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ASSESSING THE NATIONAL INNOVATION SYSTEM IN A DEVELOPING COUNTRY CONTEXT: A FRAMEWORK AND EVIDENCE FROM THAILAND

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ABSTRACT

National Innovation Systems (NISs) are a source of considerable policy interest, especially when used to enhance nations' innovative capacity and competitiveness. The study develops a framework for assessing the status and performance of NISs based on concepts of policy adoption, implementation, and evaluation. The study then examines the case of Thailand, which is building its national innovative capacity using the NIS approach. The issues relevant to Thailand's NIS are reviewed and the assessment framework is applied. A comprehensive model of the Thai NIS is also conceptualized, and recommendations for Thai innovation policy are made. These recommendations include minimizing conflicts in resource allocation, incentivizing private sector innovation, encouraging universities' participation in the NIS, and rationalizing the public sector components. Based on these policy recommendations, the study offers a "country-specific" framework for assessing the status and performance of Thailand's NIS. It is shown that the NIS is a sophisticated yet useful approach to encouraging innovation in the economy. Both commonality and uniqueness exist in developing and individual country NIS, therefore each country has to acknowledge these factors and create an NIS that best fits within its development context.

DEDICATION

To my parents, Marisa and Samarn Yennarn, for their constant love and support; and to my husband, Jeff Parkey, for his unconditional love and encouragement. Without them, it would not have been possible.

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LIST OF ABBREVIATIONS

BIOTEC	National Center for Genetic Engineering and Biotechnology
BOI	Board of Investment
CAT	Communications Authority of Thailand
COE	Center of Excellence
DIP	Thailand Department of Intellectual Property
GCR	Global Competitiveness Report
GRIs	Government Research Institutes
HDD	Hard Disk Drive
HRD	Human Resource Development
ICT	Information and Communication Technology
IFCT	Industrial Finance Corporation of Thailand
IP	Intellectual Property
IPR	Intellectual Property Right
ITAP	Industrial Technology Assistance Program
KAM	Knowledge Assessment Methodology
MOL	Ministry of Labour
MOST	Ministry of Science and Technology
MOSTE	Ministry of Science, Technology and Environment
MTEC	National Metal and Materials Technology Center
MSO	Ministry of Social and Human Security Development
NANOTEC	National Nanotechnology Center
NECTEC	National Electronics and Computer Technology Center
NIA	National Innovation Agency
NIC	NSTDA Investment Center
NIEs	Newly Industrializing Economies
NIS	National Innovation System
NRCT	National Research Council of Thailand
NRF	National Research Foundation
NSTC	National Science and Technology Commission
NSTB	National Science and Technology Board
NSTDA	National Science and Technology Development Agency
NSTDB	National Science and Technology Development Board
OECD	Organization for Economic Cooperation and Development
OEM	Original Equipment Manufacturers
OSMEP	Office of Small and Medium Enterprise Promotion
OSTI	Office of Science and Technology Innovation
R&D	Research and Development
ROH	Regional Operating Headquarters
S&E	Science and Engineering
S&T	Science and Technology
SMEs	Small and Medium Sized Enterprises

List of Abbreviations (Continued)

STI	Science, Technology, and Innovation
STI	National Science Technology and Innovation Policy Office
STPC	Science and Technology Policy Council
TISTR	Thailand Institute of Scientific and Technological Research
TFP	Total Factor Production
TMC	Technology Management Center
TOT	Telephone Organization of Thailand
TPA	Technology Promotion Agency
TRF	Thailand Research Fund
TSP	Thailand Science Park
UILs	University-Industry Linkages
USPTO	United States Patent and Trademark Office
VC	Venture Capital
WEF	World Economic Forum
WTO	World Trade Organization

CHAPTER 1

INTRODUCTION

With globalization, the pace of international economic integration has accelerated during the last two decades through innovations in communications, information processing, and other advanced technologies. Thomas Friedman (2005) refers to globalization as a process that is "shrinking and flattening the world" (p. 11). One of the important characteristics of globalization has been the reduction of domestic impediments that expose actors[1] at national and sub-national levels to the pressures of economic competition at the international level. These conditions make it increasingly inevitable for actors to seek the most innovative technologies and methods of working in order to compete globally.

