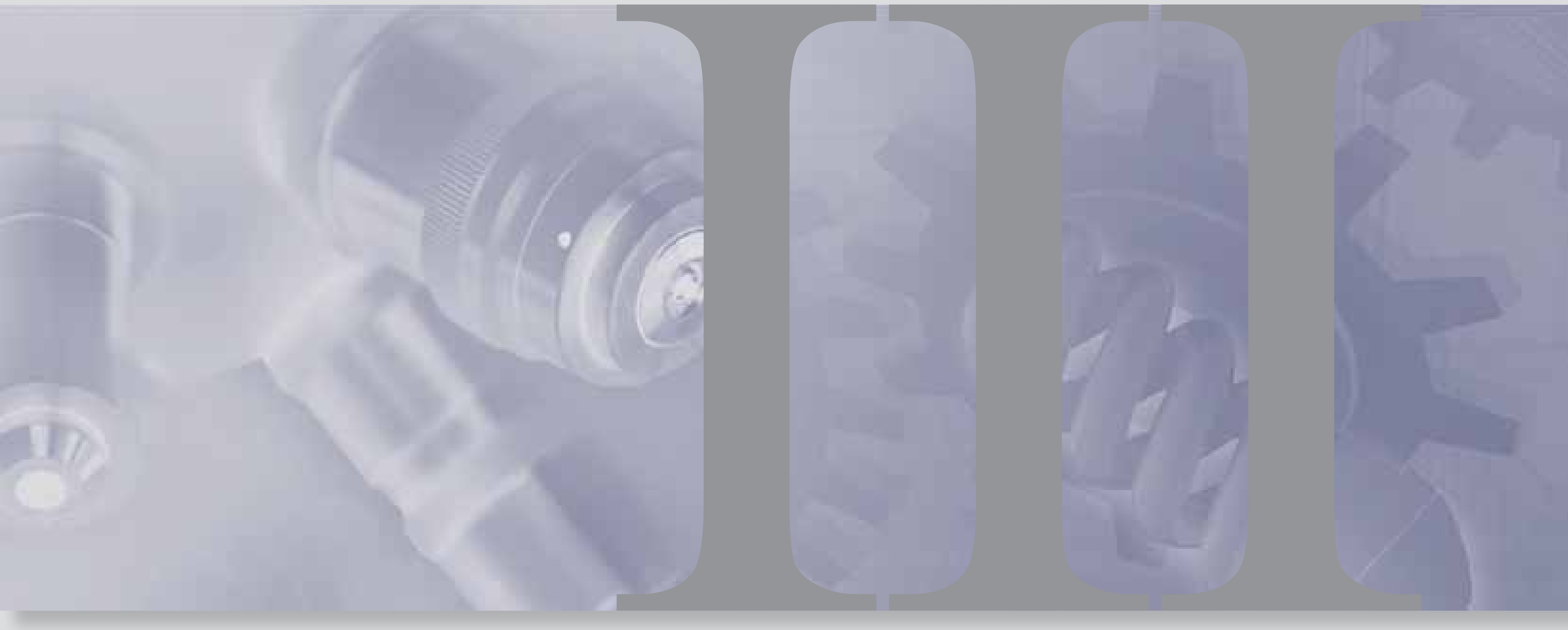
49 These and other programmes are discussed in chapter 4.

50 For a full description of Thailand's business incubators, see section 3.3 in chapter 4.

51 For a discussion on commercialization of research in Thailand, see section 3.3 in chapter 4.

52 For instance, as indicated by Thailand's increasing deficit in the technological balance of payments (see chapter 1).

53 For a brief description of the Irish linkages programme (put in place in the late 1980s) see World Bank, 2010: 239; for the Malaysian example, see section 4 in chapter 4.



Smallholder farming in Thailand's agricultural innovation system

A. INTRODUCTION

Agricultural development in Thailand in the past 50 years is considered, in many respects, a development success story (Leturque and Wiggins, 2011; Brooks, 2010). From the 1960s to the early 1980s, the sector was the country's engine of growth, growing by around 4 per cent annually as a result of the continuous incorporation of land and low-cost labour,[1] and agricultural exports (rice in particular) were heavily taxed to support industrialization(Leturque and Wiggins, 2011). From the 1980s onwards, agricultural growth slowed down to 2–3 per cent per year as labour left agriculture to work in other sectors and it became harder to expand land. However, through a transformation process of crop diversification (with the introduction of new important crops such as rubber and cassava), intensification (through a greater use of fertilizers and machinery) and the introduction of varietal improvements, land and labour productivity has improved markedly since the early 1990s (Leturque and Wiggins, 2011).

Thailand is now a major food-exporting country. Rice is the main staple and also a major export item. In 2008, Thailand was the largest exporter of rice in the world, with a 35 per cent share of the international market (Isvilanonda, 2009). In the same year, it was also the largest exporter of rubber, cassava, canned pineapple, and processed shrimp and chicken; the second largest exporter of sugar cane; and the third largest of palm oil (Isvilanonda, 2009; FAO, 2011).

While agricultural output has continued to increase, its share in GDP fell from 23 per cent in 1980 to 10 per cent in 2012 (table 1.1) – a typical indication of a maturing industrializing country. However, the proportion of the agricultural labour force has declined at a significantly lower rate,[2] and around 35 per cent of the labour force is still dependent on this sector (NSO, 2014). Labour productivity is lower in agriculture than in other sectors, as evidenced by the high proportion of employment in agriculture but the small contribution of agricultural output to GDP.[3] The sector is still largely characterized by labour-intensive farming on smallholdings and rain-fed crop production, as discussed later.

Agricultural development and overall economic development have contributed to a drastic fall in rural poverty, as farmer households have found employment in other sectors or diversified their income sources (e.g. through family remittances and rural non-farm jobs). Poverty has declined from around 60 per cent of the rural population in the 1960s (Brooks, 2010) to 13.2 per cent in 2011 (UNDP, 2014). However smallholder households collectively account for the majority of the poor.[4] Therefore, to continue to achieve significant and sustainable poverty reduction, the underlying structural problems in small-scale agriculture will need to be addressed.

Thailand's agricultural landscape is likely to undergo significant changes over the coming decades. Land has become increasingly fragmented due to inheritance of small farms by multiple heirs, but also because relatively few younger people wish to continue to farm. Agricultural land may either be lost or consolidated into larger-sized farms. Corporate farming may increase, where large producer firms buy large numbers of small holdings, and land reform programmes may be implemented that change land ownership patterns. In addition, prevailing agricultural production patterns are facing threats from the impacts of global climate change, including hydrological changes, increases in ambient temperatures, seasonal shifts, and more frequent and severe climate events such as floods. Adaptation to, and mitigation of, climate change impacts are prominent on the policy agenda in Thailand.[5] It is difficult to predict the likely impacts of climate change on Thailand's agriculture sector. The results of a climate modelling exercise indicated that the likely impact on major crops would vary significantly between crops and between regions of the country (Tangwisutijit, 2010).[6] Another study classified the north-eastern region as the most highly vulnerable, and the northern, eastern and southern regions as vulnerable (Supnithadnaporn et al., 2011).

Further uncertainty about the future agricultural landscape has to do with the ageing farmer population and the lack of young people entering the sector, either as farmers or as agricultural engineers or scientists. Fewer young people are engaged in agriculture in Thailand than ever before. The majority of Thai farmers (70 to 80 per cent[7]) are low-income smallholders with no formal education beyond elementary school. As educational levels have increased in rural areas in recent decades, younger generations have become less likely to follow their parents into farming, preferring to seek opportunities in other sectors. Vocational schools, and agricultural colleges in particular, have seen a decline in new student numbers, and universities find it hard to attract good students to agriculture-related courses. The average age of farmers in Thailand is now 51 years (Tanticharoen, 2011), and the sector may face serious labour shortages in the future, as landholding farmers retire and are not replaced by the next generation. Even today, many low-income farmers cannot afford the cost of seasonal wage labourers and have already lost unpaid family labour as the younger members seek work away from the rural areas.

Finally, the international markets for agricultural and agriculture-related products are undergoing a period of instability as a result of major crop losses due to extreme climate-related events in some major producer countries, the long-term effects of the 2007-2008 global financial crisis on Thailand's traditional export markets, the emergence of new markets in fast-growing economies such as China, and growing competition in some areas[8] that affect Thailand's short- and long-term positions as an agricultural exporter. Progressive economic integration in the ASEAN community is likely to create both threats and opportunities for Thai agricultural production.

Thailand Vision 2027, which aims to achieve national food and energy security, and environmentally-sound production systems, raises significant challenges for the development of the agricultural sector. The 11th National Economic and Social Development Plan (2012–2016) recognizes that a transformation in Thai agriculture is needed to ensure that Thailand maintains and enhances its position as a major world food producer, and to ensure energy security, promote environmental sustainability, and reduce existing inequalities between regions, and between the rich and the poor. Such a transformation will depend on the effective implementation, over the medium to long term, of a diverse set of well-designed and complementary policies[9] by different ministries. The Plan also explicitly recognizes the importance of S&T. For example, one guiding principle for the agricultural sector is to "utilize science, technology, innovation and creativity as fundamental elements in economic restructuring" (NESDB, 2012). A major challenge for restructuring in agriculture will be to address competing demands on STI resources.

The focus of this chapter is on small-scale individually owned or tenanted farms, which produce the majority of the key crops in respect of food and energy security: rice, sugar, cassava, palm oil and rubber. Increasing productivity in these and other economically important crops depends crucially on smallholders' abilities to make their production systems more efficient and environmentally sustainable in the face of challenging agro-environmental conditions, unfavourable economies of scale and an increasing shortage of agricultural labour. Innovation at the level of smallholdings is essential not only to increase productivity, but also to raise farm incomes. Small-scale farmers collectively represent a large share of the population whose welfare could improve through STI-driven growth. Improving access to technology (i.e. knowledge) that meets their needs is an important challenge for public policy. Introducing innovation in other agriculture-related areas (e.g. natural resource management or the processing and marketing of agricultural commodities) and in other aspects of agriculture (e.g. water management, the use of native varieties) is also key to agricultural development, but is beyond the scope of this study.

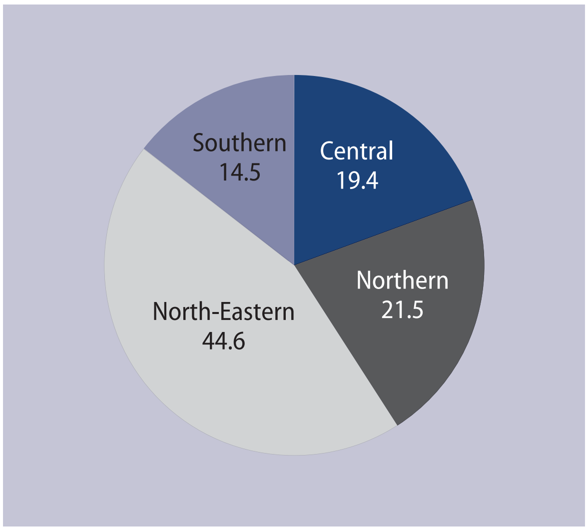
The remainder of the chapter considers two key questions:

- What are the main challenges for STI policy in the context of the existing policy environment?
- How effective is the national agricultural innovation system in supporting innovation at the farm level?

B. OVERVIEW OF AGRICULTURAL PRODUCTION

Around 47.5 per cent of land in Thailand is used for agricultural production. The north-east is the most important agricultural region of the country (figure 3.1).

Figure 3.1 Percentage of total agricultural land by region, 2009

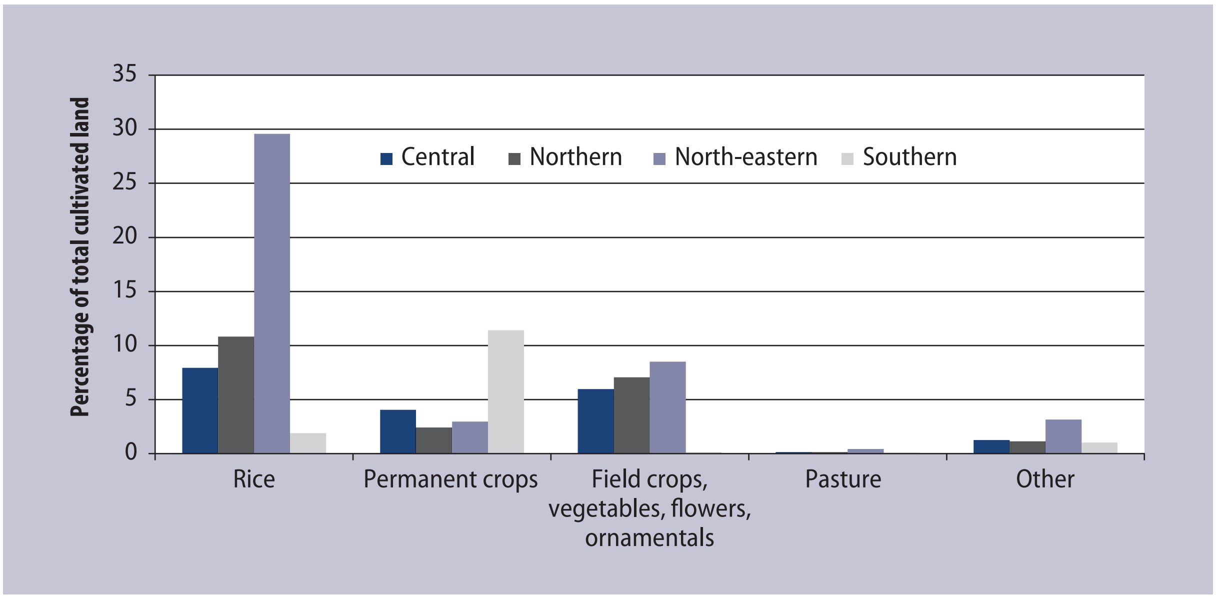


Source: National Statistical Office, 2012.

Thailand has four distinct geographical regions growing different types of crops (figure 3.2), as follows:[10]

- The northern region is mostly high altitude, growing predominantly rice and fruit. In the lowlands, rice is the main crop.
- In the north-east, which is cool and dry, with low fertility, shallow and sandy soils, rice is the main crop, though various other crops are also grown. It has the largest proportion of farmers but also the lowest agricultural productivity and the highest incidence of rural poverty.
- The central region, which has moderate humidity and the most fertile soils, is the historical rice basket of the country, with much irrigated land. In fertile, irrigated areas, two or three rice crops are harvested annually, along with soybeans, peanuts, sweet potatoes and other vegetables. This region has high agricultural productivity but the lowest share of agriculture in its economy.
- The south is humid, but has poor quality soils and insufficient sunlight to provide high crop yields. Rubber is the most important crop, but oil palm, coconut and fruit trees are also grown.

Figure 3.2 Agricultural land use by crop type and region, 2009



Source: NSO, 2012.

The major field crops in Thailand are sugar, cassava, maize, and soybeans. Several other crops are also grown, including sorghum, cotton, tobacco and sweet potato. Permanent crops include, most importantly, rubber, oil palm and fruit trees; coconut and eucalyptus are also grown.

Over half of the country's agricultural land is under rice cultivation. Rice is grown in all the provinces, but the high-value jasmine rice is grown only in the north-east. Rubber, found mainly in the southern region, is the second most important product, in terms of agricultural production value, land use and number of farms. Efforts are under way to expand its production in the north-east. The southern region dominates in oil palm production. Fruit trees are the main permanent crops in the northerly regions. Sugar and cassava are the two most important field crops, grown mainly in the central and north-eastern regions. Cassava is produced mainly for export, but is a potentially important source of ethanol for fuel production. Sugar is grown for food for the domestic and export markets, and is increasingly important as an energy crop. Other crops include maize, vegetables, coffee and chilli peppers.

There are three broad types of farm holdings in Thailand:

- Large corporate farms owned by large private firms, which are engaged in processing their own agricultural commodities. These firms dominate, particularly in shrimps and livestock products for export. There is also one very large firm in the rubber sector.

- Individually-owned medium-sized farms, which are typically engaged in the cultivation of fruit trees, flowers and ornamentals plants.
- Small-scale farms, which grow the bulk of the major crops, including rice, sugar cane, rubber, palm oil and cassava, as well as other crops.

Most agricultural production in Thailand is carried out on small farms. According to data from the National Statistical Office (NSO, 2012), the average farm holding decreased between 1983 and 2008 from 3.52 hectares (22 rai) to 2.37 hectares (14 rai). The majority of smallholders own their own land, and most small-scale farmers also engage in other income-generating activities outside their holdings. In 2003, only 20 per cent of farming households were engaged in full-time farming (NSO, 2003). Farming households in the north-east relied the most on outside sources of income and had the lowest average level of debt. The central region had the highest proportion of full-time farmers, but also the highest average level of debt per household.

Major challenges for small-scale farming

While it is difficult to draw general conclusions about the diverse agro-environmental areas and different agricultural commodities, some major common challenges for small-scale farming in Thailand are evident. Most agricultural areas face both regular water shortages in the dry season and periodic droughts. Only 24 per cent of the total area of agricultural land is irrigated (Perret et al., 2012), but there are significant regional variations. In the north-eastern region, for example, only around 10 per cent of the agricultural area is irrigated (Siripornpipul, 2014). On the other hand, floods present a further threat to agricultural production in many areas. The period 2008–2010 experienced an annual average of six flooding occurrences (NSO, 2012).

There are also problems with soil quality in most areas. Shallow soil and sandy soil are especially problematic for agriculture in the northern and north-eastern regions, and soil salinity is also a significant problem in the north-east. Soil erosion is the most serious problem in terms of land area affected, with the northern region accounting for around 50 per cent of the total 17 million ha affected. A further 16 million ha has inorganic soil, of which more than 12 million ha are in the north-eastern region. Efforts to rehabilitate soil in agricultural areas have had limited success in tackling soil problems on such a large scale (table 3.1).

