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National foresight in science and technology strategy development

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Abstract

The paper is concerned with the national foresight exercises in Thailand to devise the key science and technology (S&T) strategies. The Thai government, through the National Science and Technology Development Agency (NSTDA), has used the foresight processes to influence policy making and create national foresight programmes. The foresight exercise, covering the period from 2000 to 2020, aims to examine the potential of the Thai industry and investigate a set of development policies necessary to make the Thai industry successful by the year 2020. Three rounds of strategic conferences comprising 2677 people were set up to create a vision for the future of the industry. The results of the foresight process provide a comprehensive overview of the trends of the Thai industry. The study contributes towards the formulation of feasible technological and industrial policies, which would enhance the country's ability to improve the competitive position for tomorrow.

1. Introduction

The paper is concerned with the national foresight exercises in Thailand to devise the key science and technology (S&T) strategies. The Thai government, through the National Science and Technology Development Agency (NSTDA), has used foresight as a policy instrument to develop national S&T policies. The study has applied a foresight process to look forward the plausible paths of the Thai industries in 2020. By grasping the trends and a view of the future, Thailand aims to create national programmes to increase technological capabilities for catching up and competing in tomorrow's world. The paper

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is organised as follows: Section 2 presents the literature review on technology foresight and the role of S&T in advancing the national innovation system. Section 3 analyses the foresight exercise undertaken by NSTDA to understand future visions in S&T. Section 4 presents the process of foresight exercise for guiding S&T strategy development, foresight directions as well as the intended results of the foresight process in reinforcing the national clusters. Policy implications for policy makers as well as conclusions are drawn in Section 5.

2. Theoretical framework

2.1. Conducting technology foresight

Technology foresight constitutes a means for grasping the trend of technology development. The use of foresight can provide an information base to assist government in the policy-making process. To promote industrialisation, many countries use foresight as a means to assess scientific and technological developments, which could have a strong impact on industrial competitiveness, wealth creation and quality of life [1,2]. Foresight revolves a cycle of environmental scanning, interpretation and learning. It also aids the development of a longer time horizon for business or policy development and assists in identifying opportunities and threats. The policy measures and the governmental strategies to guide firms in selecting technologies, mastering technological activities and diffusing innovations straightforwardly concern the foresight procedure [1, 3–6].

Technology foresight implies that technology can be predicted, and therefore planned for desirable outcomes in the future. However, there are limitations in terms of making investments to undertake R&D activities for increasing S&T capabilities. In other words, the industrial restructuring outcomes may not be possible if a nation lacks sufficient resources to impact technology development guided by the foresight study. In the real foresight process, the policy makers might be less specialised and could falsely set priorities and select technologies to be developed without regard to technological capability, economic capability, industry needs, manpower and others (other factors in the national innovation system). Therefore, the well-organised foresight activities are essential. In the UK, it has set up the National Foresight Exercise to support and plan activities in various sectors of the country. In the US, the foresight exercise has taken place in the Ministry of Defense and the Ministry of Commerce. In Japan, the foresight launched by the Ministry of International Trade and Industry (MITI) enables the country's moving into the forefront of international R&D. According to Bowonder and Miyake's study [7,8], technology foresight in Japanese firms was undertaken with an aim to create a competitive advantage and a more rapid development of innovation. The development of the national innovation system in Japan utilised network structures, which facilitated the reduction of risk and uncertainty. Bowonder and Miyake also explored how Japan used technology foresight to get useful insights on what future development would be like and which parties should be involved to carry out that vision. Ayres and Axtell [9] held the view that technology foresight, a method heavily employed by the Japanese firms, is a significant factor in minimising the risk and controlling uncertainty about the future.

In national foresight programmes, the government plays a sponsor role through the appropriate departments or ministries. The foresight process requires a combination of creative thinking about the future, eliciting expert views on the future and constructing

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alternative futures to inform policy making. The Thai foresight exercise was conducted through the use of Delphi to identify the direction of Thailand's S&T development trends in consistent with the foresight programmes in Japan. The foresight exercises in Japan were conducted at various levels (including the ministries and government agencies) and on a regular basis (every 5 years since the first survey in 1971). In Thailand, the foresight exercises were conducted by the APEC Center for Technology Foresight (under the remit of NSTDA). Whereas Japan's foresight was focussed on a broad range of technologies corresponding to global trends, Thailand's foresight was focussed on the necessity and possibility of developing specific technologies with regard to the country's needs.