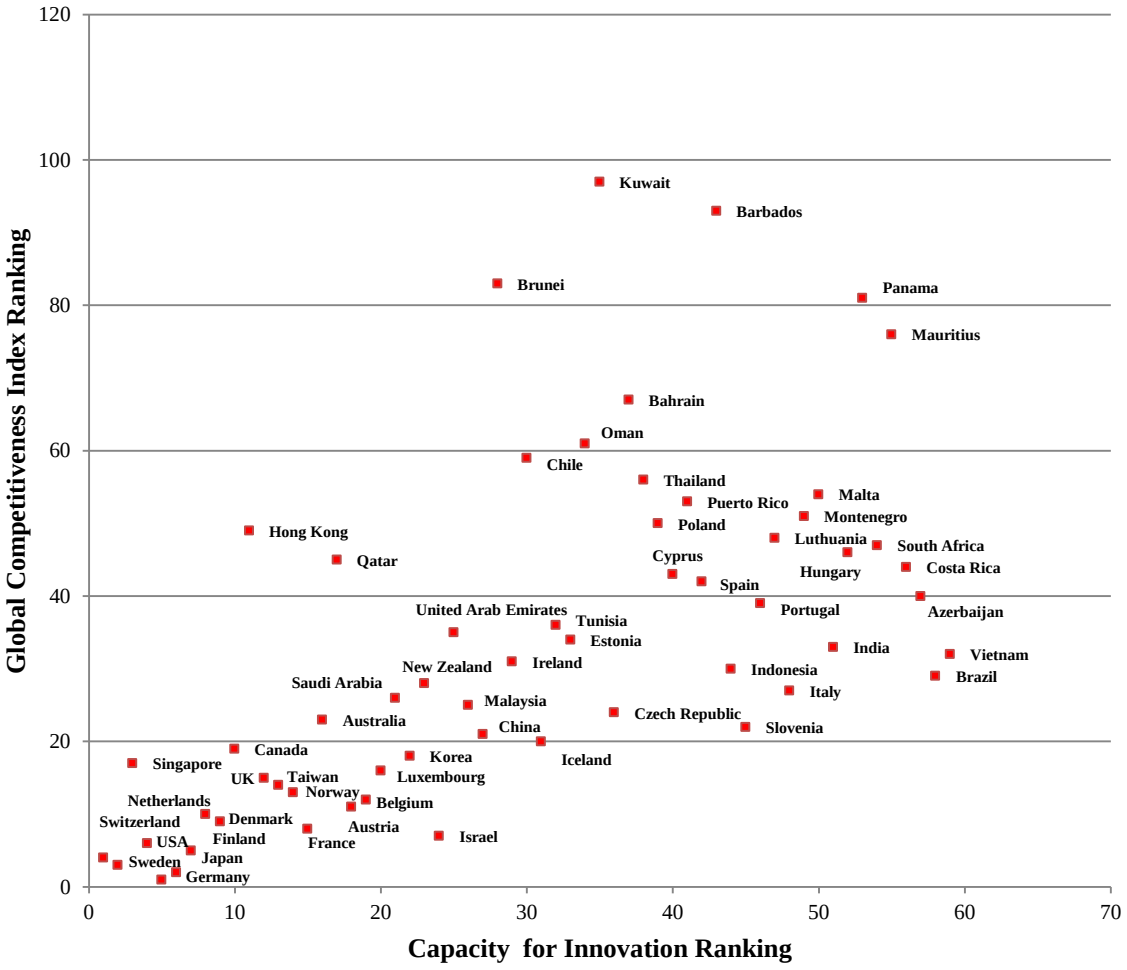
According to the Organization for Economic Cooperation and Development (OECD), *innovation* is now the key driver for economic growth in developed countries, with at least 50% of growth directly attributable to it (OECD, 2005). Innovation is the act of bringing something new into use, including a new product, process, or method of production. These trends now mean that the creation and exploitation of innovation and an understanding of the processes that stimulate it are fundamental to nations' economic growth, development, and social welfare (Kayal, 2008; OECD, 2005).

Figure 1.1 below presents countries' rankings in global competitiveness matched with rankings of their capacity for innovation. Several countries, including Denmark,

[1] Actors refer to enterprises and firms, their clients and suppliers, universities and centers of productivity, research institutes, government and standard-setting bureaus, and banks (OECD, 1997b).

Finland, Germany, Israel, Japan, Korea, Norway, Singapore, Taiwan, and the United States are among the top performers in both categories. These countries are typified by conditions that are conducive for advanced technology development, such as high levels of investment in research and development (R&D) activities, often as much as 2% of GDP.