Table 3.1 Areas of problem soil and average annual rehabilitated areas, 1999–2003

	Total area with problem soils ('000 ha) 2004	Annual rehabilitation (1999–2003 average)
Erosion soil	17 424	83
Inorganic soil	15 792	226
Saline soil	3 472	6
Acid sulfate soil	848	8
Total	**37 536**	**322**

Source: NSO, 2012.

Table 3.2 Average rate of chemical fertilizer application by region, 2003 and 2008

	2003 (Kg/ha)	2008 (Kg/ha)	Growth (Per cent)
Central	356	381	7
Northern	269	294	10
North-eastern	200	219	11
Southern	300	375	25
Total	**263**	**288**	**11**

Source: NSO, 2012.

The use of chemical fertilizers continues to rise, and their imports increased by about 20 per cent over the period 2003–2008, according to MOAC data. Over this period, the total amount of land on which chemical fertilizers were applied grew by 8 per cent across the country, with the northern and southern regions accounting for most of this increase. At the same time, the intensity of chemical fertilizer application grew by 11 per cent overall (table 3.2). The central and southern regions record the most intensive use of chemical fertilizer per hectare.

Chemical fertilizers account for around 97 per cent of the total tonnage of imported chemical inputs for agriculture (around 80 per cent of the total value), with chemical pesticides accounting for the remainder (NSO, 2012). Of the different chemical pesticides used, the increasing use of herbicides is of most concern in terms of their environmental impact and increased costs for farmers. Chemical herbicides are a labour-saving technology (reducing the need for weeding by hand), and, given the prospective labour shortages in agriculture, their use is likely to increase further. Organic agriculture still accounts for only a low percentage of the total agricultural area, and it is increasing only very slowly (e.g. from 0.11 to 0.14 per cent from 2005 to 2009 (FAOSTAT, 2013).

Chemical inputs are often applied inefficiently. In the case of fertilizers, farmers most often purchase ready-blended formulas, which may not be optimal for the soil conditions and crops of their particular farms. A more efficient fertilizer is one that is blended (and applied) according to specific needs, using separately packaged N, P and K fertilizers. Technologies are available to carry out soil analysis at the farm level, and are already used to some extent. However, small-scale farmers have been reluctant to blend their own fertilizers; for small areas of cultivation, the additional labour input, plus the potential extra costs of unused N, P and/or K, does not always bring them adequate returns. Fertilizers have also been underapplied, in an attempt to save costs, or overapplied, either because the recommended dosage is not optimal for the specific local conditions, or in the belief that a larger amount of fertilizer will further increase yields. Chemical pesticides have also been overapplied for similar reasons. Some of these inefficiencies have been facilitated by the falling costs of chemical inputs (in real terms), but also by MOAC's practice of distributing free insecticides to farmers in the event of pest outbreaks.

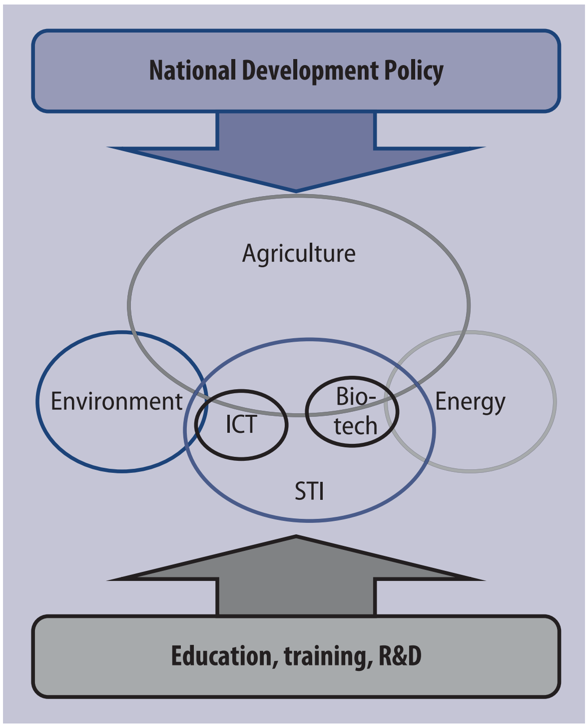
In the face of a labour shortage in agriculture, increased mechanization of farming will be a priority for the development of smallholder agriculture. Demand for agricultural machinery is increasing. One supplier firm, for example, reported that the company's annual sales had risen by an average of 10 per cent annually over the past five years. Some small-scale farms are reported to be fully mechanized, and harvesters are used (owned, or rented out) by most farmers. However, mechanized land preparation and planting is much less common.

In summary, many or most small-scale farmers are working in poor environmental conditions, particularly in terms of poor water availability and soil quality, and global climate change has introduced a high degree of unpredictability for farming operations. The use of imported chemical fertilizers and pesticides is generally high, and they are often applied inefficiently. There is a serious labour shortage and an ageing farming population, and the levels of smallholding mechanization are considered low. Many of the barriers to innovation for small-scale farmers relate to economies of scale. These, together with the difficulties inherent in information and technology diffusion to large numbers of farmers, present policy challenges that differ from those for medium and large-scale farming operations.

C. THE POLICY ENVIRONMENT

The National STI Policy and Plan (2013–2021) highlights a number of agricultural products as priorities for future STI efforts. This policy framework requires further development to translate policy objectives into workable programmes and plans. For this, it is useful to consider STI policy for agriculture, and especially for smallholder agriculture, in the context of the wider policy environment.

Figure 3.3 Key policy areas for agricultural innovation



Source: UNCTAD.

Figure 3.3 presents an overall perspective of the key related policy areas for agricultural innovation,[11] showing the most important relationships between the different areas. The National Development Policy provides the starting point for the development of sectoral policies and action plans. The use of STI for agricultural development in Thailand will depend not only on agricultural policy and/or STI policy, but also on energy policy and environmental policy. Furthermore, successful implementation of policies in these areas must be underpinned by capacity-building through complementary policies in education, training and R&D.[12]

1. National development policy

The current 11th National Economic and Social Development Plan (2012–2016) includes three key objectives for agriculture:

- To empower the agricultural sector to become an efficient production base that can produce food and energy with value, quality and high standards, and remain environmentally sound;
- To improve the quality of life, job security and income in the agricultural sector.
- To promote the participation of farmers and local communities to support food and energy security and be self-reliant.

The Plan also provides numerous and wide-ranging guidelines for the achievement of its objectives. The guidelines often imply the need for one or more ambitious and costly development programmes. Moreover, neither the objectives nor the guidelines for their achievement are prioritized. Therefore, while the Plan reflects a comprehensive awareness of the needs of the sector, the choice of priority objectives and policy measures for implementation is normally made at the ministerial level.

2. Agricultural policy

Government support for farmers since 1961 has largely involved the provision of subsidized credit and direct transfers, rather than interventions in commodity markets (Warr, 2008). Support has included the provision of subsidized planting materials, fertilizers and technical assistance.[13] However, the Government has also intervened in markets in response to large drops in world prices for key Thai agricultural commodities, including sugar, rubber, cassava and rice. Annual price-setting for sugar was introduced after global sugar prices dropped sharply in the 1980s (Oxford Business Group, 2013). Government price support for cassava was introduced in 2011–2012 and continued through 2012–2013. In 2012, the Government introduced a subsidy for rice production through the Rice Pledge scheme, which was continued in 2013.

Pricing systems and subsidies have implications for STI in agriculture, in that they tend to act as disincentives for increasing productivity through investment in innovation. Furthermore, these schemes effectively divert substantial amounts of public resources away from other agricultural development activities.

At the time of the STIP Review team's interviews in October 2013 and June 2014, the only clear policy mechanism to promote fundamental change in the agricultural production system was the plan for crop zoning. It aims not only to promote the cultivation of crops best suited to local agro-environmental conditions, but also to address problems of oversupply (rice) and undersupply (sugar). As the policy has not yet been implemented to any great extent, its impacts cannot be assessed. However, crop-switching inherently implies the discarding of some existing technological capabilities and a need for new learning.

The agriculture sector lacks a clear overall long-term policy and plan for restructuring small-scale farming. The overarching principles of sustainable agriculture and a "sufficiency economy", as highlighted in the national agricultural policy are not sufficient to guide the design and formulation of appropriate plans and policy instruments. Moreover, the set of guidelines for agricultural development in the current five-year National Economic and Social Development Plan are too wide-ranging and ambitious to be tackled across the board. Policies for different areas of agriculture are often drafted at the level of MOAC departments.[14] This has the advantage that policies formulated by key implementing agencies may be better (or at least, more realistically) designed, but the potential disadvantage that policies may favour the status quo over substantive change, which is a common issue with other areas explored in this Review. Moreover, without a clear long-term plan, there is the risk of lack of cohesion, or possibly even contradiction, between different areas of policy. It is unlikely that transformation in agriculture, particularly in respect of small-scale farming, will succeed without a clear articulation of the problems that exist, and a cohesive long-term programme to bring about fundamental change. Such a programme would be likely to incorporate policies that provide incentives for farmers to innovate (such as reducing market price support), create new markets for small producer outputs and increase farm sizes, as well as policies that build and deploy the innovative capacity needed to transform agricultural production.

3. Energy policy

Thailand's 20-year development vision includes an objective to expand energy crops. The Renewable and Alternative Energy Policy Development Plan (2012–2021) gives emphasis to the production of ethanol from sugar cane and cassava, and the production of biodiesel from palm oil. Such production has already been taking place in Thailand for some years, and infrastructure and enabling factors are also in place to facilitate expansion of the domestic markets for these products. The key issues for STI therefore relate to increasing efficiency in manufacturing, and increasing crop production and productivity to ensure a consistent supply of raw materials in a sustainable way.

One report has highlighted a division in the north-east between farmers who are engaged in the cultivation of energy crops for ethanol production, and other farmers whose production is adversely affected by the negative environmental impacts from this (MoI/UNDP/UNEP, 2010). It also finds that ethanol production in the region has resulted in increased pollution of rivers, which has affected inland aquaculture activities. Furthermore, the general principle in Thailand is that food security must take priority over the development of energy crops, as articulated in the current National Economic and Social Development Plan. On the other hand, based on information provided during interviews with stakeholders, there is also a drive to expand the area of agricultural land under energy crop cultivation, particularly in respect of sugar to meet the demand for ethanol.

4. Environmental policy

There are two main long-term broad national environmental policies now in effect that are especially relevant to agricultural development: the National Policy and Prospective Plan for the Enhancement and Conservation of National Environmental Quality 1997–2016 (AECEN, 2004), and the Thailand Climate Change Master Plan 2012–2050, under the Office of Climate Change Coordination in the Ministry of Natural Resources and Environment (MNRE).

In respect of the environmental sustainability of land and water resources, and biodiversity, there are overlapping responsibilities. The National Biodiversity Strategy and Action Plans include the objective, "To conserve agricultural ecosystems in order to minimize deterioration of agro-biodiversity", and are under the mandate of the MNRE. This Ministry's mandate also covers contaminated land. However, responsibility for managing and improving the quality of agricultural land comes under the mandate of the Land Development Department of the MOAC.

Water management is a major issue in agricultural development. Scarcity of water is to a large extent responsible for the low productivity of many crops.[15] For example, in one area in the north-eastern region, the average maximum yield of sugar cane grown under irrigation was estimated to be 125 tonnes/ha, but without irrigation it was 56 tonnes/ha.[16] At the same time, sporadic flooding has resulted in major crop losses in recent years (Supnithadnaporn et al., 2011). The efforts of the MOAC's Royal Irrigation Department to increase the area of agricultural production under irrigation are progressing slowly. In many parts, further progress will depend on long-term initiatives for water capture, storage and management that are currently under way under the Master Plan on Water Resource Management (Strategic Committee for Water Resource Management, 2012). This major long-term Master Plan, which is supported by a detailed policy and plan, considers a number of potential STI solutions,[17] embraces cooperation between ministries, and receives support at the Cabinet level. The Plan is a good example of STI integration into policy planning. Other STI-related policy areas would benefit from a similar approach.

5. STI policies

The National STI Policy and Plan, 2013–2021[18] identifies the principal sectors and areas for priority attention in respect of STI capacity-building in agriculture, including selected key crops and the development of value added from these crops. However, it does not indicate how the policy will be further developed in the area of agriculture, and how it dovetails with the STI aspects of other policies (e.g. agricultural, biotechnology or ICT policies).

Biotechnology policy

The National Biotechnology Policy, approved by the Cabinet in 2004, is an important instrument for guiding knowledge-intensive agricultural research in Thailand. None of its six goals or their associated strategies and priority measures specifically targets agricultural production or small-scale farming.[19] It might be useful in the planning process for the next implementation plan of the policy to review the existing and potential role of biotechnology in applications that are most needed by small-scale farmers. These applications are likely to include, for example, plant-breeding for improved drought, flood and salinity tolerance, and the development of bio-fertilizers and their production (including testing and quality control). Some R&D is already under way in these areas, but R&D efforts need to be coordinated and concentrated on key, well-articulated priorities.

One obvious policy gap is the lack of a national biosafety regime. A draft national biosafety policy for Thailand was produced and submitted to Parliament a few years ago, but has not been passed into law. The debate around genetically modified organisms (GMOs) at the international level in the late 1990s was very controversial and divisive, and Thailand, like other countries, took a cautious wait and see approach to this area of biotechnology. Now, more than 15 years later, more evidence is available about the impact of GMOs,[20] there is a wider range of experiences on how these can be handled, and science has progressed further. Moreover new areas of science (e.g. synthetic biology) have emerged, and it would now be appropriate to review these issues and revise the draft biosafety policy before its resubmission to Parliament.

ICT policy

Thailand's Smart Agriculture programme[21] aims to develop databases and knowledge management systems, including a consolidated national agricultural information system and a system to provide useful data to farmers in specific localities and for specific agricultural products. There are also plans to set up online communities of farmers and others to exchange knowledge and information.

There is some policy cohesion in this area of STI development for agriculture. For instance, MOAC is integrating ICT development into its policies and departmental plans based on the ICT Framework and Master Plan. However, with a development policy that is so ambitious and wide-ranging, some obstacles to implementation are inevitable. At present, human resource development in ICTs is the main hindrance, in general and also in agriculture. Promoting and supporting the use of the Internet and smart phones by farmers and building farmers' competencies in the collection and management of local agricultural and environmental information needs a sustained effort over the long term.

Research policy

National research policy is under the overall mandate of the NRCT. However, within the broad parameters set by it (NRC, 2011), the choice and design of research activities is commonly determined according to priorities set by ministries, research organizations and/or funding bodies. MOAC's own budget funds most of the R&D undertaken by its departments, though each research programme and project has to be approved by the Bureau of the Budget, and funding is approved on an annual basis. MOAC also receives funding from ARDA for the purpose of enhancing research capacity within the Ministry. It is not clear how the whole body of agricultural R&D fits together, or how policymakers ensure that research results benefit end-users of technology, including farmers. It appears that specific problems and the potential solutions that require R&D, are not clearly-articulated and prioritized at a national level. In the absence of a National Agricultural Research System, there is no single institutional mechanism to guide project funding to multiple projects within a cohesive programme of development.[22] As highlighted in chapter 2 (section C.5), a wide review of research policy (not only relating to agriculture) as well as systematic monitoring and impact evaluation of R&D programmes are needed for rationalizing R&D efforts.

6. Strengthening policies to promote innovation in agriculture

The country's long-term vision for food and energy security, and environmentally friendly production depends crucially on the large number of small-scale farmers engaged in the production of rice, sugar and other major crops. Therefore, a long-term perspective and commitment to STI for small-scale agriculture is needed in addition to policy responses for medium- and large-scale farming and for the agro-industry (where overcoming the fewer barriers to technology absorption may enable benefits to be recouped more easily and in the shorter term). Policies targeted at smallholders will often differ from those targeted at large-scale farm undertakings due to their different characteristics, namely the barriers to innovation related to economies of scale, the large number of small-scale farmers and the complexities of diffusing new information and knowledge to them.

The development of STI capabilities involves the design and implementation of long-term plans that require a good understanding of new technological developments, the systemic nature of innovation and the impact of policy implementation so as to make the necessary adjustments. STI policy analysts can contribute to effective policy planning for STI in areas related to agriculture by

- Carrying out, or coordinating, technology assessment and/or foresight exercises;
- Monitoring and evaluating the impacts of R&D activities; and
- Applying an innovation systems approach to the analysis.

It will be important to analyse innovation systems from the perspective of small-scale farming in order to design the appropriate STI policies for the sector.

D. THE AGRICULTURAL INNOVATION SYSTEM

An agricultural innovation system is composed of the actors, institutions, organizations and policies that together support innovation in agriculture, along with the necessary infrastructure and mechanisms (UNCTAD, 2010a). The key stakeholder groups in such a system are farmers, firms (suppliers, distributors, processing firms), R&D organizations, educational institutions, government ministries and other public bodies, and, often, non-governmental organizations (NGOs) and inter-governmental organizations (IGOs). The effectiveness of the innovation system depends on the innovative activities of these stakeholders, but also on the linkages within and between them that facilitate the diffusion of "best-fit" technologies to end-users. This section presents a broad analysis of Thailand's agricultural innovation system from the perspective of small-scale farmers as end-users of technology,[23] but also as innovators themselves.

Small-scale farmers are rarely "forerunner innovators" in the sense of creating novel, commercially applicable technologies, although this occasionally happens, for example where farmers also breed new varieties of crops.[24] However, farmers accumulate a great deal of technological knowledge through years of practical experience, that is, "learning by doing", and use this learning, together with their stock of traditional knowledge,[25] to select, adopt and often adapt new technologies from outside. Access to information (e.g. about new technologies, emerging opportunities in markets, new pest outbreaks) is also important for farmers to enable them to adapt or take up new technologies.

1. Farmers and farmers' organizations

Farmers in Thailand organize themselves into informal and formal groups and cooperative organizations, supported by MOAC. One reason for forming a group is to register for MOAC's extension services. Some groups may also form an enterprise to add value to their produce, for example through processing and packaging activities. MOAC also contracts with groups of farmers to undertake seed multiplication, and they can be extremely important channels for technology diffusion in small-scale agriculture.