Foresight can be seen as a way to cope with the relentless change of the business environment. The use of foresight to create multiple product innovations often requires probing the future [10]. The outcome of the foresight programme is a series of policies, programmes, products, processes and many other aspects of socio-economic activity, and networks of collaborators. The methods of foresight process include:

(1) *Brainstorming*: A process of idea generating to find solutions to specific and well defined problems. The direct discussion of free thinking stimulates a climate of creativity [11–13].
(2) *Delphi technique*: A process of elucidating scientific and theoretical principles or phenomena. The Delphi process starts with the selection of a panel of experts to provide interaction between several opinions. The process would use questionnaires or employ conferences/workshops to foster widespread debate [14]. The questionnaire is sent to a group of selected experts. The results from the first round and the development of the second round questionnaire are sent to the participants again in order to make a revised judgement of their previous answers. This process continues until a steady state is reached [4,15].
(3) *Scenario writing*: A process of creating future visions or constructing pictures of possible futures. The scenario writing method portrays a path away from the present to some hypothetical future state and generally results in options for policy [16–20].

2.2. Science and technology as an essential tool to advance the national innovation system

The national system of innovation (NSI) is the interactive system of institutions, aiming at the production, diffusion and exploitation of knowledge within national borders. Foresight in S&T has been a generally accepted instrument in developing a strategy for a specific technology whereby interconnections and interactions among the institutions play an important role in the course of technological progress [21–24]. Given that the nation-specific factors have shaped technological change of the nation, the level of resources devoted by each nation to research and development (R&D) and innovative activities represents a basic characteristic of NSI [22,25–27]. Determinants of national economic performance and technological capabilities are the size of a country, R&D intensity and market structure [28–29].

The concept of NSI helps explain the technological development and industrial innovation. Lundvall [22] argued that the most fundamental resource in the modern economy is knowledge. The governments in developing countries are considered the national agents playing a crucial role in strengthening technological capability to support the S&T system of the nation [30–31]. Promoting S&T specialisation would influence a

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nation's future economic performance since countries with technological strengths in rising areas are likely to benefit from increasing returns, which in turn would allow them to expand technological and production capabilities [29].

The government S&T efforts in guiding technology investments and competence building for the next century would increase the competitiveness of NSI [22,32]. It is argued that the launch of programmes to develop certain technologies would have influence on the performance at the national level. The national R&D programmes would lead R&D activities in the government research organisations, business firms, universities, and others. Given that technology foresight provides information for estimating consequences of new technologies, the nation needs policy coordination among various agents participating in the innovation system to promote sustainable economic growth and long-term competitiveness [28,33].

3. Management of NSTDA foresight exercise

NSTDA has recognised the need to employ technology foresight as a useful tool to bring forth a new dimension of the policy making process. It has organised the foresight exercises where the author has involved in the implementation of the main foresight stage to explore future visions in S&T. The time horizon within which the technology foresight is undertaken covers the period between 2000 and 2020. The foresight project study 'S&T 2020' (Foresight in Science and Technology) aims to formulate a coherent vision of Thailand's science and technology within a 20-year timeframe. The foresight project comprises the three core steps of (1) pre-foresight, (2) foresight and (3) post-foresight (Fig. 1). The activities of the foresight process are shown in Table 1.

To foresee the direction of future S&T development during the period of 2000–2020, the foresight exercise had been taken through three rounds of strategic conferences. The views were from 2677 people including well-qualified personnel and experts from the public sector, private sector and disparate group of people. Each conference aimed at eliciting expert opinions on the direction of future S&T deemed to be of high level importance for economic and social development of the country. The essence of the strategic conferences is also to build a network of industry-government collaboration to understand a level of changes occurring in business which would aid an evaluation of research priorities. NSTDA has conducted the forward look for industries of agriculture; manufacturing;

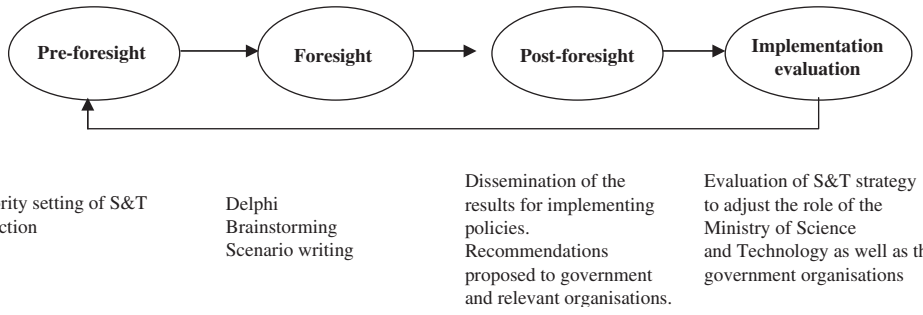

Fig. 1. The foresight process.