Figure 1.1 Competitiveness and Capacity
for Innovation Ranking of Selected Countries



Source: Based on World Bank, 2009 (for capacity for innovation ranking) and WEF, 2010 (for global competitiveness index ranking)

Many of these leading countries take a holistic approach to encouraging modern technological innovation in their economies through the implementation of strategic public policies. The "National Innovation System (NIS)" is a conceptual framework used by many of these countries for developing policies that coordinate and stimulate innovative activities in the economy (EU, 1995; OECD, 1997a; OECD, 1997b). The NIS approach holds that the process of technological innovation is enhanced with the interaction of public and private institutions and the coordination of relevant policies, incentives, and initiatives (Edquist, 1997; Freeman, 1982; Lundvall, 1992; Nelson, 1993; Smith, 1997).

The innovation system approach takes the view that private firms are the primary innovators in the economy. Innovating firms undertake R&D activities in pursuit of "new-to-the-world" products and processes for markets and/or for internal use. However, firms also face the risk that innovative efforts might not turn out as they intended or that or their benefits may spill over to others. Firms therefore face disincentives to undertaking innovative activities.

To help in the innovative process, government can play an important role. Government can stimulate technological innovation in firms by providing supportive institutions and rules, targeted incentives, R&D collaboration and investment, and a coordinating infrastructure. Measures such as these can be incorporated in a systemic approach, which government can use to create an environment that is conducive for innovation in firms. This is the idea of the NIS.

Statement of the Problem

The systemic approach to the promotion of innovation in the economy has gained popularity in both developed and developing countries. Governments around the world are aware that countries pursuing a systemic innovation development strategy have technological advances and a competitive edge. Therefore, several countries are adopting the NIS approach in an attempt to repeat these same successes. This is the idea of "policy diffusion" and "best practice." Moreover, the OECD, which promotes international standards and best practices for economic development policy, has promoted the NIS concept among both its member and non-member countries.[2]

For policymakers in developing countries, however, the adoption of the NIS as a policy framework may pose challenges. Developing countries often lack the scientific and technological foundation and the institutional components necessary to close innovation development gaps through the NIS approach (Shulin, 1999). Studies of NIS implementation in developing countries have therefore focused on facilitating NIS "best practices" as well as identifying "country-specific" aspects. This may require the design and implementation of NIS to be based more on domestic needs, capabilities, structures, and intuitions instead of "one-size-fits-all" international standards (Intarakumnerd, 2007; Kayal, 2008; OECD, 2005; Shulin, 1999).

From these experiences, national-level policymakers, especially those in developing countries, need a solid understanding of the NIS concept. Critical questions emerge for policymakers in evaluating the potential of the NIS. What are the necessary

[2] http://www.oecd.org/innovation/strategy

components of a fully-functioning NIS? How should NIS be structured and implemented in a given country? What criteria should policymakers use in determining the status of the NIS and how can the status and performance of the NIS be assessed? Few governments, even in developed countries, appear to have established systematic evaluation mechanisms for innovation policies. A framework for making a comprehensive assessment of the NIS approach could be particularly helpful to developing-nation policymakers.

To demonstrate how an assessment framework can be created and applied in a developing country context, a detailed case study of the NIS of Thailand is presented. Thailand is in the "efficiency-driven" or "investment-driven" stage of economic growth, and is in the process of transitioning to upper-middle-income status (WEF, 2010). To compete successfully with other countries and move into the "innovation-driven" stage, Thailand must build capacity to absorb complex technologies, accelerate productivity through innovation, and develop and commercialize new products (Brimble, 2003, p. 340; USAID, 2011; WEF, 2010). Since 2008, Thailand has been formally consolidating its policy to enhance the nation's competitiveness by encouraging innovation in firms under the NIS concept. Applying the assessment framework to the Thailand case helps to show: (1) why the country adopted the NIS approach; (2) the specifics of the system including its history, structure, and function; and (3) ways of evaluating the overall performance of the system in terms of fostering innovation. Moreover, perspectives of key government officials involved in Thailand's NIS, gathered through interviews, compliment the assessment.

Purpose of the Study

The above questions demonstrate the need for a comprehensive analysis of the NIS approach. The purpose of this study, therefore, is to develop a broad framework for assessing NIS which will investigate several key issues. First, an understanding of the NIS concept itself is required. What are the basic concepts of the NIS approach for encouraging innovation and what are the fundamental components of a system? Second, a comprehensive assessment should address the rationale for the adoption of the NIS approach. What motivates policy selection and what are the goals the policy is intended to address? Third, the assessment must investigate real-world organizational and institutional practices involved in designing and implementing the system. Finally, a comprehensive NIS assessment should provide guidance on ways to determine its effectiveness. Once NIS is adopted and implemented, how can its performance be measured? How do we know the system is working?