Over 6 million farmers are members of agricultural cooperatives,[26] another type of farmers' organization, promoted and overseen for many decades by MOAC. Cooperatives are essentially business units that provide access to credit[27] and other services (e.g. supplying seeds from MOAC, and selecting and ordering fertilizers and pesticides from commercial suppliers) for their members. Some cooperatives own and manage rice mills, and engage in other income-generating activities. Cooperatives are more formally instituted than other types of farmer groups. They have to meet strict criteria to be registered with MOAC, and are audited by that Ministry. The cooperative system was not designed to act as a channel for technology diffusion, though it is an important channel for disseminating information to individual farmers.

As the use of ICTs expands in Thailand, the role of agricultural cooperatives in the diffusion of new knowledge and technology-related information is likely to grow. They are well-placed institutionally to facilitate the collection and collation of local agricultural and agro-environmental data from farmers and to feed it into relevant databanks, as well as to facilitate the use of newly developed applications for farmers. The Department for Promotion of

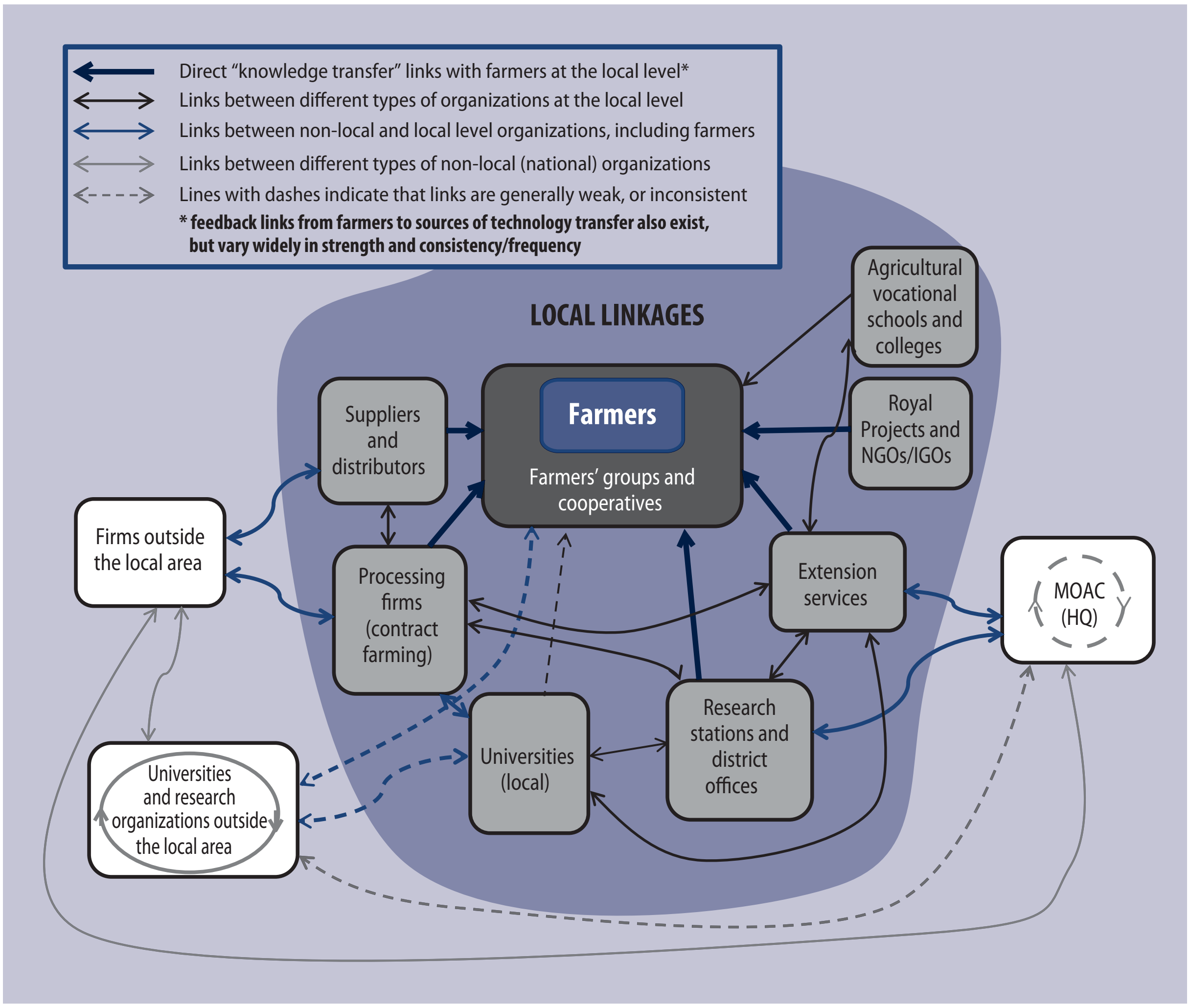
Cooperatives aims to build their capacity to carry out these data management activities, and a pilot model is under development. The Department also launched a strategy in 2013 to improve the business model of cooperatives, designed to, among others, boost their capacity to facilitate market access for their members.

Technology and innovation linkages between farmers at the local level (within *tambons* and districts) are strong. Farmers' groups elect a representative to liaise with technology and information providers, and that person diffuses new knowledge and information to other group members. Farmers also exchange knowledge informally. Some resources, particularly farm machinery, may be shared. However, at present, there are few channels for interaction between farmers in different areas.[28]

2. Major sources of new knowledge and information for small-scale farmers

Figure 3.4 presents a schematic view of a local agricultural innovation system in Thailand, showing farmers' direct links with various sources of technology at the local and national levels. The technological capacity of the different sources and their linkages are assessed in this section.

Figure 3.4 Farmers' linkages within the agricultural innovation system



Source: UNCTAD.
Note: For the sake of clarity, the figure simplifies what is, in reality, a more complex picture. In particular, it should be noted that the unidirectional arrows from sources of technology to farmers is not intended to indicate that farmers are merely passive recipients; in most cases, there is a two-way interaction between farmers and the other stakeholder groups.

The Ministry of Agriculture and Cooperatives

In Thailand, MOAC has historically been the most important source of new knowledge for farmers. It has specialized departments (for rice, rubber, other crop agriculture, silviculture, fisheries, land development and irrigation) that undertake research, development and diffusion (RD&D) activities. Crop-breeding for the country's major crops is also undertaken mainly by MOAC.[29]

The Department of Agriculture (DOA) carries out R&D and technology transfer activities for crops other than rice, offers testing and advisory services, is in charge of enforcing several regulations on safety and quality standards, administers Thailand's Plant Breeders' Rights regime and is responsible for the expansion of farm mechanization. The Land Development Department (LDD) is responsible for improving and maintaining the quality of agricultural land. MOAC's Royal Irrigation Department is an engineering department tasked with expanding the area of agricultural land under irrigation. Some MOAC departments have local representation in some agricultural areas in the form of local offices and/or research stations and seed multiplication facilities. The Department of Rice, for example, has 27 rice research centres and 23 rice seed centres. LDD also has field offices across the four agricultural regions, and has built up a large network of around 55,000 volunteer farmers (soil doctors) to carry out soil testing at the farm level. In addition, MOAC has a central department of agricultural extension and a countrywide network of extension offices. All *tambons* in agricultural areas have an extension office, and in some, the office is the farmers' sole link with MOAC.

Agricultural extension services, often considered outdated, are still important channels of knowledge diffusion to farmers in Thailand. At the local level, extension officers typically maintain informal linkages with relevant firms, university departments, agricultural colleges, and, where these are nearby, the local offices of other MOAC departments. The extension officers undertake testing and carry out demonstrations for farmers, and they also organize training courses on specific topics (such as customizing fertilizers) at the *tambon* level, in collaboration with staff from local universities and agricultural colleges. However, farmers do not seem to be using the extension services as much as before,[30] partly because they obtain information and knowledge through various other channels (e.g. mass media[31]). Furthermore, links between the Department of Agricultural Extension Services (DAES) and other departments at MOAC headquarters seem to be weakening. When DAES was set up as a separate department, new technologies developed for farmers by all other departments were supposed to be channelled through DAES. However, some departments are now working directly with farmers. A common view is that extension officers generally do not have sufficient technical expertise to diffuse specialist knowledge from all the different MOAC departments. At the same time, extension officers are concerned they have little to offer, as they are not receiving sufficient new knowledge from R&D activities at the Ministry's central offices. In addition, in some cases links to feed information and knowledge from farmers in local areas back to MOAC headquarters are weak. The use of ICTS by extension officers to connect to headquarters and to extension officers in other areas may help ameliorate this situation. E-learning has already been instituted for sub-district agents, and DAES has applications on mobiles. MOAC is actively developing and expanding its use of ICTs for exchange of information and knowledge. The development of applications for farmers' direct use is constrained at this time by the relatively low level of ICT use by farmers.[32]

MOAC has a policy on smart farms, and collaborates both at the national and local levels with the Smart Farm programme of the National Electronics and Computer Technology Center (NECTEC). However, as noted by an existing collaborator, where ministerial departments are involved, funding commitment for multi-year projects is a problem, as the ministries' project funding is approved on an annual basis by the Bureau of the Budget. When several ministries, such as MOST, Ministry of ICT (MICT) and MOAC, collaborate on a 2–3 year programme, they have to align their research activities to fit budget schedules. MOAC's activities are largely funded through the Ministry's regular budget. In addition, ARDA, which is administratively part of MOAC but operates as an autonomous funding agency, allocates 30 per cent of its annual budget to MOAC for the purpose of increasing the Ministry's research capacity (table 2.5). Some of MOAC's RD&D activities also receive technical support and other non-financial resources from international organizations. Overall, MOAC's resources are extremely stretched, given its remit. MOAC also has problems in recruiting new staff with appropriate qualifications owing to an inadequate supply of graduates in agricultural subjects.

Public sector research institutions

Outside MOAC, a number of public sector research organizations are engaged in agricultural or agriculture-related R&D activities, including NSTDA (particularly BIOTEC and NECTEC), TISTR, HAII and GISTDA.

The agricultural R&D of NSTDA and its institutes covers the whole range of the R&D continuum, from basic/strategic research (e.g. in genomics) to the development and commercialization of products. Numerous activities relate directly to farm-level innovation, including R&D on flood, drought and saline-resistant rice varieties, R&D to breed higher yielding varieties of energy crops such as oil palm and jatropha, R&D on seed improvement technology and NECTEC's Smart Farm project.

The extent of linkages between projects and small-scale farmers depends primarily on the type of R&D undertaken. NSTDA's Food and Agriculture Cluster focuses on food safety and standards, which has less direct relevance for small-scale farmers.[33] Much of BIOTEC's R&D that is directly relevant to farmers is pre-development research. Some researchers work with farmers on field trials, but other types of linkages, such as farmers' inputs into problem formulation early in the research design, are rare. Projects are not routinely evaluated or monitored for their impacts on farmers.

NECTEC's Smart Farm project is a large-scale, long-term initiative that involves hundreds of in-house researchers who collaborate extensively with other agencies (including MOAC's departments) across the country. The project's rate of progress is constrained by the extent and rate of ICT infrastructure expansion, and the take-up of ICT technologies by farmers, as well as farmers' varying abilities to use and manage the data effectively.[34] NECTEC has been working with farmers' associations at three learning sites to build capacity at the local level for data collection and management. Building trust and eliciting local tacit knowledge to incorporate into the data has required several years. This suggests that rolling out the Smart Farm project, even once the ICT infrastructure is in place, is likely to take some time and require significant resources. Policy should ensure that current or future institutional structures at the district and *tambon* levels are sufficient to facilitate this rolling out, that appropriate resources are allocated, and that targets are set and reviewed periodically.

GISTDA is using remote sensing (particularly satellites) and geographic information systems (GIS) to produce data and high-resolution images that can be used to monitor the condition of agricultural land (at the surface), identify what is grown in specific areas and make forecasts about harvesting schedules. It also carries out R&D to develop user applications for the data gathered, targeting use by government agencies (national and local) rather than small-scale farmers; but there is potential for developing products for large groups of farmers, such as farmers' cooperatives. GISTDA has also developed a demonstration system for an Agricultural geographic information portal to allow different types of data (e.g. on soil, water and land titles) to be shared amongst different public agencies. It does not collaborate on the Smart Farm project,[35] but closer links are likely to be fostered in the near future.[36] It also has informal links with HAII.

HAII has integrated datasets on water from five agencies into a data warehouse, and developed the data to be used in a flood warning system. Data management activities continue, but the institute is now also developing community water management systems. These water projects have had direct impacts on local small-scale farmers, allowing more effective planning of farm activities and enabling crop diversification. Around 200 villages are part of the programme, and more than 50 have developed capabilities to expand their own water distribution networks.

There is a certain degree of overlap in the objectives and areas of activity of TISTR and NSTDA, both of which aim to commercialize the outcomes from R&D in the areas of renewable energy, food and bio-products. TISTR carries out research on bio-fertilizers and bio-pesticides, but no products have been commercialized so far. TISTR is based on the outskirts of Bangkok and has research stations in the north-eastern region.

All the key research organizations are located around Bangkok, far from most of the small-scale farming areas (with the exception of TISTR research stations). Some researchers work directly with local communities and farmers' groups, but it may take several years to build an effective understanding between researchers and farmers. Some university researchers have links with local university researchers, either informally (e.g. with former students, classmates or colleagues) or as part of formal research projects, and some maintain links with local MOAC offices and researchers, but the effectiveness of these linkages is unclear.

University R&D

Thailand has an important specialized agricultural university (Kasetsart University), whose main campus is located on the outskirts of Bangkok. In addition, each agricultural region has at least one national research university, where agricultural R&D with a more regional-specific focus is undertaken. The following are some general observations: [37]

- The extent and nature of linkages with smallholder farmers depends on the nature of the R&D, and perhaps also on the approach to R&D of individual research leaders (who may have few incentives to work closely with farmers).
- R&D activities are carried out as relatively short-term, discrete projects where the expected outcomes are often articles for scholarly journals, and/or (increasingly) applications for IPRs. These two outcomes are the most important key performance indicators for academic research and for researchers' careers but do not benefit farmers or agricultural innovation directly.
- Project design is most often determined by researchers, and is rarely demand-driven, in the sense of potential end-users of the results requesting or commissioning the research. Moreover, the research is not necessarily part of a wider programme of R&D that is intended to lead to the diffusion of innovations.
- Projects may be carried out with funding allocated at the university level, or with project grants from funding agencies such as ARDA, NSTDA and TRF, but these organizations do not monitor the projects' impacts after completion.

As discussed in chapter 2, these issues are not specific to agricultural R&D.

Private sector firms

Various kinds of technology and information are provided to small-scale farmers by the following types of firms:

- Suppliers and distributors of agricultural technology products (e.g. seeds, fertilizers, pesticides and agricultural machinery);
- Processing firms, some of which are also engaged in cultivation, either on corporate farms or through contracting arrangements with small-scale farmers; and
- Distributors of agricultural commodities to domestic and international markets.

Seeds, other than those supplied by MOAC, and also chemical inputs are mostly imported. These are turnkey technologies,[38] not designed specifically for Thai farming. Knowledge about the use of seeds and chemical inputs in Thai agro-environmental conditions – and not only access to them – is important for innovation at the farm level. Extension services are important in this respect, together with subsequent farmer experience and experimentation.[39]

Agricultural machinery firms include distributors of imported equipment, manufacturers and firms that are both distributors and manufacturers. Large equipment (e.g. combine harvesters) is imported. Some agricultural experts have noted that much of the imported farm machinery now in use is overspecified for small-scale agriculture, and, while local firms can develop more basic/appropriate technologies, these firms face difficulties entering the market.

Processing firms include large firms and SMEs.[40] Where large processing firms contract small-scale farmers to cultivate agricultural commodities, the firms act as important sources of production technology. Where this is not the case, the relationship between firms and farmers is often limited, but may involve the diffusion of information and new knowledge about quality standards. The contracting firms that participated in this Review are engaged in sugar production and processing. They have their own R&D departments, and company extension officers work closely with the farmers to transfer new knowledge and information. Links are also maintained with their local universities and with Kasetsart University, as well as with MOAC's local extension services and research stations. The firms[41] also supply fertilizers and pesticides to their contracted farmers, and act as guarantors for low-interest credit from the Bank for Agriculture and Agricultural Cooperatives so that farmers can acquire farm machinery or make farm improvements (e.g. pond installation).

Many farmers sell raw products to agents at the farm gate. For others, their cooperative acts as an agent (and, sometimes, as a processor (e.g. rice milling)). Where farmers' groups undertake some processing at the local level and sell value-added products through distributors or directly to wholesalers and retailers, this is likely to lead to an exchange of information that is useful to support farmer innovation.

Farmers and farmers' groups' interactions with firms, even if limited to the purchase of commercially available seeds, or equipment and/or the sale of farmers' produce, are important. For example, through these local linkages, suppliers of agricultural technologies receive information about farmers' needs and feedback on the performance of their technology, which are useful for future corporate R&D. For instance, the R&D department of a large agricultural engineering firm interviewed for this Review has a special interdisciplinary research team to understand the production process at the level of farm production. This unit has links with MOAC departments, including the extension services department, agricultural vocational colleges, and grower firms and growers' associations.

Overall, private firms have effective technology transfer linkages with farmers at the local level, and links with national and/or international sources of technology. Large private firms sometimes carry out R&D activities in the agricultural regions in which they operate, and usually maintain informal links with MOAC extension offices and research stations, and with university researchers. No evidence of formal research links between private firms and public sector research institutions was found at the local level.

At the national level, large-scale processing firms largely rely on their own R&D departments, although collaboration with public sector researchers is becoming more common, particularly in respect of food safety and quality, which has less direct relevance for farmers.

Local development projects: Royal projects, NGOs and IGOs

A wide range of development activities take place at the level of local communities, instigated and coordinated by various local, national and international actors.