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Table 1
Activities of the foresight process

Phase	Activities
1. Pre-foresight	The process is a forward thinking about possible critical technologies. NSTDA has developed the vision of the future by looking at possible future needs, opportunities and threats to identify the scope of the priority setting for important technologies
2. Foresight	The process involves an in-depth analysis and discussions to identify key issues and trends in terms of market and technological opportunities up to 2020. The foresight exercise is conducted to develop a set of priorities for the government's investment in S&T
3. Post-foresight	The process involves the dissemination of results and their integration into government decisions
4. Implementation evaluation	The submission of the results of the foresight process to the foresight steering committee with policy recommendations proposed to the government. The main activity in the process is generating commitment to the results (commitment in translating the results into the future development)

service; education, culture, healthcare and welfare system; environment, energy; and communication and telecommunication. Table 2 shows specific considerations when undertaking the research and development in creating the future of Thailand's industries (the base of scientific and technological activities that need to be stimulated over the years).

The support of government through budget to enable the move into the future is shown in Fig. 2. The R&D budget for developing technological capabilities can be seen as policy enabler. From the year 1992 to 1997, it can be seen that the budget increased by 1229 million THB or 387%. However, after years of economic growth, then things changed. The currency crisis forced Thailand to float the THB currency on July 2, 1997. This devaluation plunged the country into a financial turmoil and had an important influence on the budget allocated to support the government's planned activities. The downward trend outlined in this graph after the year 1997 was a consequence of a financial crisis. Even so, the overall budget in the forthcoming years is increasing (although at the decreasing rate). This increase could be seen as a deliberate commitment throughout the economic uncertainty to maintain the momentum in developing S&T capabilities.

4. The process of foresight exercise for guiding S&T strategy development

Thailand has carried out the foresight exercises by learning from other countries' experiences and obtaining advice from developed countries. The foresight exercise conducted by NSTDA aims to guide S&T development in 6 sectors: (i) research, development, design and engineering (RDDE), (ii) technology transfer, (iii) S&T human resources development, (iv) enhancement of S&T infrastructure, (v) internal management and (vi) S&T information services. The results of an opinion consensus suggest the creation of 12 clusters (Table 3), based on the national competitiveness agenda recommended by Prof. Michael Porter [32,34,35]. The results of the foresight study suggest that the clusters should be built upon the strengths of Thailand to improve the nation's competitiveness. It is hoped that the results of the foresight process to reinforce the national clusters would create higher productivity in the Thai economy. From the foresight exercise, the experts'

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Table 2
Technology foresight considerations in creating the future of Thailand's industries

Economic sector	Specific considerations
1. Agriculture	• Biotechnology to improve plant and animal breeding • Food quality assurance system for export increase
2. Manufacturing	• Reduce vulnerability and risk of foreign technology dependency • Clean technology for reducing environmental impact • Improvements in materials—composite material for effective production
3. Service	• R&D in supply chain management, customer relationship management, electronic commerce for online marketing • Multimodal transportation for improved service operation • Simulation for increased ability of aviation, shipping and transportation system
4. Education, culture, healthcare and welfare system	• Classroom instruction with wide applications to improve human capital • Advanced medical systems for replacement of traditional treatment to improve the quality of life for patients • Research in post-genomic medicine for improved genetic study • Production of essential pharmaceuticals for domestic use
5. Environment	• R&D to improve and sustain the environment • Development of eco-system to protect the environment • Energy saving and pollution control • Clean technology for environmental quality • Contribution to technology recycling
6. Energy	• Energy-saving and energy-efficiency • Biomass – natural gas, water as alternative energy sources to aid sustainable economic development • Solar cell to improve electricity generation
7. Communication and telecommunication	• Hardware (computer components) and software to support high performance computing activities • Advanced network of internet protocol to better communication

Source: S&T 2020 Vision—Status and Strategies (The National Science and Technology Development Agency).

views suggest the government science policy to incorporate a research programme, aiming at innovations in the long term.