The following chapters develop and apply a framework for NIS assessment. In Chapter 2 the study reviews the scholarly literature on the role of technology in the economy, technological innovation, and the theoretical underpinning of NISs. Chapter 3 reviews relevant literature on the adoption and diffusion of public policy, and policy and program implementation and evaluation. It also presents three cases of NIS in innovation-leading countries, Finland, Korea, and Singapore, and reviews the techniques and measurements recommended by the OECD, the World Bank, and the World Economic Forum for evaluating countries' innovative performance. Chapter 4 presents and discusses the methods used in this study and includes the fully-formed NIS assessment

framework. Chapter 5 provides a case study of Thailand focusing on relevant economic development trends and the formulation of science and technology policy including the country's NIS program. Chapter 6 provides an assessment of Thailand's NIS performance based upon a number of assessment criteria adapted to the Thailand case. As a result, the impediments to innovation in Thailand become clear, and policy recommendations to address these impediments are discussed. Finally, Chapter 7 summarizes the study, presents a "country-specific" assessment framework for Thailand's NIS and draws conclusions about NIS in developing countries generally.

CHAPTER 2

INNOVATION, ECONOMIC DEVELOPMENT, AND THE NIS

In the global economy, technology, innovation, and national economic progress have become closely connected. It has been widely mentioned that technological innovation is an important source of competitiveness, economic development, and prosperity (Kayal, 2008; OECD, 2005; Roos, Fernstrom, & Gupta, 2005). It is said that "if you don't have innovation, you have nothing."[3]

This chapter begins developing an assessment of NIS by addressing several key points. First, the idea of innovation and its place in the economy is presented. Next, the role of government in encouraging innovation for economic development is discussed. The concepts of the systemic approach to innovation and the evolution of the NIS idea are then presented. Finally, the need for developing countries to catch up in the global economy and the possibility that NIS can assist this process is noted.

Technology and Innovation

Technology is a process or technique embodied in products, designs, manufacturing, or service provision which transforms inputs of labor, material, capital, information, and energy into outputs which are distributed to the market by firms (Burgelman, Christensen, & Wheelwright, 2004; Christensen & Bower, 2004). Firms adopting and exploiting the same technology can be grouped into industries, for example

[3] Mandel, M. (2001, February 16). Obama's innovation push: Has US really fallen off the cutting edge? *Christian Science Monitor.* Retrieved from http://www.csmonitor.com/USA/Politics/2011/0216/Obama-s-innovation-push-Has-US-really-fallen-off-the-cutting-edge

the automobile industry or the pharmaceuticals industry. Emerging technologies can create new industries when a technology embedded in a new product progresses from entering the market to growing, maturing, and ultimately declining from the market (Abernathy & Utterback, 1978). This process is referred to as the technology life cycle or the product life cycle.

Innovation is the act of bringing something new into use. This definition of innovation is differentiated from the idea of "invention," which is the act of bringing something new into being. In commercial or industrial applications, an innovation is a new product, process, or method of production. In organizational terms, innovation can mean the process of generating and implementing new ideas (Mohr, 1969; Rogers, 1995; Schumpeter, 1934; Smith-Doerr, Manev, & Rizova, 2004; Tidd, 2002).