Royal Projects are community-based development projects undertaken under the patronage of His Majesty King Bhumibol Adulyadej. These projects focus on environmentally sound technologies for small-scale agriculture and on the improvement of livelihoods, and have benefited, and often transformed, many local communities. Their outcomes are well documented and the lessons learned have been taken up by others. For example, MOAC has adopted the New Theory on Managing Agricultural Land and the use of vetiver grass to prevent soil erosion.

Many projects implemented by NGOs and IGOs are reported to have a significant impact in building technological capacity at the farm level. Some projects have introduced new types of crops to farmers, engaged farmers in research and/or helped local communities develop new value-added products from agriculture. Usually, the projects aim to promote sustainable livelihoods in specific communities. And while these could provide more widely applicable lessons for future development projects, many have no further plans to extend the impact outside the original communities involved. A more detailed assessment of the existing and potential contributions of these projects to local and national agricultural innovation systems could provide recommendations on how their learning and impact may be multiplied.

Educational institutions

A system of agricultural vocational schools and colleges has been established for many decades. However, these institutions are now finding it difficult to recruit students. Potential students, or their parents, are not attracted to careers in agriculture. There are also obstacles to progression to university education for graduates of vocational schools.[42] Besides, in these more scientifically and technologically complex times, agricultural extension officers are expected to be educated to at least degree level.

Agricultural schools and colleges are still linked with small-scale farming, as some students become farmers themselves, and agricultural colleges carry out, or participate in, demonstration activities for farmers in their local areas. However, it is unclear how well linked the schools are to new sources of knowledge, especially in respect of teaching staff. Other teaching approaches and focuses also require consideration. For example, the younger generation may find training in entrepreneurial farming (i.e. training in entrepreneurial, in addition to agricultural, skills) more relevant and attractive.

University departments specializing in agricultural subjects are also finding it increasingly difficult to recruit students and lecturers – a particularly acute problem as many of the latter will retire within a few years. High-quality agricultural education is provided at Kasetsart University and at most of the other national research universities, as well as at more teaching-focused universities across the regions. However, those interviewed by the STIP Review team emphasized the need for upgrading the skills of researchers on modern techniques and to encourage multidisciplinary approaches (i.e. developing farmers' skills beyond only agricultural skills). There are particular concerns that too few agricultural researchers are being produced to meet the country's future needs.

Summary of linkages and knowledge flows in agricultural innovation

Within local areas of agricultural production, there is a relatively effective informal innovation system, with significant information flows and knowledge transfer between farmers, farmer groups, MOAC local representatives and research stations, and firms. However, direct links between farmers/farmers' organizations and university researchers seem to be weaker.

At the national level, many agricultural institutions and activities are concentrated around Bangkok, where organizations collaborate formally, if at all. Despite the physical proximity between MOAC's central research departments and Kasetsart University, linkages between them seem to be weak. Some public sector researchers around Bangkok link directly with farmers or local researchers because this is required for project funding or they have personal contacts. However, many activities seem to bypass local researchers and extension services. As in other sectors, there is limited formal collaboration between industry and research institutions.

3. Key issues for policy

Three main, related findings from this study arise for policy in respect of agricultural innovation.

The first is that, in the absence of a formally constituted national agricultural research system, there is no central policy or institutional mechanism to direct, support and ensure the effectiveness and cohesion of R&D (or, RD&D) activities in Thailand. Within a broad set of parameters laid out in the National Economic and Social Development Plan and the areas of application prioritized by the National Research Council, it seems that research departments within MOAC and other relevant ministries, R&D institutions and university researchers are generally acting independently. Moreover, there are few controls in place to evaluate or monitor the impacts of R&D results on end-users, and particularly on small-scale farmers. As a result, R&D efforts cover many disparate areas, with limited opportunities to build synergies and strategically address complex problems and development objectives. For public funding for agricultural R&D to be used more efficiently, clearer overall guidance on priority needs and specific research questions is needed, based on well-articulated long-term objectives for agricultural development. Further, stricter proposal criteria and evaluation and monitoring mechanisms should be designed to ensure that R&D activities are more demand-oriented and result in real benefits for smallholders.

Second, activities to support and promote innovation in agriculture should be better linked to long-term planning, and should build an effective enabling environment for STI activities at the farm level. This may include institutional innovations at the local level to address the problems related to small farm sizes. One example of this type of long-term planning for structural change in agriculture is the case of Japan's 1999 New Basic Law on Agriculture, which is implemented by means of a Basic Plan for Food, Agriculture and Rural Areas (OECD, 2009).[42]

Finally, there is a concentration of STI resources in and around the capital, and a lack of effective channels for the diffusion of benefits from STI resources to small-scale farmers in the regions, and, in the reverse direction, for feeding planners and researchers with information on farmers' needs, technological learning and experiences. At the local level, the system of linkages works relatively well.

E. RECOMMENDATIONS

Based on these three key issues, this review makes a number of recommendations. Several other important issues require detailed investigation before other appropriate policy recommendations can be made.

1. Policy recommendations

Articulate an "innovation roadmap" for transformation of the agriculture sector

The "innovation roadmap" should address the four major long-term agricultural challenges: land fragmentation, inadequate water supply and management, poor and deteriorating soil quality and lack of human resources. STI, including institutional innovation, are crucial to tackling these challenges. The current medium- to long-term vision needs to be more clearly articulated in order to guide innovation policy planning, direct STI resources more efficiently and stimulate new interest in the sector.

The roadmap should be supported at the highest level of government, and pay special attention to the needs of small-scale farmers.

A long-term soil improvement strategy

The future viability of the agricultural sector, however restructured, is likely to depend to a significant extent on improved environmental conditions, particularly water and soil. Despite the efforts of MOAC's Land Development Department (LDD) to rehabilitate problem soil, soil quality remains a major constraint on productivity, and more support is needed for the achievement of LDD's objectives. A cross-sectoral long-term programme for water management already exists, and a similar approach should be taken to develop and implement a long-term strategy for soil improvement. A combination of a wide range of technologies – both low-tech (e.g. production and application of green manure, cultivation of vetiver grass) and high-tech (e.g. GPS and nanosensors for soil analysis) – may be appropriate, and research and academic institutions could support the LDD in carrying out technology assessments. At the same time, the problem of the increasing use of chemical inputs, particularly fertilizers, should be addressed, either as part of planning for soil improvement, or as part of a separate policy planning activity.

A national biosafety regime

The lack of appropriate biosafety regulations at the national level constrains the useful development and deployment of biotechnology in key areas such as health and agriculture, and in some areas it may act as a disincentive to inward investment. At present, R&D on GMOs is allowed, but their release is prohibited. A forum on biosafety has already been proposed, and this should be followed through as a first step in the potential revision and re-submission of a new set of biosafety guidelines for Parliament's consideration. Wide stakeholder participation will be critical to the success of a new biosafety regime, but the different levels of understanding of the science between different stakeholder groups may present difficulties. Therefore, this forum should be convened, at least initially, as a series of meetings and/or seminars, to allow different stakeholder groups to engage and familiarize themselves with this topic at an appropriate level.

2. Policy research needs

To inform the design of STI programmes and policies, further research is required on the following.

Raising awareness and engagement in STI at the provincial, district and *tambon* levels.

The STIP Review team was unable to carry out a wide survey of STI awareness and policy activities at the provincial, district or sub-district levels. However, stakeholders noted that the authorities at these levels usually have a weak understanding of STI, in general, and of the potential role of STI in agricultural development, in particular. As a result, the public resources allocated to local agricultural needs are likely to be inadequate. It is therefore recommended that the NSTIPO undertake further research on this topic, perhaps from a more general STI perspective than simply STI in agriculture.

Local focal points for major national STI-related programmes

MOAC has an established structure of local focal points for its activities, including in extension services, local offices of different MOAC departments, research stations and agricultural cooperatives. Other programmes related to agriculture (e.g. water management, ICT) also engage with stakeholders at the local level. It was beyond the scope of this study to determine the nature of these relationships – who is involved, and whether the links are formal or informal – or their role in ensuring the success of the programmes. NSTIPO should collaborate with NECTEC, and the Ministries of ICT, and Natural Resources and the Environment, as well as other appropriate programme coordinators, to identify, collate, analyse and disseminate examples of best practice in establishing local links to improve the participation of farmers, and enhance knowledge and information flows between producers and users of various technologies.

Agricultural extension

It might be an appropriate time for MOAC to review its provision of agricultural extension, which is seen as an outdated model of technology transfer, especially in the light of new opportunities afforded by the use of ICTs. It is therefore recommended that MOAC set up an internal dialogue between relevant departments to identify the major barriers to effective technology diffusion and consider alternative solutions. The views of different local communities regarding the utility and impact of extension services should also be collected to inform that dialogue.

Evaluation and monitoring of agricultural R&D undertaken outside MOAC

A significant amount of publicly funded agricultural R&D is undertaken in other public sector research institutions and universities. Demand-driven R&D has had some success at the downstream end of the agricultural supply chain (e.g. research collaboration with firms engaged in food production), but at the upstream end, the "science push" linear model of innovation persists.

Moreover, evaluation of R&D is still most commonly based on the number of journal articles published and IPRs. The utility of such R&D activities in terms of supporting agricultural development, and farmers in particular, is likely to be limited. The promotion of R&D activities that support agricultural development, and in particular small-scale farmers, should be a priority in the further development of STI policy. It is therefore recommended that the following studies be carried out, either by the STI Policy Office or by an independent organization, with the collaboration of ARDA and other funding bodies:

- A survey of past project proposals and final reports on publicly funded agricultural R&D projects to identify the nature of their final outputs and their impacts;
- A related survey of R&D project leaders to establish the original impetus for each project, i.e. who decided that the specified R&D should be undertaken, and on what basis; and
- A survey of university-held patents and other types of IPR, to determine to what extent they have facilitated innovation.

Results and analyses from these studies might usefully be collated and distributed for further discussion among government funding bodies.

The above recommendations propose a number of areas in which STI efforts could further contribute to increasing productivity in small-scale agriculture. The contribution of STI will largely depend on addressing a number of strategic areas also identified in the general assessment of the national innovation system (chapter 2), including: (i) realizing the need for fundamental change in the agriculture sector; (ii) mobilizing national leaders around common goals (which requires a clear, long-term agricultural policy to address four key challenges); (iii) jointly realizing economic, social and environmental objectives; (iv) strengthening governance and management of STI in agriculture (including the adoption by consensus of a national biosafety regime); (v) improving resource management through the independent monitoring and evaluation of agricultural R&D, training and extension programmes, particularly their impacts on farmers; and (vi) further linking agricultural innovation actors – particularly central offices and local players, as well as MOAC central research departments and other public research organizations, including through the strengthening of extension services and ICT use.

NOTES

1 By 1980, over 70 per cent of the labour force was employed in agriculture.

2 Over the period 1980–2009, agriculture's output share declined at an average annual rate of 2.31 per cent, compared with an average annual decline of 1.76 per cent in its employment share (Briones and Felipe, 2013).

3 Bosworth (2005) attributes Thailand's low labour productivity in agriculture to underemployment, as the sector has an underemployed reserve of seasonal and unpaid family labour and the majority of farmers work only part-time in agriculture.

4 Nearly half of the population living in poverty can be found in the north-east region, with most of the remainder in the border mountain provinces in the northern region, and in the four southernmost provinces (FAO, 2011).

5 Particularly since the 2011 floods, which damaged over 2 million hectares of land under crop cultivation – mostly rice – with adverse impacts on 1,280,000 farming households (Supnithadnaporn et al., 2011)

6 For example, the study predicted that, under a particular scenario of the Intergovernmental Panel on Climate Change (IPCC), cassava production would be severely affected but productivity of rain-fed rice and sugar cane might actually see increase (Tangwisutijit, 2010).

7 Interview with ARDA officials.

8 For example, Thailand lost its status as the world's top rice exporter in 2012 –2013, due to government stockpiling of rice. India and Viet Nam both gained ground in export shares as a result. Moreover, average yields of paddy rice per hectare in China, India, Indonesia, and Viet Nam are all higher than in Thailand (World Bank, 2012a), although it should be noted that Thailand's high-value jasmine rice is inherently low-yielding.

9 Including agricultural, environmental, energy and STI policies.

10 This section draws on Chainuvati and Athipanan, 2001 and Leturque and Wiggins, 2011.

11 Some other important related areas, such as industrial policy, have been omitted in order to avoid overcomplexity.

12 National policies for human resource development are discussed in chapter 4.

13 Previously, support policies included the provision of credit and subsidies to farmers to facilitate wider use of fertilizers, but at present, government support is limited to credit provision through the Bank for Agriculture and Agricultural Cooperatives (Poapongsakorn and Aroonkong, 2013).

14 For example, the rice and fertilizer policies.

15 A recent paper on agriculture in Thailand identified the limited extent of irrigation as one of the major causes of low productivity (Yoovatana, 2013).

16 Data provided by a large firm based on the yields from their own contracted farmers in the same area. It is reasonable to assume that other factors (e.g. more fertile soils) did not vary sufficiently to account for the large difference in yield.

17 Including engineering projects, for example for dam rehabilitation, groundwater drilling and construction of pumping stations; remote sensing, GIS and database development and management of early flood warning systems; and R&D, for example to better understand the natural mechanism through which saline soil is formed (Siripornpipul, 2014).

18 See annex 2 (only an executive summary of the policy document is available in English.

19 Though biotechnology R&D that is relevant to small-scale agriculture is certainly undertaken in universities and in BIOTEC.

20 The evidence shows both positive and negative findings (see, for example, Gilbert, 2013), but some uncertainties have at least been resolved sufficiently for informed decision-making. The World Health Organization and FAO provide guidance on genetically modified (GM) foods (see, for example, WHO, 2014). The Codex Alimentarius Commission (Codex) developed principles for human health risk analysis of GM foods in 2003.

21 Which is guided by the Thailand Information and Communication Technology Policy Framework (2011–2020)

22 That is, where several different R&D activities are needed to dovetail with each other (for example, where the results from one project are needed in order to carry out a second, related project) or to address a specific application or objective.

23 Technologies for farmers consist of hard technologies (agricultural machinery, seeds and other planting materials, fertilizers and pesticides), and also soft technologies/techniques (systems of intercropping, fertilizer application and planting methods).

24 One Thai example is that of a small-scale farmer who has developed two new varieties of glutinous rice (Chinvarakorn, 2010).

25 Traditional knowledge in respect of farming is tacit knowledge that has been accumulated by, and passed down through, previous generations of farmers/country dwellers.

26 In 2012, there were 3,768 agricultural cooperatives, with an average membership of 1,652 farmers.

27 The cooperative takes out the loan from the Bank for Agriculture and Agricultural Cooperatives, and uses it to supply credit to its members.

28 A National Farmers Union was set up by an Act of Parliament in 2010, but it has only around 80,000 members to date.

29 In the past, MOAC also supported the development and growth of Thailand's seed industry, which imports seeds for a wide variety of minor crops grown in the country.

30 According to comments made during field interviews in June 2014.

31 Mass media, even if not included as a stakeholder in this study, can often be very effective channels for diffusion of knowledge and information relevant to farmers. In fact, the Bank for Agriculture and Agricultural Cooperatives produces TV programmes for farmers. However, many rural areas in the regions lack TV or radio transmissions: the central region is the only agricultural region with good coverage (as reported during interviews in June 2014).

32 A cooperative based in an area with relatively good connectivity estimated that about 70 per cent of its members have mobile phones but only 30 per cent have smart phones. In the regions, only about 20 per cent of the population uses the Internet (chapter 1).

33 The current focus, is on meeting safety and quality standards for food exports, is less relevant for most small-scale farmers as they mostly sell to the domestic market. As domestic standards continue to be strengthened, for example to include good agricultural practices and traceability criteria, these may become a significant barrier to market access for small-scale farmers.

34 The development and content of the "apps." is reported not to be problematic.

35 At least until June 2014.

36 The Director of GISTDA has recently been appointed to the Executive Board of NECTEC.

37 Time constraints prevented a broader survey of agricultural R&D activities carried out in universities, but a number of general observations could be drawn from the interviews held in October 2013 and June 2014.

38 Turnkey technologies are those developed to be sold, ready-to-use, to any buyer, as opposed to customized technologies that have been developed to respond to specific needs or technologies and may be customized further after delivery.

39 Sriboonchitta and Wiboonpongse (2008) found that information about fertilizers and other chemical inputs was the single most important knowledge requirement cited by their sample of small-scale farmers.

40 Processing SMEs were not surveyed as part of this review.

41 These firms are keen for farmers to increase productivity, as security of supply of raw sugar for processing is an issue across the country, but one firm noted that the current pricing system acts as a disincentive for farmers in this respect.

42 Under the present system, students may progress to advanced vocational education to gain a vocational degree (three-year programme) or vocational diploma (two-year programme). Holders of a vocational diploma need to undertake a further two-year course of study at a university in order to gain an academic degree. Progression from a vocational school directly to university is not possible.

43 In recent years, the Basic Plan has emphasized the need to increase farm sizes by introducing the concept of "core farmers" who will drive agricultural transformation in Japan. Core farmers include certified farmers and community-based farming cooperatives that have, or are able to, consolidate small farm holdings into large business farms (OECD, 2009).

IV

Enhancing the availability and quality of human resources in STI

To support its aim to transform its economy into an innovation-based one and escape the middle-income trap, Thailand needs to enlarge its human resource base for STI activities and ensure that the level and range of skills adequately respond to the country's needs. There is growing demand for STI-related human resources, from vocational to doctorate levels, and certain technical skills and entrepreneurial competences are particularly scarce. Raising the quality of its STI training and education has become a major challenge for unleashing Thailand's potential.

This chapter examines the extent to which the existing training and education systems provide the STI skills that industry, academia and the Thai economy at large require, and suggests a number of policies and concrete actions to be considered by policymakers, educational institutions and industry. Most of the key concerns for STI-related human resources development (HRD) highlighted here are closely linked to broader national educational issues, which deserve in-depth examinations, but are beyond the scope of this study.