The specific cluster development shown in Table 3 indicates the S&T area and foresight directions. It is argued that the foresight studies need government commitment to affect purposeful changes. However, within the national system of innovation, there has been a lack of collaboration between the government organisations, the private sector companies and academics. It is thus challenging for NSTDA (as a policy advisory and organisational mechanism) to address the coordination problems. Collaboration at the national level and a comprehensive action plan to implement policies are needed in the process of industrial development. Currently, the Thai researchers, who mostly work in the government and

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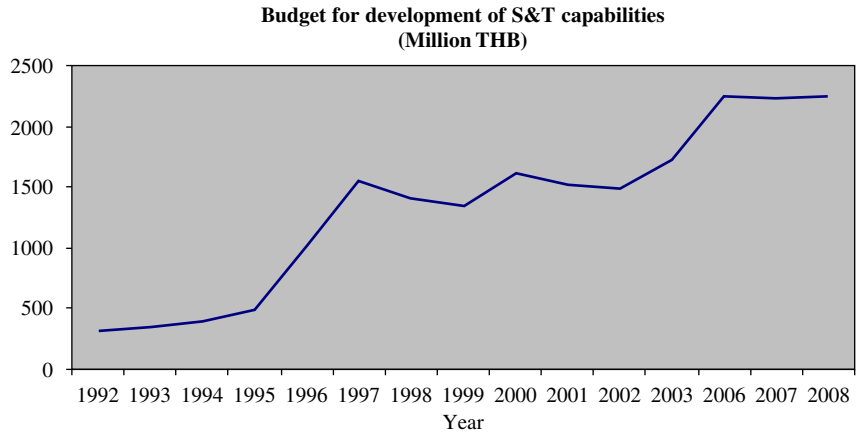

Fig. 2. Budget for development of scientific and technological capabilities.

universities' laboratories, lack a full understanding of the technological demands of the industry. Further, the industry is not aware of what kind of technology is under development in the government research institutions as well as the universities. If the possible/desirable outcomes are to be achieved, multi-disciplinary R&D through collaboration among government research institutions, firms and universities is necessary. Otherwise, the development of implementation plans would be difficult in practice and the results of the foresight exercise might result in the low effectiveness of the policies. NSTDA holds the key responsibility to facilitate the policy implementation to support the development of the S&T system of the country.

5. Policy implications and conclusions

The conduct of national foresight in science and technology strategy development would create economic opportunities in Thailand. As a developing country, Thailand faces the need to develop simultaneously their economies and their technological capabilities. The Thai government, through the NSTDA, has used the foresight processes to influence policy making and create national foresight programmes with the purpose of improving the national competitiveness. NSTDA has used technology foresight as a process to set priorities and select key technologies to be strategically developed. The policy implications from the study are as follows:

(i) The foresight exercise developed by NSTDA was aimed to offer a perspective for a vital research system in 2020. Regarding effectiveness, sufficient and comprehensive policies are necessary for the implementation of the expected outcomes. To catch up with rapid technology changes, future policies need to be clear and consistent. It is important that NSTDA emphasises on educating the researchers to keep the R&D activities right on the scheduled track. Otherwise, the process of catching up with other countries might have been delayed. The opportunity for catching up needs strengthening S&T policies since the technological capabilities are a major source of the national competitiveness.

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Table 3
Framework of cluster development

Clusters	Framework of cluster development
1. Food	• Use of biotechnology, information technology, post-harvest storage and processing technology to improve food quality and functionality • Constructing research, development and innovation system in shrimp, meat, vegetables, fruits, herbs and spices to promote Thailand as 'Kitchen of the World' • Integrated supply chain development linking farms to consumers • Creating the Biopark focussing upon food research equipped with one-stop services from farm to table • Breed improvement of fish, meat, vegetables, fruits quality with the use of marker assisted breeding. • Quality system development of GMP, HACCP, ISO, GAP, GHP
2. Automotive	• Automotive cluster development to turn Thailand into the 'Detroit of Asia' • Training and supporting entrepreneurs to improve skills from lower tiers to higher tiers • Collaborative research to develop product champion of the Thai auto industry
3. Software, microchip and electronic products	• Enterprise software development for government agencies and small- and medium-sized enterprises (SMEs) • Commercial development of animation software, software for smart cards, radio frequency identification (RFID), agritronics, auto-electronics, factory automation
4. Fashion	• Home textile development with the use of computer-aided manufacturing, automation and total quality management • Use of nanofiber technology and nanoencapsulation technology, technical textile technology for the production of phase change materials • Development of software for textiles and apparel product design and manufacturing
5. Tourism	• The use of S&T to improve the environment at tourism sites and standard and quality of tourism services in moving Thailand towards 'Tourism Capital of Asia' • The use of information technology (IT) to provide the tourists with information about tourist attractions, hotel rooms and bookings • Establishing tourism call centres to improve the information system and service quality • The use of global positioning system (GPS) technology on vehicles to monitor travelling and provide safety for the tourists
6. Healthcare	• The use of genomics and post genomics technology for near-patient care (point of care/ preventive healthcare) • The use of combinatorial chemistry, high throughput screening technology and biotechnology for administering new drug candidates • Improvement of drug delivery systems to enhance therapeutic potential and efficacy of the drug products
7. Energy	• Expanding research on alternative/renewable energy of gasification, direct combustion, biofuel, fuel cell, solar cell, wind, water • Using agricultural/biological waste for energy • Human capital development in nuclear energy studies • Promoting an increased use of co-generation system for bio-gas production