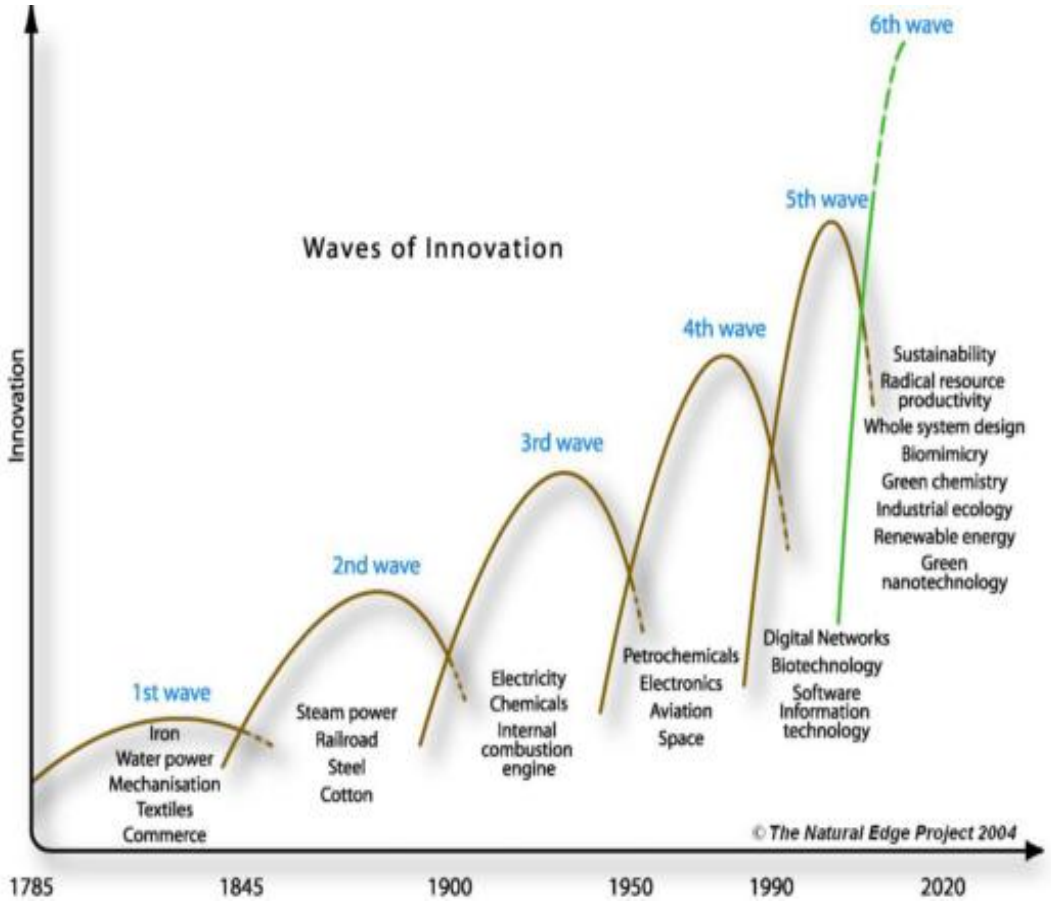
Technology is often viewed as an integral part of innovation. Many examples of technological innovations can be identified, such as the first microprocessors or digital cameras, which were new products based on new technologies. The MP3 player is also considered an innovation because it was a new product based on existing technologies. Using GPS for tracking transportation and delivery is an example of an innovative process. Introducing new management systems such as supply-chain management or quality-management systems is an organizational innovation (OECD, 2005).

This study views innovation primarily as the generation and implementation of new ideas that involve new technologies. However, innovation dealing with non technological applications is also recognized (OECD, 2005).

The Role of Technological Innovation in the Economy

Successful technological innovation has been described as the creation of value through transforming new knowledge and technologies into products and services for national and global markets (IBM, 2004). Increasingly higher rates of innovation contribute to economic growth in a pattern described as a "cycle of innovation" (Schumpeter, 1939) or "innovation waves."

Figure 2.1 Innovation Waves



Source: http://www.naturaledgeproject.net/Keynote.aspx

Figure 2.1 above shows that through time individual innovation waves introduce new technologies and therefore set up the following wave by stimulating new innovation opportunities. This ripple effect of continued innovation enables further economic growth by creating more technological advance, markets, business development, spinoff products and firms, jobs, and continued innovation.

Potential increases in productivity in an economy are seen by some to be heavily influenced by technological innovation and technological learning (Koh, 2006; OECD, 2005). National economic growth is viewed as a progression through "stages" of technological change and expanded productivity.[4] Three stages of economic growth have become well-known: (1) the factor-driven stage of growth, (2) the investment-driven (or efficiency-driven) stage of growth, and (3) the innovation-driven stage of growth (Koh, 2006; WEF, 2010).