A. THE CONTEXT OF STI-RELATED HUMAN RESOURCE DEVELOPMENT

Human resources in STI are essential inputs for the development and diffusion of knowledge and for the formation of an indigenous capacity for innovation. This analysis covers the development of human resources in STI needed for an innovation-driven economy. Thus, it encompasses the development of competencies in scientific and technological areas (natural sciences, engineering and technology, medical sciences, agricultural sciences and social sciences) as well as of entrepreneurial, managerial and innovation skills.[1] It considers training and education at the technical and vocational levels as well as at the higher education levels, along with skills development in the workplace. It also considers additional mechanisms beyond education and training systems that contribute to the development of STI skills, including those that providing learning opportunities, interaction between teaching/research institutions and the private sector (e.g. mobility of teachers and researchers), the contribution of TNCs to the development of technological capabilities in domestic firms and to training, as well as the opportunities provided by international and regional collaboration and mobility.

1. Key education trends

Thailand has experienced a steady and substantial increase in student participation at all educational levels as a result of explicit public policies (World Bank, 2009; Mounier and Tangchuang, 2010). In 2012, there were 1 million students enrolled in vocational education and 2.2 million in higher education. Gross enrolment ratios have substantially increased in the last decade (2001–2012), from 63 per cent to 87 per cent in secondary education and from 39 per cent to 51 per cent in tertiary education.[2] Tertiary enrolments exceed the expected level for Thailand's per capita income (World Bank, 2012b). Public educational institutions are the main providers of education (table 4.1).

Table 4.1 Number of institutions, teachers and students at each educational level, 2012

	Institutions			Teachers			Students		
Education level	Total	Per cent of public	Per cent in Bangkok	Total	Per cent of public	Per cent in Bangkok	Total	Per cent of public	Per cent in Bangkok
Basic/general education	34 378	90.7	2.5	506 598	79.1	7.4	9 120 556	80.5	7.0
Vocational	874	48.2	12.1	43 476	58.1	13.4	1 007 468	65.6	13.4
Higher education	150	52.7	30.7	58 694	82.3	41.7	2 196 859	88.0	44.6

Source: Ministry of Education, 2012.

Public expenditure on education has more than doubled in the past decade to 493,892 million baht ($15 billion) in 2013, and remains a stable 3.9 per cent of GDP (Ministry of Education, 2012). However, its share in the national budget fell from 25.3 to 20.6 per cent during the period 1999–2013 (Ministry of Education, 2012). Over 90 per cent of the education budget has been allocated to personnel and other recurrent expenditures, whereas the proportion of investment expenditure has declined over the past five years, and was only 7.4 per cent of that budget in 2013 (Ministry of Education, 2012).

While Thailand's educational policies and investments have resulted in much greater access to education, there needs to be considerable improvement in learning performance. School-age children, on average, display unsatisfactory performance in analytical and synthesizing abilities as well as in critical and creative thinking (Ministry of Education, 2012). The results of international assessments, such as PISA[3] and TIMSS,[4] indicate that the average Thai student's performance in basic education is relatively poor. For instance, in 2012, the PISA mean scores for Thailand in mathematics, reading and science were well below the OECD average, and half of Thai students were low performers in mathematics – below level 2 (table 4.2; OECD, 2014a). In addition, there is disparity in learning achievement between Bangkok and areas outside Bangkok, which is attributable to differences in the quality of education children receive, and not just to their socio-economic background (World Bank, 2011).

Table 4.2 PISA results of student performance in mathematics, reading and science, selected Asian countries, 2012

	Mathematics				Reading		Science	
	Mean PISA score	Share of low achievers in mathematics (< Level 2) (Per cent)	Share of top performers in mathematics (Level 5 or 6) (Per cent)	Annualized change in score points	Mean PISA score	Annualized change in score points	Mean PISA score	Annualized change in score points
OECD average	494	23.0	12.6	-0.3	496	0.3	501	0.5
Shanghai-China	613	3.8	55.4	4.2	570	4.6	580	1.8
Singapore	573	8.3	40.0	3.8	542	5.4	551	3.3
Rep. of Korea	554	9.1	30.9	1.1	536	0.9	538	2.6
Viet Nam	511	14.2	13.3	m	508	m	528	m
Thailand	**427**	**49.7**	**2.6**	**1.0**	**441**	**1.1**	**444**	**3.9**
Malaysia	421	51.8	1.3	8.1	398	-7.8	420	-1.4

Source: OECD, 2014a.

2. Overview of the education system

In 2012, 16 million students were enrolled in formal and non-formal education, with 81.5 per cent of the school-age population studying in the formal education system (Ministry of Education, 2012).

Figure 4.1 Thailand's formal education system: Structure, students and gross enrolment ratios,[1] 2012

Age (Yrs.)	Education level		Degree	
24	**Doctoral degree**		PhD/advanced professional degree	
22-23	**Master's degree** 199 437 students (approx. 175 000 master's and 20 000 PhD students)		Master's degree	
20-21	**Undergraduate** 1 651 599 students (43.4 per cent)	**Higher vocational**	Bachelor's degree	
18-19		321 705 students (8.4 per cent)	Diploma	
15-17	**Upper secondary/general** 1,424,476 students (48.7 per cent)	**Vocational secondary** 716 813 students (24.5 per cent)	Basic education/ vocational certificate	
12-14	**Lower secondary** 2 497 692 students (97.6 per cent)			Compulsory education
6-11	**Primary** 4 935 721 students (104 per cent)			
3- 5	**Pre-primary** 1 799 125 students (77.1 per cent)			

Source: Ministry of Education, 2012; World Bank, 2009.

[1] Gross enrolment ratio: Student enrolment in a specific level of education, regardless of age, expressed as a percentage of the population in the official age group corresponding to that level of education (school-age population)

2.1 Basic education

The budget allocated for basic education and the number of institutions has increased significantly since the 1999 Education Act came into force, and Thailand has made impressive progress in providing basic education to most of its population. Two main challenges remain: (i) enhancing the quality of education, particularly that of training; and (ii) ensuring greater equality in terms of students' participation and performance. The significant inequalities in participation and performance of students are largely due to the heterogeneity of schools performance along urban/ rural divides (OECD, 2013b; Tangkitvanich and Sasiwuttiwat, 2012).

2.2 Technical and vocational education and training (TVET)

Formal TVET is offered at three levels: upper secondary, post-secondary, and university (figure 4.1), and is administered by the Office of the Vocational Educational Commission (OVEC), Ministry of Education (MOE). In 2012, over one million students were enrolled in the normal and dual vocational training programmes. Two thirds of students were enrolled in the 421 public colleges administrated by OVEC and the remainder were enrolled in private vocational schools and colleges overseen by the Office of Permanent Secretary, MoE. Colleges under OVEC are undergoing a restructuring process and being merged into 19 vocational education institutions and four agricultural education institutions.

Non-formal TVET, overseen by the Department of Skills Development (DSD), Ministry of Labour, comprises short-term vocational training courses provided by firms and public institutions. These involve pre-employment courses and skills upgrading for the self-employed and for employees. Most non-formal TVET training is provided by firms to their employees, supported by a tax deduction of up to 200 per cent of the cost of the training course. This incentive has succeeded in improving quantity but not quality. For example, in 2013, 4.6 million employees were trained as a result of this incentive, but the average training expenditure per head was only 742 baht (around $22).[5] Short-term vocational training courses are also provided by DSD's own training centres, although their capacity is more limited. Under both schemes, the training is of uneven quality and subject to limited evaluation (World Bank, 2012b). The Skills Development Fund, set up to promote non-formal TVET, has had only a limited impact, reportedly due to an inherited outstanding debt and insufficient promotion of the fund.

The development and adoption of standards for national skills are also promoted by DSD. Around 100 national standards have been developed in Thailand but are not yet widely adopted. Being certified in a skill gives the right to a minimum wage, but skill certification is not compulsory. DSD plans to make certification in certain standards of skills compulsory starting with those relating to health and safety.

2.3 Higher education system

There are currently 152 higher education institutions,[6] mostly universities and colleges, including 72 private colleges and universities, 15 public universities, 16 autonomous universities, 40 Rajabhat universities and 9 Rajamala universities. Around 2 million students are enrolled in undergraduate programmes (52 per cent of school age population), 174,000 in master's programmes and 20,000 in doctoral programmes (figure 4.1).

2.4 Other educational and training institutions

A number of public educational institutions have also been established to promote science education. For instance, the Mahidol Witthayanusorn School provides specialized education with full scholarships to 720 gifted students in mathematics, science and technology from grades 10 to 12. This model has been replicated in12 regional Princess Chulabhorn's Colleges. The Institute for Promotion of Teaching Science and Technology (IPST) provides teachers' training and develops teaching materials for science education.

In addition, a number of large firms have set up corporate educational institutions (Box 4.1), not only to train their own personnel, but, more importantly, to generate a sufficient supply of the skilled manpower these firms require, which the public system is unable to provide. Such institutions have strong links with the private sector and tend to combine academic tuition with practical training.

Box 4.1 Private sector initiatives to address shortages of management, technical and scientific skills

The **Thai Nichi Institute of Technology**, founded in 2005 by the Thai-Japanese Technology Promotion Institute, provides education at undergraduate and graduate levels in engineering, information technology, business administration and language skills. The programmes combine academic teaching with practical training in Japanese companies based in Thailand. Since 2007, over 2,600 students have enrolled. The institute also collaborates with 40 academic institutions in Japan.

The **Panyapiwat Institute of Management** was founded in 2007 by a firm of the Thai CP Group, which operates 7,500 7-Eleven convenience stores around the country. The institute was set up to offer skills training to personnel and managers required for expanding its retail stores in Thailand. More than 6,000 students are enrolled in its bachelor's and master's programmes.

The PTT Group, Thailand's largest petrochemical company, is establishing an academy and a research and training institute to train qualified persons in S&T and conduct high-level research. The **Rayong Institute of Science & Technology** will offer master's and PhD programmes in chemical engineering and materials science. The PTT Group has allocated $70 million (or 2,150 million baht) per year for five years to build the necessary infrastructure and support the R&D activities of the institute, which is modelled on the Korean KAIST, and will cater to 350 students. The **Rayong Science Academy** will be a science-based secondary school in Rayong province to serve the petrochemical industry in the Eastern Seaboard Project. Both are scheduled to open in 2015.

Sources: UNCTAD based on interviews held in October 2013 (see: www.pim.ac.th/en/; www.raist.pttplc.com; www.tni.ac.th/web/en/).

3. Education policy

After more than a decade of educational reform, Thailand has been successful in promoting education for all: enrolments have significantly increased and student loan programmes have effectively boosted participation. However, the overall performance of the system remains poor (Fry and Bi, 2013; OECD, 2013b; Tangkitvanich and Sasiwuttiwat, 2012). Learning outcomes are poor, teaching and learning processes are still very much teacher-centred, and there are considerable difficulties in recruiting qualified teachers and in holding educational institutions accountable. There remains a considerable shortage of STI personnel and productivity growth has stagnated.

The following sections examine in more detail the education policy and programmes pertaining to human resources development in STI in Thailand.

3.1 Key national policies for STI-related human resources development

National policy clearly acknowledges the need to develop human resources in STI (box 4.2). Overall education policy provides for HRD in STI, but its implementation faces several hurdles. One of the main problems lies in the fragmentation of education policy: its formulation and administration under the Ministry of Education is managed by five distinct offices,[7] each of which is relatively powerful, and has its own governing structure, though with some overlapping functions with other offices (World Bank, 2009). Other offices independent of the Ministry of Education are also involved in the administration of education. Furthermore, budget decisions are made by the Bureau of the Budget rather than by the Ministry. This fragmentation and overlapping has generated a complex system that hinders overall coordination and accountability in education (World Bank, 2012b). While some policies have guided implementation (e.g. the National Education Act of 1999) others (such as the National STI Policy and Plan, 2012–2021) do not seem to guide policy action. In addition, the high turnover of ministers of education has not helped to steer and provide the continuity that educational programmes require. Policy implementation is also hindered by limited monitoring and evaluation of education programmes and policies.

Box 4.2 National policies that include support to STI-related human resources development

The **11th National Economic and Social Development Plan (2012–2016)** identifies a number of reasons for improving Thailand's human capital: an ageing society, labour shortages, low skills and productivity, and the forthcoming ASEAN economic community (AEC). Key target indicators include: increasing the number of personnel in R&D to 15 per 10,000 population and increasing labour productivity by at least 3 per cent per annum. The plan also provides guidelines on how to promote HRD, including: promoting student-centred learning processes, encouraging teachers to have education certificates relevant to the subjects they teach, building workforce capacity in the agricultural sector, supporting the development of researchers and innovators, developing semi-skilled labour through vocational education, preparing for the free flow of labour within AEC, providing incentives to attract professional and high-skilled workers, and providing the infrastructures and resources required for lifelong and flexible learning.

The **National Education Act of 1999** underlies the national vision for educational reform. Its main objectives are: the promotion of education for all, encouraging wider participation in the provision of education and the development of educational bodies based on the principles of unity in policy and diversity in implementation; decentralization of authority; establishing educational standards and quality assurance; raising the professional standards of teachers, faculty staff and educational personnel; mobilizing resources from a wider range of sources; and establishing partnerships with stakeholders. The Second Decade of Education Reform (2009–2018) focuses on managing the internationalization of education in Thailand, improving education quality and standards, addressing regional inequalities, and developing S&T and R&D (UNESCO, 2011).

The **National STI Policy and Plan 2012–2021** also identifies HRD in STI as a key strategic issue, and sets specific targets: the proportion of graduates in science and technical fields to be increased to at least 60 per cent; labour productivity for S&T graduates to grow by at least 5 per cent annually; the ratio of R&D personnel to increase to 25 per 10,000 population, 60 per cent of whom should work in the private sector.

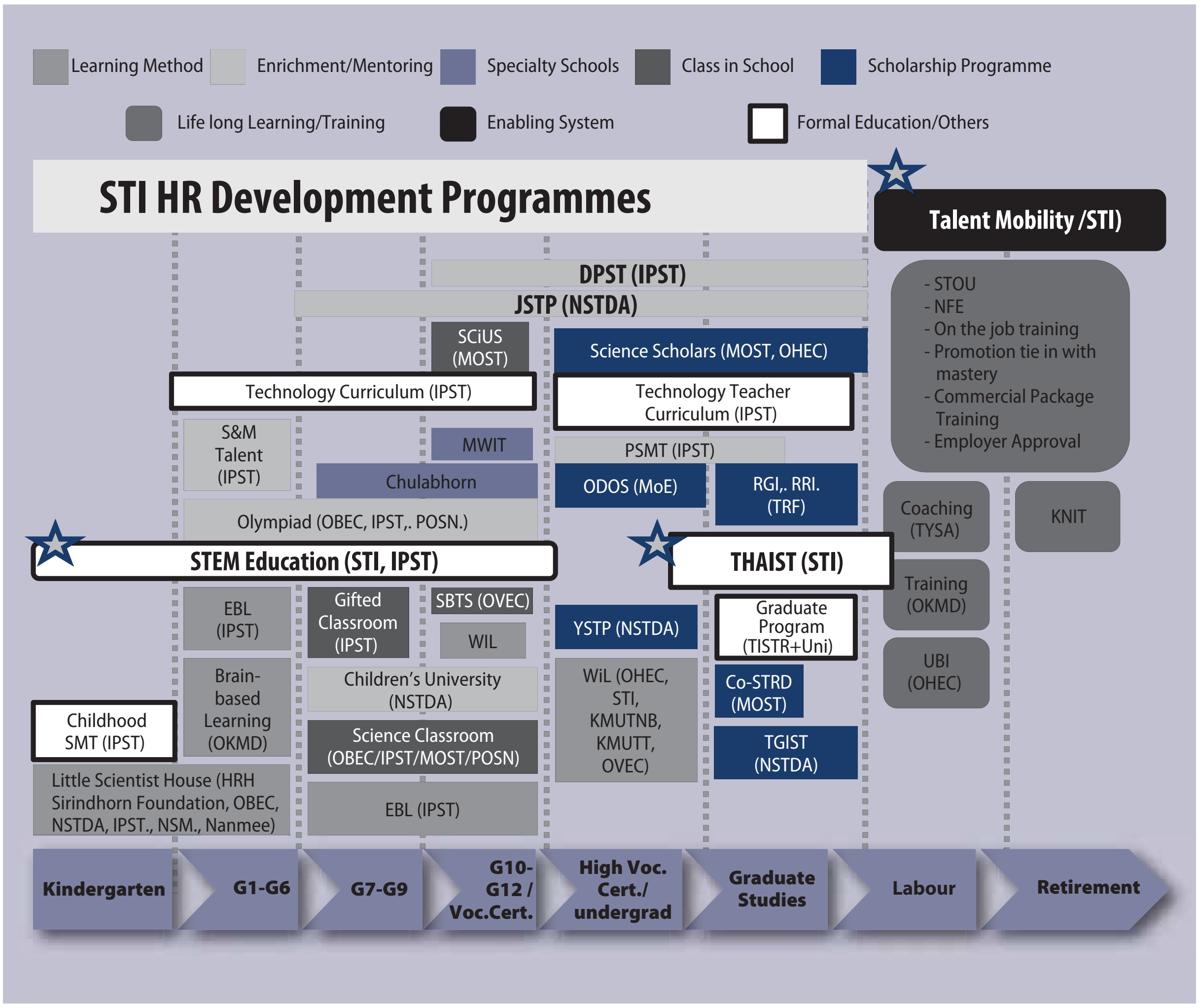
The **Skills Development Promotion Act 2002** promotes pre-employment training, skills upgrading and training for job change; it has established a Skills Development Fund to support skills development; and promotes the development of national skills standards.

The **Vocational Education Act 2008**, in accordance with the National Economic and Social Development Plan and the National Education Plan, aims at developing the human skills, techniques and technology that the market demands.

3.2 Policy measures and programmes promoting STI-related human resources

Thailand has put in place a large number of programmes to support the development of human resources in STI (Figure 4.2). These programmes are being implemented at all levels of education and financed/ implemented by a myriad of institutions with the various objectives of supporting STI teaching and STI learning, providing research scholarships and promoting cooperative education. A number of key policy measures are discussed next.