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Table 3 (*continued*)

Clusters	Framework of cluster development
8. One Tambon One Product (OTOP) programme development	• Creating high-value products with government programme supports in production, marketing, packaging • Improving food products with safety under Food and Drug Administration (FDA)'s jurisdiction • Increased emphasis on material quality and manufacturing process to improve production efficiency • The use the information and communication technology (ICT) to provide information for improving the quality and efficiency of products for exporting to global markets • Developing OTOP portal links with e-commerce services to facilitate the selling of innovative products
9. Modern technology	• The use of Thailand Earth Observation Satellites (THEOS), National Spatial Data Infrastructure, Broadband Communications Satellite and GIS Workstation in the aerospace industry to improve communication speed and transmission efficiency • Improving human capital to develop Thailand's capacity in space science • Enhancing the spatial data infrastructure system and digital one-stop portal to enable Thailand to be Digital Thailand and establishing coordination with foreign countries in moving towards Digital Asia and Digital Earth • Developing the national innovation system and reverse engineering capability for technological catch-up
10. Science for society	• Using information and communications technology (ICT) to support e-Learning and e-Education • Developing e-Government and e-Health system to support infrastructural development • Setting up science camps, science exhibitions and festivals for young people to foster the development of future leaders in S&T • Developing Prime Minister Operations Center (PMOC), Ministerial Operation Center (MOC) and Department Operations Center (DOC) for government's decision support
11. Mathematics and science education	• Developing the educational system emphasising science and mathematics • Developing human capital in S&T programmes • Developing technician skills for working in high-value industries • Developing skills in critical thinking including science-based thinking for young people
12. Nanotechnology	• The use of nanobiotechnology, nanoelectronics, nanomaterials to improve the economic value of product innovations • Competitiveness-enhancing policies to be leader of nano-materials in Asian countries • Human capital development in nanotechnology

Source: The National Science and Technology Development Agency.
Note: Cluster 8—one tambon one product (OTOP) programme development 'Tambon' means village or town. Thailand has been involved with the One Village One Product (one tambon one product or OTOP) as a national policy since 2001. There are 76 provinces in Thailand. The Thai government has designated OTOP for each village of the provinces. The government ministries and agencies cooperate by providing production and marketing skills to assist the local residents. The OTOP programme initiated by former Prime Minister Thaksin Shinawatra aims to create new jobs and increase income for people in the communities all over the country.

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(ii) The government needs to provide an infrastructure and environment conducive to the institutionalisation of organised problem-solving. Currently, NSTDA has shaped the plans for the development of S&T priority setting. The Thailand science park and the software park have provided facilities in terms of technology support, production support and marketing support to strengthen research efforts which can bring improvements of S&T capability. However, in the interim period until 2020, the operation of scientific research system should be innovation-driven to promote competitiveness of the economy. The government policies need to be in line with the broad aims of the industrial development plan. Technology planning should be developed in an integrated way of all the interacting actors/institutions in order to implement the results of a foresight programme effectively.

(iii) The foresight exercise is an important investment of the government. However, technology foresight is a process whose payback is usually long, and thus requires the foresight committee to follow up the task of translating the results into advice for government activities. It is important that NSTDA plays a key role to articulate the objectives of a desired national endeavour and to proactively induce R&D activities of enterprises. The feedback from an implementation process would provide useful information for the government to improve an industrial development plan with appropriate continuity of policy.

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