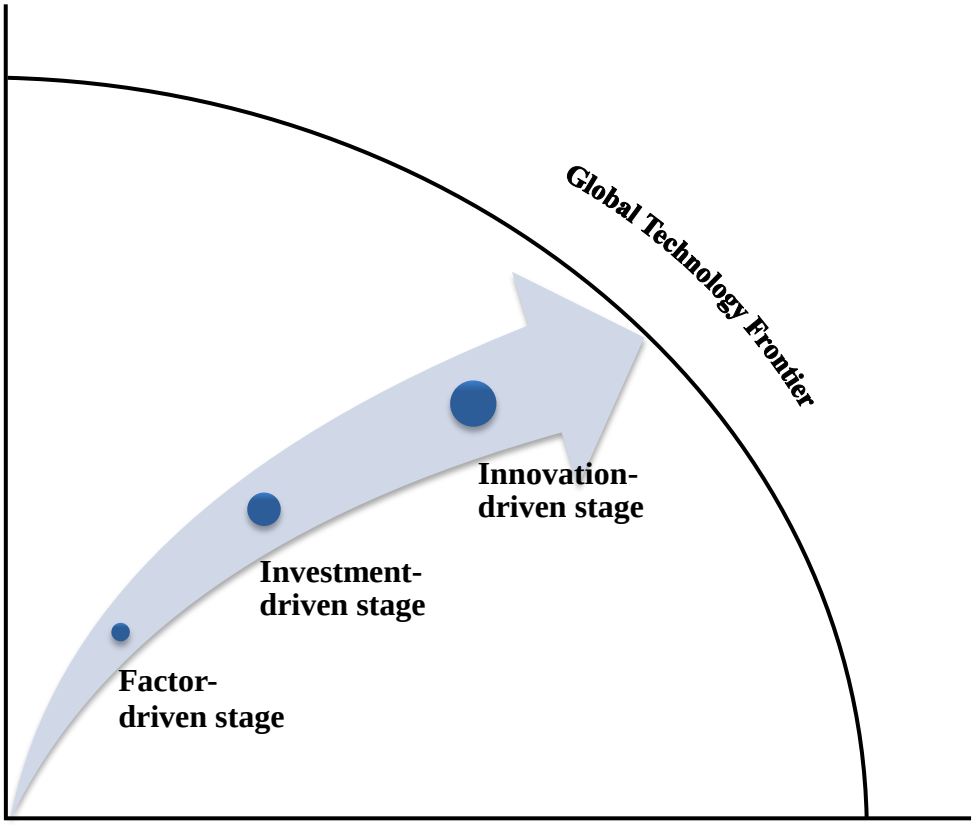
Countries in the factor-driven growth stage produce commodities based on natural endowments and low cost labor or very simple products designed by others. Typically, firms in these countries compete through resource extraction, assembly, or simple manufacturing. Moreover, productivity and wages are typically low. Technological learning comes from imitation, imported technology, and foreign investment (Koh, 2006; WEF, 2010).

In the investment-driven growth stage, countries emphasize accumulating technological, physical, and human capital. Physical infrastructure and economic regulations are improved, and investment incentives are offered. Foreign investment and

[4] See Rostow (1959) as one well-known example of this literature.

technology flows more easily into countries in the investment-driven stage. Domestic technological improvements are also facilitated. Science and technology policy emphasizes applied research, and productivity increases through efficiency gains (Koh, 2006; WEF, 2010).

Figure 2.2 Stages of Growth and the Global Technology Frontier



Source: Based on WEF, 2010

Finally, countries in the innovation-driven stage of growth place emphasis on R&D, entrepreneurship, and innovation. These countries create new knowledge and new and unique products. Investments, incentives, and institutions in the economy enable

firms to produce innovative products using state-of-the-art processes. Science and technology policy emphasizes basic research and significant investment in R&D is made by the public and private sectors. Science-based learning and the ability to shift rapidly to new technologies are significant to competitiveness in the innovation-driven stage (Koh, 2006; WEF, 2010).

Figure 2.2 above shows countries' progress through these economic growth stages toward the "global technology frontier." Moving from stage to stage involves transitioning from a technology importing economy; which relies on endowments, infrastructure, capital accumulation, and technology imitation; to a technology generating economy. This means that the country is innovating at the global technology frontier in some sectors (Koh, 2006; Porter, Sachs, & MacArthur, 2001; WEF, 2010).

The Role of Government in Promoting Innovation

Previously, innovation was thought of as a linear process where science, human capital, fiscal capital, and R&D were the inputs; and innovation was the output. In today with intense and complex global competitiveness, however, a simple linear process for creating innovation is not sufficiently productive. In developed countries, improvements to innovation performance means enhanced competitiveness at the global level. In developing countries, improved innovation creates the potential to compete after first catching up.

Countries are now taking control of innovation by imposing a systemic approach to the process. In the systems approach to the process of innovation, government plays a key role because of the public goods aspects of innovation itself. According to Brimble

(2003), the investments in human resources and R&D needed for innovation are indivisible and the returns may not be seen until the long term (p. 342). Under these conditions, markets will have difficulty efficiently allocating the resources required for innovation. The process of innovation also contains risks. It involves R&D under uncertainty, where outputs may not yield the expected benefit. It also includes spinoffs and externalities where the benefits that are created may spill out from the innovating firm. Because of these circumstances, firms may underinvest in innovation and R&D and levels of innovation will be lower than society would prefer.

The above discussion provides a rationale for government involvement to promote innovation. As Kenneth Arrow (1962) pointed out, the market for innovation can fail due to the existence of externalities and spillovers related to the nature of information, which is what Arrow sees as the key commodity involved in innovation. These external effects are uncertainty, inappropriability, and the indivisibility of innovation. Uncertainty means there will be risks involved with innovation, inappropriability means innovators may not be able to capture the full benefits of their innovations, and indivisibility means an innovation is non-rival because the quantity available does not diminish with use.