Figure 4.2 Overview of Thailand's programmes for human resources development in STI



Source: (Durongkaveroj, 2014a).

Scholarships

Scholarship programmes have long supported the generation of highly qualified human resources in STI, largely contributing to the supply of researchers for public research organizations and ministries. The Thai Government provides long-term STI-related scholarship programmes through various government agencies (see box 4.3 for a description of three major programmes). However, they provide only a limited number of scholarships in relation to the size of the student population: less than 700 scholarships per year, while there are over 1.8 million students enrolled in undergraduate, master's or doctorate programmes (figure 4.1). Public scholarships require recipients to work for several years[8] in a specific public research institution upon completion of their studies.

Box 4.3 STI-related scholarships provided by Thai public agencies

The **Development and Promotion of Talents in S&T Scholarship Programme** by the Institute for the Promotion of Teaching S&T (IPST) has provided scholarships to talented students in science and technology since 1984. DPST collaborates with 10 schools, pairing each school with a mentor university. Each year, the programme offers 100 scholarships at secondary level and 180 at higher levels. It has granted 3,360 scholarships to 1,953 students since its inception, 65 per cent of which were awarded in the fields of science, physics, mathematics, chemistry and biology.

The **Ministry of Science and Technology (MOST) Scholarship Programme** has granted scholarships to students (high-school level to doctorate), civil servants and university faculty members since 1990, 3,449 for studying abroad and 238 scholarships for studying in Thailand. By 2011, 1,941 persons had graduated from the programme and were working in universities and government agencies.

The **Royal Golden Jubilee PhD Program**, an initiative of the TRF, provides 300 fellowships annually for doctoral students to conduct research, including one year of study abroad with foreign co-advisers. Since 1993, over 2,000 PhD students have graduated from the programme and over 1,600 doctoral candidates are in various stages of completing their studies. The programme has involved more than 1,400 Thai advisers and more than 2,300 international co-advisers in 40 different countries. Its new International Research Network supports researchers and networks formed around a research topic of interest to Thailand.

Source: MOST, IPST and TRF.

Creating national research universities

In 2009, nine public universities[9] with strong research capabilities to produce research outputs and human resources in advanced fields of study were selected to become national research universities (NRUs). The Thai Government initially pledged[10] to provide the selected NRUs an additional budget of 9.45 billion baht for the period 2010–2012 to enable them to fulfil their research missions. In fact, the nine NRUs only received a total of 2,000 million baht, as the Bureau of the Budget allocated 70–200 million baht to each selected NRU. The annual government budgeting system limits the funding of long-term projects and thus restricts the NRUs' ability to propose strategic research plans.[11]

Promoting research networks

Nine centres of excellence established by the Postgraduate Education and Research Development Office (PERDO), under the Office of the Higher Education Commission (OHEC), support research excellence through inter-university academic networks. The networks, initially supported by the Asian Development Bank, have been financed by the government budget since 2007, with an annual allocation of 400–600 million baht (30–70 million baht per centre). Two additional centres of excellence, in physics and mathematics, were established in 2007. From 2000 to 2009, these centres published 2,863 papers in international journals, 1,370 papers in national journals, were granted 88 patents (10 under the Patent Cooperation Treaty and 78 in Thailand), enrolled 1,717 PhD and 6,119 master's students, graduated 609 PhDs and 3,541 master's students, conducted 1,093 joint research programmes with industry, provided 11,729 contracts of technical consultancy services, and licensed 1,203 contracts for technology transfer. The centres have enabled smaller universities to establish contacts and networks with institutions beyond their usual range.

The Thailand Advanced Institute of S&T (THAIST), a more recent MOST initiative, also promotes training and research networks. THAIST does not provide training itself, but links national and international research and training institutions that offer courses in various technology fields and in STI management. THAIST human resource development networks formed by Thai institutions, foreign education and training bodies, and industrial partners are being set up for railway technology, manufacturing design and rubber technology. Two further networks at the vocational school level are also being established.

Developing science parks

The Government has supported the establishment of several science parks across Thailand.[12] The most advanced one is the Thailand Science Park located north of Bangkok, which hosts 60 technological firms (with around 300 researchers), four national high-tech research centres (with 1,800 researchers) and incubator facilities. There are plans to also establish three regional science parks.

Promoting university business incubators (UBIs)

Two public initiatives have supported entrepreneurship in knowledge institutions: the UBI programme supported by OHEC (Ministry of Education) and the science park incubators established by NSTDA (box 4.7). As discussed in detail in section B.3.3, except in a limited number of institutions (notably those in leading science parks and research institutions), business incubators have not produced tangible results in terms of establishing new technology firms or spinning out research.

B. STI-RELATED HUMAN RESOURCES DEVELOPMENT IN THAILAND: KEY ISSUES

Thailand suffers from chronic shortages of qualified human resources in STI, and the steady increase in those resources (chapter 1) has not been sufficient to respond to market demands (see, for instance, EIU, 2012; and World Bank, 2012b). Moreover, there are persistent difficulties in training people in the STI skills required by an economy that aspires to become innovation-based and able to compete in higher value-added activities. The following sections discuss a number of critical areas requiring attention in this regard.

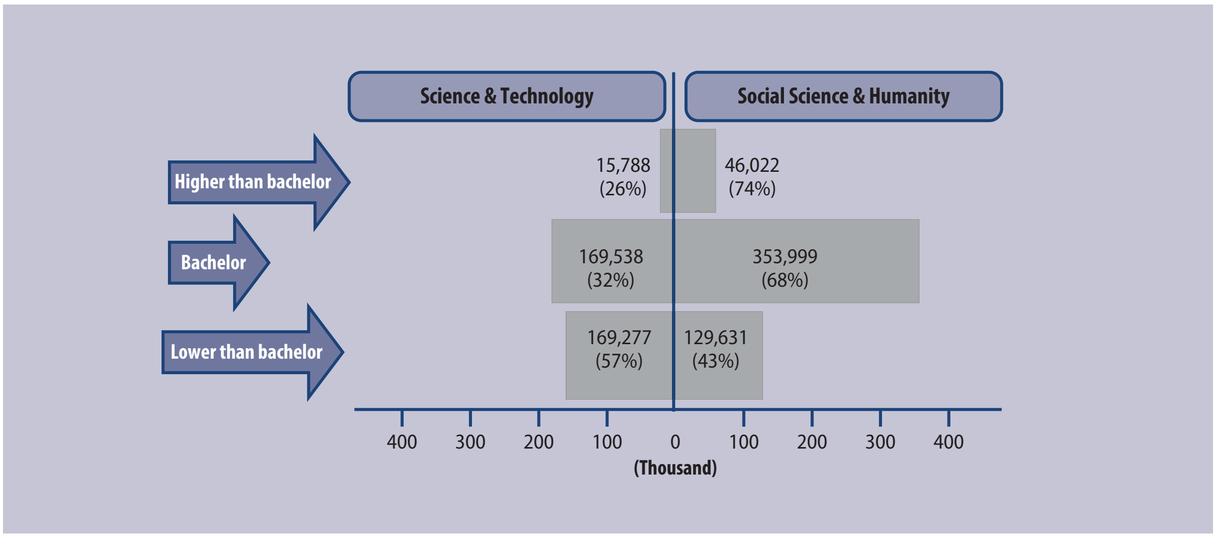
1. Developing human resources in STI to keep pace with an increasingly sophisticated economy

1.1 Increased demand for STI-related human resources

The 2008 labour force survey estimated a shortage of 70,000 skilled workers, including 40,000 workers with vocational education and 30,000 with at least higher education.[13] Yet the demand for STI human resources is only expected to increase as the country expands its high-tech industries and attempts to become an innovation and knowledge-based economy.

Similar to many other countries, the proportion of graduates in science, technology, engineering and mathematics (STEM) in Thailand is relatively small and remains too low to support domestic technological capabilities (World Bank, 2011). In 2011, enrolments in S&T accounted for 40 per cent of all new enrolments (at all levels of education). However, enrolment ratios in S&T were much fewer at higher levels of education. Only a third of the new enrolments in bachelor's degree programmes and a quarter in post-graduate programmes were in S&T (figure 4.3).

Figure 4.3 Total new enrolments in S&T vs. social sciences, 2011



Source: National STI Policy Office, 2013.

Thailand has seen an impressive growth in R&D personnel. In just one decade (1999–2009), the number of persons conducting R&D has doubled, and the number of full-time equivalent (FTE) R&D personnel has tripled (table 4.3). However, much of that growth has taken place in public and academic institutions. In the private sector, although the number of FTE R&D personnel, has more than doubled, their ratio has fallen steadily, from 26 per cent to 20 per cent, because they have more than tripled in the public sector (table 4.3). Private demand for trained R&D personnel is likely to continue, and even accelerate, given the low levels of private sector participation.

Table 4.3 R&D personnel, Thailand, 1999–2009

Year	R&D personnel: Full-time equivalent				R&D headcount			
	Private Sector	Share (per cent)	Other sectors (Government, academia, NGOs, State enterprises)	Total	Private Sector	Share (per cent)	Other sectors (Government, academia, NGOs, State enterprises)	Total
1999	5 291	26	14 756	20 047	16 230	31	36 399	52 629
2001	9 710	30	22 301	32 011	18 209	33	37 539	55 748
2003	7 010	17	35 369	42 379	12 105	16	64 085	76 190
2005	7 750	21	29 217	36 967	11 757	17	56 125	67 882
2007	8 645	20	33 979	42 624	12 902	18	60 596	73 498
2009	11 846	20	48 496	60 342	14 687	13	95 800	110 487

Source: National STI Policy Office, 2013.

1.2 Demand for skilled workers in specific STI fields

Shortages of skilled workers in certain industries and economic sectors, both at the technical and graduate levels, have been a recurring challenge to Thailand's industrial development. Currently, most critical skills shortages are estimated to be in the largest high-tech industries (automotives and electrical and electronics). In addition, demand for skilled workers is expected to increase in smaller high-tech sectors (software, alternative energy, biotechnology, medical services/ healthcare, film and entertainment) (EIU, 2012). There are also concerns about future shortages of agricultural researchers and lecturers (chapter 3).

Two large infrastructure development programmes that will demand considerable amounts of skilled and specialized human resources, both at the technical and graduate levels, have been under consideration for some time. The Water Management Project, proposed following the flood crisis of 2011, will invest 350,000 million baht in a water management and flood prevention system. Its implementation will require expertise in urban planning, civil engineering, water resource management, computer modelling and simulation. The Transport Infrastructure Investment Plan, which includes proposals to upgrade the railway infrastructure, is estimated to require over 30,000 skilled workers for its operation and maintenance (box 4.4). Staffing of the railway programme will be challenging, particularly its more advanced aspects, which will require railway engineers, a specialization not currently taught in Thai universities. A number of institutions in Thailand have taken steps to train human resources in rail technology, but these efforts are still modest due to the uncertainties surrounding the scope of the programme and the lack of public resources assigned to it. To develop sufficient human resources, a more ambitious capacity development programme for railway technicians and engineers will be required. To increase the opportunities for technological spillovers from these and other large infrastructure projects and the building of indigenous technological capabilities, the capacity development programme would need to be accompanied by the inclusion of local content and technology transfer considerations in the public procurement process related to the development of these projects and services.

Box 4.4 Human resources development for the railway system megaproject: Addressing the challenge

Thailand's competitiveness is currently under threat due to the lack of an integrated transport system and of a well-developed and competitive railway sector. For instance, the internal transport cost of moving goods to ports is 60 per cent of the overall shipment cost – twice the comparable percentage for both China and Malaysia (Wood, 2013).

To redress traffic congestion problems and high transport costs, in 2013 the Parliament approved Thailand's largest transport infrastructure investment plan in decades. It passed a special bill on infrastructure development, allowing the Government to raise 2 trillion baht over seven years (2013–2020) to finance transport infrastructure investment beyond the traditional budgeting system. The plan, which intended to spend 1.66 trillion baht on upgrading rail infrastructure between 2013 and 2020 (Surakampontorn, 2013), is currently under revision and is likely to be scaled back and financed under the fiscal budget. The current proposal focuses on developing a double-track railway and mass rapid transit, for which an estimated 6,000 engineers will be required (box table 4.1).

Box table 4.1 Estimates of human resources required for the railway project*

Project	Executives	Experts	Engineers	Architects	Admin.	Labour
Track doubling	208	787	2 368	1	589	13 764
Track rehabilitation	35	10	34	5	70	17 789
Mass rapid transit (8 lines)	30	-	3 539	220	3 933	39 705
Total	**273**	**797**	**5 941**	**226**	**4 592**	**71 258**

Note: *As estimated in a proposal by the Ministry of Transport, June 2014.

Domestic firms have the technological capacities to contribute to the civil work on the railway infrastructure, and could also produce a large proportion of the spare parts and peripherals required, such as rubber parts, electric wiring and low-voltage transformers.

The key providers of railway services in Bangkok (BTS and BMPCL) have strong operational capabilities, up to international safety standards, as well as the capacity for routine maintenance. However, they lack advanced technical knowledge, and rely on foreign technology suppliers to supply, maintain and upgrade critical components such as the rolling stock, signalling and control software. The lack of domestic capabilities required to maintain the planned railway services poses significant technical challenges to the realization of the project and to local firms' participation in the provision of those services.

To address the lack of technological capabilities, NSTDA, in cooperation with NSTIPO, a number of universities, research institutions, railway operators, and leading suppliers is carrying out a number of actions to build awareness, support HRD, promote technology transfer and build R&D capabilities in railway technology.

As a first step, three training courses to build awareness on railway technology were conducted for public and private stakeholders. A more ambitious project to develop competent human resources and technical expertise in rail technologies, through the establishment of a Thai Railway Technology Development Institute by 2016 is being developed. In 2013, 19 institutions (including the STI policy office, universities, a research institute, industrial companies and service providers) agreed to collaborate in this Institute. That year, the NRCT granted $830,000 for the Institute to develop a strategic plan for rail system development in 2014, to conduct research on a half-height platform screen door, for driving simulators for training, and for a high-speed rail teaching platform. It is expected that NRCT will grant another $930,000 in 2014. Substantial work is in progress to develop a railway technical curriculum (at the vocational and technical education level), and to develop, with King Mongkut's Institute of Technology Ladkrabang, the first bachelor's degree course in rail transportation engineering in Thailand.

These initial steps are necessary but insufficient to build significant rail technology capabilities. The development of indigenous capabilities at the relevant scale will require a more ambitious programme with substantial resources. This will only occur if the development of domestic rail technology capabilities becomes a priority for policymakers and is accompanied by sound and stable financing. For instance, allocating just 1 per cent of the budget planned for the railway infrastructure to HRD would provide significant resources to develop a solid base of railway engineers. Secondly, policymakers could also decisively contribute to building domestic capabilities by making technology transfer considerations an integral part of negotiations with international suppliers. Also, local content provisions could be included to foster the competitive procurement of spare parts from local firms. In addition, more ambitions requirements for training local engineers and technicians could be considered.

Sources: Wood, 2013; Surakampontorn, 2013, and interviews with rail transport experts in Thailand (Mr. Nakorn Chantasorn, Adviser to the President of NSTDA; National STI Policy Office; Ministry of Transport).

1.3 Underdeveloped entrepreneurial skills

Thailand has a dynamic SME and business sector but with limited appetite and capacity for innovation. Two key obstacles to the emergence of innovative SMEs and entrepreneurs in Thailand are the lack of relevant entrepreneurial education and training, and limited capacities to incorporate S&T in new ventures (GEM et al., 2012).

Entrepreneurial skills encompass attitudes (e.g. persistence, networking, self-confidence) and enabling skills (e.g. business planning, financial literacy and managerial skills), combined with vocational/ professional skills. In Thailand, education is still largely based on rote learning methods that do not foster critical thinking and creativity or entrepreneurial attitudes. Various educational policies and actions[14] could help build innovation entrepreneurial skills. It will be necessary to supplement the teaching of science, technology, engineering and mathematics with training in business management, while also fostering the individual and collective attitudes that foster entrepreneurship. A number of Thai values, such as perseverance and eagerness to learn, support entrepreneurial attitudes and should be built upon. Developing adequate pedagogical methods and addressing the trade-off between teaching to pass standardized tests and teaching to promote creative thinking will be critical for promoting entrepreneurship.

Beyond the formal education system, entrepreneurial skills can be supported by fostering mentorships and networks, and strengthening spaces such as business incubators (see section B.3). Special efforts should be devoted to inculcating in potential entrepreneurs the skills needed to become more innovative. For example, they should be able to identify technology needs and skills to innovate in products and processes.

Thailand already has some good examples of educational institutions that promote entrepreneurial skills, such as the Mechai Pattana School (or Bamboo School), which could be emulated (box 4.5). This secondary school, located in an impoverished district in north-east Thailand, uses project-based learning to encourage creativity, analytical thinking and entrepreneurship. Students learn and experiment in areas relevant to the local community, thereby also contributing to local economic development. As jobs are created locally, school graduates no longer need to leave to find jobs in large cities.

Box 4.5 The Mechai Pattana School (Bamboo School)

The Mechai Pattana School, located in Buriram province in the north-east, is a private secondary school with an innovative pedagogical approach. The school was founded in 2008 by Mechai Viravaidya, a former politician and local activist, and is supported by private donations. It aims to equip new generations with good citizenship through education, regardless of social and economic backgrounds. Teaching focuses on enabling students to analyse and create, rather than memorize. Students learn at their own pace, they choose topics they wish to explore and teachers facilitate the learning process. Pupils actively participate in the school administration and establish social enterprises aimed at having positive impacts on their community. There are no tuition fees, but the students, together with parents, contribute 400 hours of community service.

The pedagogical approach emphasizes project-based learning. Pupils use the Internet along with textbooks, and various elective courses (e.g. cooking, arts) are offered to harness creativity. They are also asked to identify local problems and think of solutions, which may include setting up local social enterprises. Grade 10 students spend one year in the Pattaya Campus on the east coast. Apart from their regular curriculum, they have lessons in the hospitality industry, renewable energy, water resource management, industrial operations, maritime affairs, marine life and business skills.

The School also serves as a life-long learning centre for the entire community and a hub for economic and social advancement. Everyone in the community is welcome to use the school to improve their agricultural, business, and general vocational skills. Microcredit funding is available to families, and teachers from the neighbouring rural areas can improve their teaching skills at the school's teacher training facility.

Source: UNCTAD based on interview with the founder, and: www.mechaifoundation.org.

2. Enhancing the overall quality of STI education and training

Raising the overall quality and addressing institutional quality gaps

Thailand needs to make substantial efforts to improve the quality of STI education and training at all levels. For instance, national stakeholders (both public and private sector actors) interviewed by the STIP Review team were of the opinion that around 20 universities out of 150 provide good education. Moreover, they believed it would be necessary to reduce the disparities among teaching institutions, especially between those in Bangkok which, overall, provide much better quality education, than those located outside the capital. This issue could be addressed by better implementation of policies aimed at providing more autonomy to educational institutions and promoting regional science parks. Also, schools based on a similar model to the Mechai Pattana School (box 4.5) could provide good and relevant secondary education outside Bangkok.

Holding educational institutions and stakeholders accountable

Improving the quality of national education is an extremely strategic and complex issue involving discussions on what quality education means for Thailand, but it is beyond the scope of this analysis.[15] However, an important means of raising the quality of education is to hold educational institutions and stakeholders accountable. This is a pressing issue for Thailand, which emerged repeatedly during the interviews held by the STIP review team. There are reported difficulties in holding underperforming educational institutions (such as those identified by the Office for National Education Standards and Quality Assessment) accountable. Training provided by firms, whether as part of dual vocational training programmes or through skills development programmes, has not been adequately evaluated. School principals and education managers are not being held accountable for providing the educational services expected from them. Budget allocations are not linked to performance. Education policy objectives are not necessarily supported with the necessary funds or tools. Regular monitoring of programmes is lacking and, more importantly, evaluations of programmes are scarce and rarely made public for general scrutiny. Current quality assurance processes are concentrating too much on narrow key performance indicators and diverting attention away from achieving educational objectives. While this is a problem with most evaluation systems, its effect seems to be particularly worrisome in Thailand. Focusing on quality enhancement rather than on quality assurance would be a better means to improvement and reduce the distortions caused by quality assurance systems.

Overhauling technical and vocational education and training (TVET)

The existing TVET system is no longer considered a major mechanism for training skilled workers and requires a major overhaul. There is a common perception in Thailand that TVET is a second-best education option; consequently, the number of students entering vocational education has declined significantly. In 2012, only one third of students in upper secondary education were enrolled in vocational education, far from the target of 60:40 vocational to general student ratio set by the Minister of Education.

The perceived low value of vocational education[16] and the increasing opportunities to access higher education[17] explain this decline. Thailand suffers from «diploma disease» – obtaining a degree or diploma is more important than acquiring knowledge (Mounier and Tangchuang, 2010) – and the labour market provides economic incentives for investing in higher levels of education (World Bank, 2012b).

The quality of TVET has deteriorated as a result of a shortage of qualified teachers, poor teaching methods and insufficient investment.[18] In order to improve the quality of TVET and make it more appealing, it needs more and better qualified teachers through retraining and recruitment, and incentives that reward good teaching performance, as well as updated teaching methods, materials and equipment. Difficulties in recruiting teachers are exacerbated in vocational education, where incentives are lower,[19] and to make matters worse, half the existing teachers will be retiring in the next five years. The current student-to-teacher ratio in vocational education is 44:1 while that in basic education is 22:1 (TDRI, 2013). Teacher turnover in schools has also become a major problem.[20] A large proportion of teachers has not been trained for technical teaching and has no industry work experience. Although there are policies and programmes[21] that promote the training of science and maths teachers, it is also necessary to update teaching curricula and training materials, and to provide learning opportunities that promote practical learning and keep pace with industries' needs.

Dual vocational education, a mode of formal TVET that provides most training in the workplace, has not been very successful in Thailand (Rupavijetra, 2010) partly because only a limited number of firms participate,[22] and often the training they provide is of poor quality and the trainers do not have the specific teaching skills required.

To overcome the shortage of technical graduates, a number of programmes have been put in place in coordination with OVEC, but not mainstreamed in the general vocational education programme. For example, Science-based technology schools were established in 2012 for enabling talented students develop their technology skills. The pilot Work-integrated Learning Program (WiL) coordinated by the National STI Policy Office offers two degree courses, at the high vocational and bachelor levels, where 40 students and their teachers spend part of their time in industry, and classroom teaching is closely related to industry practice.

3. Fostering effective linkages between universities/research institutions and industry

One important reason for the shortage of the STI skills required in Thailand is the absence of systematic interaction between universities and industry that could contribute to the identification of the skills requirements of industry, the upgrading of university lecturers' and researchers' skills and the design of appropriate curricula.

University/research institutions' linkages with industry in Thailand have been weak traditionally, have involved fairly low levels of technology, and have been mainly of an informal nature (World Bank, 2011; Brimble and Doner, 2007; Doner et al., 2013). The strongest linkages have been found in electronics (hard-disk drives) (box 2.3) and in biotechnology connected with agro-industry development (see, for example, box 2.6) (Brimble and Doner, 2007).

There are scattered efforts to promote university-industry linkages in teaching. At the undergraduate level, cooperative education (a collaborative education programme where students spend one term in firms) was first offered by Suranaree University of Technology (SUT) in 1997, and is now also offered by other universities. At the graduate level, KMUTT has established engineering practice schools in the chemical and food industries (box 4.6).

Box 4.6. Engineering Practice Schools at KMUTT

Recognizing the growing demand by specific industries for engineers, in 1997, KMUTT founded two practice schools: its Chemical Engineering Practice School (ChEPS), which offers a two-year international master's degree programme run in collaboration with MIT practice school (United States); and the Food Engineering Practice School (FEPS), which is run in collaboration with the food industry. Internships are arranged with large companies that can provide sufficient support.

Each school admits 50 students per year, with full scholarships provided by the firms involved. Students spend one term in firms, on a designated project whose objectives have been jointly agreed by project coordinators, advisers and senior firm staff. Coordinating units support instructors, students and company's staff. The project involves planning, consulting services, coordination and site visits, and its results are presented to the firm's management and evaluated by mentors, advisers and programme coordinators. The curriculum provides a proper balance of practical and theoretical learning.

KMUTT's management leads and supports these programmes with a clear policy and the allocation of adequate financial and human resources. Trust, top management engagement, clear expectations for the projects, capabilities of coordinating units, incentive schemes and strong networks of participants have been key success factors. Most graduates have been offered a full-time position by the host firm after the completion of the research projects.

Source: UNCTAD, based on field interviews in October 2013; NSTDA, 2005; see also: www.chemeng.kmutt.ac.th/cheps/.

The main reasons for the limited linkages between education institutions and industry are discussed below.

3.1 Lack of common vision: Persistence of linear thinking

Thai research universities and institutions have traditionally focused their attention on publishing their research and have paid little attention to issues of technology transfer and commercialization. Academics and part of the public administration believe that research eventually trickles down somehow to find solutions for industry, society and consumers. Most public research, including potentially commercial research, is carried out independently of firms. On the other hand, firms expect research institutions to carry out research that is relevant and ready for commercialization. However, university research outputs often need further development and engineering or testing in a pilot phase before commercialization – an area in which neither research institutions nor firms have invested significantly, and for which firms often lack the technical and managerial skills.

There is no systemic relationship between universities/research institutions and the private sector involving multidirectional interactions along the different stages, including identification of S&T needs, designing and conducting research, and adapting it for commercialization. As a result, there is limited research that is of interest to the private sector.

3.2 Lack of incentives for researchers and research institutions to collaborate with industry

The performance criteria for researchers and their institutions place excessive value on publishing and patenting research, and provide little recognition (and therefore few incentives) for activities carried out in collaboration with industry, such as joint research projects or advisory services. For example, research carried out for/with a firm is considered a university service and does not contribute to researchers' career advancement if it remains unpublished (as is often the case because of confidentiality agreements or because its practical nature does not lend itself to publication). At the same time, research universities are largely evaluated based on the number of students trained and the research published (and more recently on the intellectual property registered), but not for their capacity to transfer technology.

Mobility of researchers between the private and public sector is rare. Public researchers tend to spend their entire academic life in public research institutions or universities for two reasons. First, many researchers have benefited from public scholarships that require them to work for several years in a specific institution upon completion of their studies. Second, time spent researching in industry will not be recognized for their career advancement. At the same time, researchers in private firms have little (economic) incentives to work at research institutions.

Two recent initiatives promote mobility of researchers between universities and industry (box 4.7). The Researchers for Research in Industry Program provides funding for PhD students to conduct research in industry. And the Talent Mobility Program aims to induce public researchers to spend 20 per cent of their working time in industry. It is a voluntary programme and its success in fostering mobility of researchers will depend on the adjustment of incentives for them (i.e. recognition of mobility as a key performance indicator, regulatory reforms to assure continuing tenure and academic promotion) and further support from university management.

Box 4.7. Thai initiatives aimed at promoting the mobility of researchers

The **Talent Mobility Program**, set up by the STI policy office, promotes the participation of public researchers in industrial research, and aims to mobilize 200 researchers per year from 15 institutions to spend 20 per cent of their time in industry (identifying technological problems and conducting industrial research) for a maximum of two years. Researchers receive grants or consulting fees from the participating firms. Firms reimburse universities by making use of tax incentives. SMEs are exempted from payment and are subsidized by MOST. Universities' participation is uncertain, as the programme, currently in its pilot phase, is voluntary, and neither faculty members nor universities have a particular incentive to participate.

The **Researchers for Research in Industry (RRI),** launched by TRF in 2011, provides scholarships for PhD students to conduct research in firms under the co-supervision of university professors and industry professionals. The programme expects to involve 10,000 PhD students over a period of 10 years. In 2013, RRI granted scholarships to 300 PhD students. The programme targets researchers at the beginning of their careers who may be encouraged to opt for a career in the private sector, and it is therefore unclear to what extent it will promote mobility.

Source: UNCTAD, based on interviews.

3.3 Limited capacities for promoting entrepreneurship and commercializing research

Despite the significant efforts made in the past 10 years, Thailand's current capacity to promote entrepreneurship in universities and research institutions is insufficient to stimulate the emergence of a solid base of technology and knowledge-based firms.

Support for entrepreneurship has largely been driven by two public initiatives: the UBI programme supported by OHEC, and NSTDA's Business Incubation Centre (box 4.8). Except in a limited number of centres (mostly those in leading science parks and research institutions), business incubators have not produced tangible results in terms of establishing new technology-based firms or spinning out research.

Supporting technological start-ups and spin-offs has not been a policy or an institutional priority in Thailand, and the private sector has not participated in these efforts. OHEC's UBI programme has not focused on technology-based start-ups; it usually provides general business support similar to that provided by other public programmes.[23] This lack of strategic support is coupled with insufficient, fragmented and uncertain financial resources. There is often a lack of understanding of the risky nature and financial needs of start-ups (particularly technology-based ones). Financial resources provided by UBI have been spread too thin, and at times, due to programme rigidities, have been spent inefficiently (e.g. in duplicate training).

At the operational level, UBIs and technology licensing offices also experience significant difficulties in recruiting and retaining managers with the necessary skills and experience for promoting entrepreneurship and for helping to commercialize research.

Box 4.8 Business incubation in knowledge institutions

NSTDA's **Business Incubation Centre,** located in Thailand's Science Park, has incubated 74 start-ups and supported established companies with a total of 320 million baht annual revenue. The centre supports start-ups, such as Flexoresearch (an R&D service provider for the pulp, paper, printing and packaging industries that has developed an enzymatic technology to recycle the laminated paper waste contained in milk cartons) as well as established firms with new innovative products, such as KEEEN (a bio-remedial firm that has developed biotechnological solutions for wastewater treatment and waste management).

In 2004, OHEC launched its **University Business Incubator (UBI)** programme, to support incubators in public and private universities. The programme has expanded rapidly, and today there are over 60 UBIs. However, of these, only 10 are considered successful. The expansion of UBIs has not been matched with increased funding. OHEC currently allocates 72 million baht per year to the programme. During 2011–2012, 150 start-ups and 50 spin-offs, which generated revenues amounting to 140 million baht and created 150 new jobs, had been incubated.

The average UBI incubates five new firms a year with the support of four or five staff, and it offers business advice and access to university laboratories and experts. Most incubated firms are involved in low-tech activities in food processing, cosmetics and ICT. For example, a typical start-up is a small food processing firm that may have introduced a slightly improved product to the local market. In leading research universities, start-ups or spin-offs may comprise firms offering more technology-intensive products. For example, Olizac Technologies is an R&D-based firm that commercializes an orchid bio-elicitor which modulates stress and enhances orchid flowering based on the chitin-chitosan technology platform developed at Chulalongkorn University.

Local authorities and the private sector are not involved in these business incubation programmes. Two other recent or forthcoming incubation initiatives are the incubator centre established by TISTR in 2013 and the incubation programme to be established in NIA's new Innovation Center.

Source: UNCTAD, based on a round table discussion with UBI and TLO managers and officials (7 March 2014); interviews with stakeholders; Oxford Business Group, 2011; and Thailand Biotech Guide 2013, 2014.

Commercialization of R&D and IP management is still in the early stage in Thai universities. A number of technology licensing offices (TLOs) have been set up recently in universities to facilitate and promote the patenting and commercialization of research (box 4.9). However, so far they have done little international patenting and licensing of technology. Universities have limited research that can be patented, commercialized or transferred, largely because research is done in isolation from the private and social sectors. In addition, lack of awareness about IPR management issues among university staff and unclear technology transfer regulations of IP derived from publicly funded research hinders the commercialization of technology.

In the short term, the potential for licensing technology is largely constrained by the limited commercial value of the IP held by the host institutions. Therefore, at this stage, TLOs' main priorities should be to create greater awareness about IP among academia and the private sector and promote coherent institutional IP policies. In addition, they should facilitate research that responds to economic, social and market needs from the outset, and they should foster collaboration with other economic and social actors, enabling the emergence of research that has greater commercial potential and public relevance.

Box 4.9 The challenge of commercializing university research

In 2007, OHEC launched the Technology Licensing Office (TLO) programme and today 10 universities have such offices. The programme has supported applications for 526 patents, 260 design patents and 340 petty patents, and licensing revenues of 250 million baht. TLOs manage institutional IP, negotiate research agreements with outside partners and support the evaluation and patenting of inventions. They also raise awareness of IP issues, deliver training in this area and provide advice on institutional IP policy.

The average TLO has only a few national patents and petty patents registered, whereas TLOs from larger research institutions may have several international patents registered. For example, Chulalongkorn University holds 400 domestic patents and petty patents, and 20 international patents and petty patents; and it has 70 licensing and technology transfer agreements, including in nanotechnologies and ICTs.

The main challenges TLOs face are the limited number of IPRs owned by the institutions and their limited commercial value, a lack of awareness of IPRs among staff, and difficulties in recruiting managers for TLOs with the appropriate experience.

Box table 4.2 Technology licensing offices in Thailand

	CU	MU	KU	KK	CMU	SUT	PSU	KMUTT	Total
Year of establishment of TLO	1995	1998	1996	2006	2007	2007	2007	1995	
Number of staff (FTE) engaged in licensing activities, business development and spin-offs	4	..	..	2	2.5	2	2.5	2	15
Number of staff (FTE) engaged in patent filing and other technology transfer activities	6	..	6	4	4.5	6	4	..	30.5
Licensing agreements (2008–2011)	42	..	19	..	..	10	..	..	71
Revenue from licensing out (million baht) (2008–2011)	19.5	..	10.4	1.7	5.9	3.2	0.9	1.2	42.74
Number of invention disclosures	51								51
Local utility patents, 2011–2012 (applied/granted)	44/1	0/2	12/0	14/0	..	17/0	21/0	14/0	122/3
Cumulative local utility patents (applied/granted)	..	../34	209/28	71/4	../67	96/4	../51	162/14	538/202

Notes: CU=Chulalongkorn Univ., MU=Mahidol Univ., KU=Kasetsart Univ., KK=Khon Kaen Univ., CMU= Chiang Mai Univ., SUT=Suranaree Univ. of Technology, PSU=Prince Songkla Univ., KMUTT = King Mongkut Univ. Technology Thonburi

Source: UNCTAD, based on a roundtable discussion with UBI and TLO managers and officials (7 March 2014), and Thanasukarn, 2013 (only in Thai).

3.4 Limited demand from the private sector

Thai firms have not approached universities and research organizations for technological support because to some extent they have not been under pressure to innovate (Doner et al., 2013). Ninety per cent of Thai SMEs do not carry out any innovation activities (OECD, 2011). Another reason for not demanding technological support is that SMEs often have limited internal capacity (both in terms of personnel and financial resources) to undertake collaborative research programmes. Stakeholders report that SMEs have difficulties identifying their technological needs, while larger innovative firms have little confidence in universities' capacity to respond to their research needs, and prefer setting up internal R&D units or acquiring technology equipment/services from abroad. Moreover, in many sectors, firms find it difficult to collaborate among themselves and to work jointly to upgrade their technological competences (see, for example, Brimble and Doner, 2007; Chunhavuthiyanon and Intarakumnerd, 2014).

3.5 Inadequate coordination between research, education and industry

Inadequate coordination between research, education and industry is hampering the ability of the education and training system to respond to industry needs. Ministries and their departments tend to operate in silos, with little coordination. Policy coordination is often limited to consultation with stakeholders in multiple forums without clear action plans[24] and control systems. Informal coordination can work well to organize specific collaboration in STI,[25] but at higher levels of policymaking more formal coordination mechanisms are required. Multiple players (Doner et al., 2013), notably the Bureau of the Budget [26], can veto proposals. And a lack of effective policy monitoring, evaluation and control mechanisms also hinders policy coordination.