Because of these characteristics, the market on its own will not supply a socially optimal level of research and innovation. Government often intervenes in the market to correct market failures and also to provide public goods and protecting property rights. Government's reason for intervening in the market with respect to innovation therefore is to correct the market failures inherent in research, information, and innovation.

Table 2.1 Public Policy Effects on Innovation

Policy	Effects on Innovation
R&D funding	R&D funding impacts scientific direction and production of scientists and engineers.
	R&D funding supports innovation infrastructure of universities, research centers, federal labs, and industry research.
	R&D funding supports pre-competitive collaboration, small manufacturers, and tech-based start-ups.
	Public R&D goals and administrative procedures can conflict and misalign with private sector goals, expectations, and management requirements.
Technology transfer	Technology transfer impacts the incentive for industry-university collaboration and rate of knowledge flow to innovators.
Human resource policy	Federal education and training programs, education subsidies and research funds to support universities are a determinant of the supply of qualified workers needed for scientific research, development and commercialization of innovation.
Tax policy	A policy provides R&D incentive.
	Rate of depreciation affects transfer of knowledge embedded in new capital.
	A policy provides level of incentives for consumers to adopt innovation.
Standards	Standards can facilitate platform technologies, including internet, computing systems, and software.
	Standards can also function as a barrier to technical change and can restrict markets.
Procurement	Government can stimulate market and standards development through large scale aggregation.
	Design specifications can restrict introduction of new technologies.
Antitrust	Antitrust can encourage industry innovation collaboration and new market entrants.
	Antitrust can delay innovation introduction.
Intellectual property (IP)	IP acts as incentive for innovators.
	IP can restrict entry of competitors.
	IP protection can be weak globally, reducing return to innovation.
Market access	Choice and access to foreign markets, export conditions and foreign direct investment influence market potential, risk and growth.
	Export controls can inhibit competitiveness.
Employment and manufacturing initiatives	Political pressures add to protectionist risks, constraints on global investment, domestic purchasing provisions, employment transition costs, and higher skill standards.

Source: Based on IBM, 2004

Government can act to overcome these circumstances and help to manage the risks of innovation for firms. Government can encourage innovation with policies that define and enforce rights so that benefits of innovation can be captured by firms; provide incentives to encourage R&D in firms; assist in the incubation of new innovative firms; help to modernize technology in existing production facilities; build technology centers; and increase the supply of technologists, scientists, and engineers through university programs and other related policies (Atkinson, 1993; Eisinger, 1988; Lugar, 1987; Lundvall, 1988; Nelson, 1987). Table 2.1 above notes these public policy measures and their potential effects on innovation.

NIS: Historical Background

Implementing the policies above requires understanding the relationship between technological innovation, industry, firms, R&D, and government. Various ideas have evolved over time concerning the best way for countries to facilitate these relationships to undertake innovation in their economies. The NIS approach has evolved from these trends of thinking. The most fundamental of these ideas is the linear model of innovation, mentioned above.

Similar to the linear model, neoclassical growth theory sees innovation as the result of market forces in perfect competition, in which information and knowledge are equivalent commodities and automatically diffused at no cost. Firms have full information and similar technology. The optimal level of innovation is achieved when property rights are fully defined, resources flow freely, and the market is in equilibrium (Solow, 1956).

Although some countries achieved levels of innovativeness and economic growth by implementing policies based on the linear model and neoclassical growth theory, in other countries innovation and economic development lagged. For these countries, endogenous growth theory addressed some issues absent in the earlier theories. In this theory, investments; capital accumulation; and incentives for R&D, the education system, and entrepreneurship determine long term economic growth (Romer, 1990). Emphasizing these factors leads to the view that innovative performance can be shaped by the institutional make-up of the economic system.

The systemic approach to innovation is more integrated with economic policies. This means that the flows of technology and information among people, enterprises, and institutions are the key to the innovative process. The systemic approach puts emphasis on the role of system-specific institutional factors that encourage innovation and technological change (Edquist, 2001; Lundvall, 1992; OECD, 1999). It shows how the components for fostering innovation are connected to each other, the system, and the environment. In this way, strengths and weaknesses in the system can be revealed. As Aronson (1997) notes,

> Systems thinking . . . can play a key role in producing the understanding of the overall system needed to target innovation efforts more effectively (it) does so by providing a methodology and a set of tools for constructing maps of systems and determining the points at which change can have the greatest impact on . . . performance (p. 1).