Enhanced coordinated efforts are required to foster curricula design and teaching methods that respond to industry needs and train sufficient numbers of students in S&T fields and in relevant skills, and which encourage the private sector to effectively participate in appropriate training programmes. A robust labour market information system that informs HRD policies, educational institutions and students on current and future trends is needed in conjunction with incentives for educational institutions to adjust their courses accordingly. The Ministry of Labour surveys labour market needs,[27] but the system is not sufficiently developed to anticipate labour market trends, identify which labour skills are needed in sufficient detail and clearly communicate that information to the relevant stakeholders.[28]

Policy coordination is crucial to promote efficiencies and spillovers in national strategic projects. For example, the railway infrastructure proposal drafted by the Ministry of Transport in June 2014 does not include an HRD plan, which the Ministry of Transport believes is beyond its mandate. Efforts to develop HR in this area are taking place in parallel through more informal mechanisms. As a consequence, no adequate financial resources have been allocated for HRD, and priorities have not been adequately signalled for training and research institutions to make investments in advance.

4. Leveraging more HRD and technology transfer from TNCs

In order to improve the technological base of the Thai economy, FDI could be exploited more effectively. In a number of industries (notably the hard-disk drive (Box 2.3), automotive and food industries), TNCs' investments have contributed to upgrading local technological capabilities through the training of human resources and collaborative R&D projects. But FDI could contribute more to enhancing the technological base of the economy if linkages between foreign and domestic firms were to be fostered.

Linkages between TNCs and domestic firms can be bolstered by identifying local enterprises that have the potential to become suppliers to or partners with foreign investors and through the promotion of networks. Another means of fostering linkages is through incentives and requirements (e.g. local content requirements or favouring the establishment of joint ventures with local firms) for TNCs to educate and build local firms' capacities to become their suppliers. Lessons can be learned from the state government of Penang, for example. Penang is a major electrical and electronics manufacturing hub in Malaysia, and its government has successfully promoted business linkages among local and international firms through strong networking and collaboration. Through coordinated policies the government has played a pivotal role in targeting FDI willing to create linkages, promoting strong networking and collaboration between companies and the local government, responding to TNCs' demands for a skilled workforce (by facilitating the establishment of the Penang Skills Development Centre) and in upgrading local SMEs through public-private partnerships (UNCTAD, 2010b).

5. Maximizing international and regional collaboration and mobility for HRD

(a) International collaboration and mobility

Thailand has a long-standing tradition of international collaboration on STI training and research at governmental and academic levels. It is also worth noting Thailand's recent efforts, such as the International Research Network (Box 4.3), to ensure that joint international collaboration in research is done in areas of interest to Thailand.

International collaboration in STI policy design and evaluation is one area that requires attention. Currently, no international STI experts participate in the evaluation of national institutional and STI programmes except in the context of bilateral and multilateral programmes. International experts can help raise the quality of research, training and other STI programmes as well as their visibility, and, as outsiders, they can provide independent and impartial assessments of STI programmes.

Attracting human capital to conduct scientific research and training in Thailand, as well as to address local firms' needs for highly qualified staff also deserves further attention. Foreign talent is an invaluable source of knowledge and ideas, and can provide access to valuable networks and resources. Current regulations concerning the recruitment of foreign workers[29] are limiting the staffing of highly skilled people. Such general restrictions should be made more flexible to enable the recruitment of foreigners with the skills needed by firms and organizations in Thailand, including those firms with no "Bureau of Investment-promoted certificate". Moreover, most innovative countries have introduced programmes that attract international talent to expand their workforce, conduct world-class research, and even to promote an entrepreneurship culture, skills and assets. For instance, Singapore has a comprehensive policy and supporting programmes[30] to attract talent into the country. Chile's Start-Up programme[31] encourages international entrepreneurs to establish their start-ups in the country and help promote an entrepreneurial culture there. The programme provides local and foreign entrepreneurs with $40,000 of equity-free seed capital and a one-year visa to develop their projects for six months, along with assistance in accessing human and financial capital networks.

Language can still be a barrier to further international collaboration and mobility, despite efforts[32] to promote language training.

(b) Regional integration and collaboration within ASEAN on training and research

Collaboration within ASEAN on training and R&D has been limited so far. To start with, ASEAN countries are at different stages of technological development, and they face shortages of R&D personnel. Thus, countries such as Thailand traditionally cooperate with institutions in Europe, Japan and the United States.

The ASEAN Economic Community scheduled to be established in 2015 may provide Thailand with wider pools of trained human resources (but also with greater risks of a brain drain), further prospects for STI cooperation and learning, and greater opportunities for providing educational services to international students. A number of programmes and instruments have been put in place to facilitate HRD and mobility. For example, the ASEAN International Mobility for Students programme promotes undergraduate student mobility on a small scale,[33] eight ASEAN Mutual Recognition Agreements facilitate the movement and employment of qualified and certified personnel between ASEAN member States,[34] and an ASEAN qualification recognition framework is to be finalized by 2015. The ASEAN Committee on Science and Technology is also promoting regional collaboration (e.g. through the ASEAN University Network). More recently, Thailand has promoted preliminary discussions on what could be a programme for ASEAN Talent Mobility.[35] These programmes are still too small or recent to have had a significant impact. The major obstacles to regional collaboration and mobility are language barriers, limited financial resources to support student mobility and research collaboration, and the lack of commitment by universities in the absence of financial resources.

C. CONCLUSIONS AND RECOMMENDATIONS

National education has made considerable strides as a result of proactive public policies. Thailand's achievements in increasing enrolment rates in secondary and tertiary education are outstanding. However, to become an innovation-based economy, it needs to increase its STI-related human resources, and, most importantly, ensure that they possess the technical, entrepreneurial and innovative skills required not only at present but also in the future.

Thailand faces increasing demands for STI-related human resources, both at the vocational and higher levels of education. The number of R&D personnel per population, particularly in the private sector, is relatively low. In addition, there are major skills shortages in certain fields and industries, including in the larger high-tech sectors, in smaller high-tech sectors that are set to expand and in new infrastructure projects (water management and railways), as well as a shortage of researchers and lecturers in agriculture. Other much-needed cross-sectoral skills, in particular innovation and entrepreneurship (e.g. to facilitate the development of businesses in rural areas and the emergence of more technology-intensive firms) are also lacking.

At the same time, Thailand needs to improve the quality of STI education and training at all levels. Quality education has been concentrated mainly in Bangkok and the large discrepancies in quality among teaching institutions needs to be addressed. A key means of for raising education quality is by holding educational institutions and stakeholders accountable. Current quality assurance processes have been insufficient to make underperforming educational institutions accountable and to foster collaboration with industry. Moreover, they divert attention away from improving quality.

Existing vocational education is no longer recognized as a major mechanism for training skilled workers, and requires a major overhaul. A revival of TVET will require the retraining of current staff and the hiring of more qualified teachers, as well as the provision of adequate incentives that reward good teaching performance. In addition, teaching methods, materials and equipment will need to be updated.

A major reason for the shortage of the STI skills required in Thailand is the lack of systematic interaction and linkages between academia and industry that would enable an identification of industry's skill requirements, the upgrading of university lecturers' and researchers' skills and the design of appropriate curricula. Researchers and their institutions have few incentives to collaborate with industry. In turn, industries' demand for technological services or research from universities has been sparse. Inadequate policy coordination between research, education and industry is also hindering such linkages.

The improvement of human resources in STI will largely depend on the ability of the country's policymakers to tackle serious weaknesses throughout education system – from pre-primary to post-graduate levels. This will require extensive efforts and a holistic approach, including changes in entrenched perceptions in a number of fundamental areas. First, the potential for skills development and training of students from rural areas cannot be underestimated. Second, vocational and agricultural education as well as teaching careers must be fully recognized and respected. Finally, the development of knowledge, competencies, skills and values – rather than the obtaining of diplomas – deserve to be accorded greater value.

Thailand has made considerable efforts to support human resources development in STI, carrying out multiple programmes, often based on good international practices. However, those efforts now need to be scaled up and combined with a review of the incentives (remuneration, budget allocations, recognition) and processes (skills mapping, planning, monitoring and evaluation) needed to systematically enhance the quality and relevance of STI education and training. To tackle the weaknesses identified, a number of strategic actions are recommended below, in line with those suggested for strengthening the overall national innovation system.

Moving leaders and institutions out of their comfort zone

It will be imperative to create awareness of the pressing need for improving the quality and relevance of STI education and training, in particular for revamping vocational education, upgrading entrepreneurship and innovation skills, and strengthening industry's participation in training and research activities.

To achieve the level of transformation required in STI education and training, actors need to move out of their comfort zone and make greater commitments. Public agencies need to progress from sponsoring pilot educational projects to promoting strategic changes and the wider use of relevant models. Firms should participate more in teaching and research activities. Research organizations, as institutions and not only individual researchers, ought to reach out and collaborate with firms, farmers and users.

Mobilizing for common goals and aspirations

The Government of Thailand should work together with industry, education leaders, policymakers, teachers and trainers to establish and implement a common agenda on human resources development in STI. This requires long-term commitment and policy coordination built around shared goals, and should include specific short-, medium- and long-term objectives to be achieved within specified time frames. It should designate clear responsibilities, accompanied by sufficient financial resources and institutional commitments.

Strengthening STI governance and management

Take appropriate measures with regard to underperforming educational institutions and actors identified through the established quality assurance processes. Quality assurance processes should be adjusted to reward institutional collaboration with the private sector. Over time, the performance standards for all higher education institutions should be raised.

Budget allocations should increasingly be linked to performance in a manner that provides adequate incentives for quality enhancement and that takes into account the varying purposes and roles of different educational institutions.

It would also be advisable to conduct a review of the quality and relevance of skills development training, and introduce mechanisms to ensure that employee training provided by firms is relevant.

Policy coordination is vital to ensure that education and training respond to industries' needs and promotes strategic spillovers. The formal participation of a wide range of stakeholders in policy design, implementation and evaluation would strengthen policy coordination. It may be necessary to strengthen information and analysis of labour market needs and the dissemination of the findings, while also enhancing incentives for educational and training institutions to better align their curricula, education and training so as to equip students with the skills needed by industry. At the same time, to encourage institutional investment in teaching, research and infrastructure, greater certainty in budget allocations and clearer information about STI human resource needs should be provided to educational institutions. For example, the railway megaproject should include a plan for HRD.

Improving resource management

Education and research budgets should be streamlined to provide sufficient resources for training teachers on STI skills, for the development of STI teaching materials, and for supporting linkages with the private sector. The inclusion of specific budget allocations and requirements for HRD in national mega projects (e. g. the railway project), as noted below, would support efforts to bridge the skills gaps and provide strategic opportunities for industrial development.

Linking innovation actors

Efforts should be made to promote effective interaction and collaboration between academia and industry. There is a greater incentive for such collaboration when evaluation of universities also includes assessing their ability to collaborate with industry, and when researchers' participation in industrial research and the provision of advisory services to firms is formally recognized and valued for the advancement of their careers. A clearer IP policy for publicly funded research would also facilitate industry-academia collaboration.

The mandates and management capabilities of UBIs and TLOs should be strengthened, for example by establishing business like approaches and structures and ensuring these are managed by staff with strong experience in or with the private sector.

Programmes that expose students, teachers and academics to working conditions in the business sector, including internships, dual vocational training, mobility programmes for researchers and combined studies, should be reinforced and scaled up significantly. Restrictions on mobility in current public scholarship programmes should be relaxed. Successful cooperative educational programmes (e.g. the Mechai Pattana School, the pilot work integrated learning programme, and the engineering practice schools at KMUTT) should be expanded to reach a critical mass of beneficiaries. Mainstream dual vocational training requires a major overhaul, including upgrading teachers' qualifications and teaching methods and resources.

Supporting decentralization

Most quality education and training is concentrated in Bangkok. The development of STI-related human resources beyond Bangkok should be supported by expanding the number of schools that promote innovation and local development (e.g. the Mechai Pattana school), by further boosting regional science parks through sound development plans financed with adequate resources, and by continuing to back research networks such as centres of excellence networks.

Expanding international connections

Thailand could leverage more HRD from TNCs by promoting business linkages between foreign and domestic firms (including incentives and requirements for TNCs to train and build the capacities of local firms), and by encouraging TNCs' involvement in sector-specific training programmes.

A programme to attract skilled workers from abroad to compensate for specific skills shortages and widen international connections should be considered. Thailand's participation in international research networks would also be worth expanding, particularly in those networks that address issues of national interest. To enable further integration into international teaching and research networks, the development of improved foreign language skills will require continued support.

International experts should be involved in the evaluation of STI programmes in order to provide an independent assessment of policies and new learning opportunities.

Taking advantage of megaprojects

Considering practical needs and strategic opportunities, the railway megaproject should identify, at an early stage, its main human resource needs as well as the industrial areas with development potential. It should include specific budget lines for HRD (including for the development of training institutions). To encourage timely investments, it should provide clear indications to training and research institutions on its current and future human resource requirements. Technology spillovers can be generated if technology-transfer considerations, including, local content provisions that favour joint ventures with local enterprises, and requirements for the training of local engineers and technicians, are made an integral part of negotiations with international suppliers.

Prioritizing the agenda: Short-term perspectives and long-term developments

The development of human resources in STI requires long-term investment that may take time to yield results. To provide concrete results rapidly, public action can start by introducing simple measures that do not require substantial resources or negotiation (for example, adjusting performance indicators to value institutional and researchers' collaboration with industry) or by scaling up good practices/programmes that already exist.

On the other hand, to enable substantive and sustained change, more extensive reforms will need to be negotiated, agreed upon and carefully implemented, even if their impact will become apparent only in the medium or long term. The more urgent reforms are an overhaul of TVET, building industry-university collaboration, and increasing education, research and industry policy coordination.

NOTES

1 Entrepreneurial and innovation skills encompass attitudes (e.g. persistence, networking, self-confidence, creativity) as well as enabling skills (e.g. business planning, financial literacy and managerial skills).

2 UNESCO UIS data at: http://data.uis.unesco.org/# (accessed 21 May 2014).

3 The OECD's Programme of International Student Assessment (PISA) assesses the extent to which 15-year-old students have acquired key reading, mathematics, science and problem-solving knowledge and skills.

4 The Trends in International Maths and Science Study (TIMSS) reviews the extent to which pupils in 4th and 8th grades can understand and apply essential maths and science knowledge.

5 Data provided by Thailand Development Research Institute

6 Based on data provided by the National STI Policy Office, 2014. No public data were found. Rajabhat universities are limited admission universities that merged from the integration of teacher training colleges. Rajamangala Universities are the result of merging technical and commercial colleges.

7 The five offices are: Office of the Permanent Secretary (which, among others, oversees private educational institutions and non-formal and informal education), the Office of the Education Council (responsible for national education policy formulation and coordination), the Office of Basic Education Commission, OHEC and OVEC.

8 Usually, double the number of study years financed by the scholarship

9 The nine national research universities are: KMUTT, Chiang Mai University, Chulalongkorn University, Mahidol University, Thammasat University, Kasetsart University, Khon Kaen University, Suranaree University of Technology and Prince of Songkla University.

10 See: OHEC press release, July 1, 2009 at: http://www.nru.go.th/.

11 The government budget is approved on an annual basis, and the funding for public multi-year research projects needs to be renewed annually even if the overall budget for a project has been approved.

12 For further details, see chapter 2.

13 National Statistical Office, at: http://web.nso.go.th/en/stat_theme_socpop.htm.

14 The module on enhancing entrepreneurship education and skills development of the UNCTAD Entrepreneurship Policy Framework and Implementation Guidance provides policy guidance on how to promote entrepreneurship through education (see: http://unctad.org/en/Pages/DIAE/Entrepreneurship/EPF-3.aspx).

15 For discussions of this issue, see, for example, Tangkitvanich and Sasiwuttiwat, 2012; TDRI, 2013; Mounier and Tangchuang, 2010.

16 TVET qualifications are poorly recognized in the workplace due to the heterogeneous quality of TVET. Students also perceive technical jobs entailing hard work and risk, and are not interested in the more technical or practical jobs.

17 The admission criteria for general upper secondary education have been lowered, and higher education institutions are eager to increase student enrolments as their budget allocations depend on student headcount.

18 Vocational education receives a lower budget per student than general education. Technical colleges receive 25,042 baht per technical student, while public high schools receive 28,261 baht per secondary level student (TDRI, 2013).

19 The average budget for upper secondary TVET teachers is only 6,753 baht compared with 20,460 baht for basic education teachers (TDRI, 2013).

20 In 2012, 43 per cent of teachers in public TVET colleges were employed with short-term contracts, which, by the time they have been trained in a specific position, require them to move to another position.

21 For example, the Institute for Promotion of Teaching Science and Technology (IPST) and a new teacher development programme where teachers spend six months working in industry.

22 According to Huang (2012), 3,000 firms are participating.

23 Such as the New Entrepreneur Creation program of the Department of Industry Promotion, Ministry of Industry.

24 The National STI Policy and Plan has not provided an effective road map for action, in part because it is too broad.

25 For example, in the field of biomedical engineering, experts from eight universities offering biomedical engineering programmes work together with industry to determine an action plan and develop PhD programmes.

26 The Bureau of the Budget does not participate in policy discussions but has a large impact through budget allocations.

27 See: http://manpower.mol.go.th/.

28 A number of the education stakeholders interviewed were not aware of the results of surveys on labour market needs.

29 For instance, an employer must hire four Thai employees in order to employ one foreigner (Order of Immigration Office No. 110/2546), and firms must have a fully paid registered capital of 2 million baht (data provided by TDRI).

30 Contact Singapore, at: www.contactsingapore.sg.

31 See: www.startupchile.org.

32 For example, 2012 was Thailand's Year of English Speaking. In 2014, the Ministry of Education decided to start implementing the Common European Framework of Reference for Languages in some schools.

33 From 2010 to 2013, only 134 students from S&T disciplines studied abroad or came to study in Thailand.

34 They concern engineers, nurses, architects, surveyors, tourism professionals, dentists, accounting services, and medical practitioners.

35 A first ASEAN Talent Mobility Workshop took place on 27–28 March 2014.

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