With this new paradigm, innovation is the result of the complex set of relationships among actors in the system, including enterprises and firms, their clients and suppliers, universities and centers of productivity, research institutes, government

bureaus, and banks (OECD, 1997a). These actors comprise a system that contributes to innovation in a country. Actors and the linkages that connect them are the important components of the innovation systems approach when viewed at the national level. Moreover, policies conducive to innovation are also essential. The so-called National Innovation System (NIS) operates at this broadest level (Dosi, Freeman, Nelson, Silverberg, & Soete, 1988; Edquist, 1997; Feinson, 2003; Freeman, 1987; Lundvall 1992; Nelson, 1993; Niosi, 2002).

Freeman (1987) states that an NIS is "the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies" (p. 1). Its key features are the organization of R&D and production in firms, inter-firm relationships, the role of government, and the interactions among these (Freeman, 2004). Lundvall (1988) focuses on the design of innovation-supporting institutions and the process of technological learning. Nelson (1987) focuses on the role of private firms, government, and universities in the production of new technology within the NIS. Edquist (1997) considers the innovation system most broadly by examining all important actors and interactions in economic, social, political, organizational, and institutional realms with influence on the development, diffusion, and use of innovations.

Components of a "Good" NIS

With the theoretical basis for NIS described above, what does an NIS look like and what is it supposed to do? A well-functioning NIS should produce several important outputs, including: (1) the creation and diffusion of new knowledge, products, processes, and technological opportunities; (2) innovation resources, including fiscal capital,

financing options, a competent labor force, and supportive educational structures; (3) guidance for technology, market, and partner research; (4) networking and linkages for knowledge exchange; (5) facilities, equipment, and administrative support; (6) research and development; and (7) rules and regulations that enhance market access and protect innovators' rights (Edquist, 2001; Feinson, 2003).

To produce the outputs described above, some fundamental components of the NIS are required. Recent studies have attempted to demonstrate the necessary elements in the NIS concept and their effectiveness (e.g. Kayal, 2008; Kuhlman & Arnold, 2001; OECD, 1997b; OECD, 1999; Speirs, Pearson, & Foxson, 2007). From these studies, two models of NIS format are reviewed: the Innovation Policy Terrain Model and the Generic Model.

Innovation Policy Terrain Model

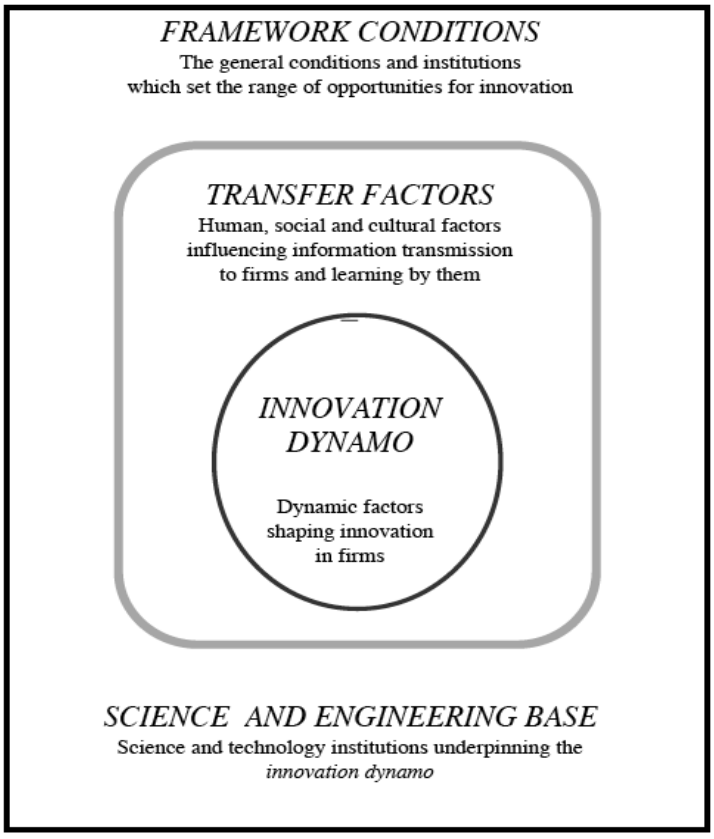
The "Oslo Manual" is one of the guideline documents developed by the OECD for analyzing innovation (OECD, 1997b; OECD, 2005). The manual examines factors that contribute to the innovative capacity of firms and groups them into four domains: (1) framework conditions, (2) the science and engineering base, (3) transfer factors, and (4) the innovation dynamo. Together these domains are referred to as the *Innovation Policy Terrain Model* (OECD, 1997b). They are presented in Figure 2.3 and Table 2.2 below.

Framework conditions compose the larger environment that surrounds the innovating firm, including: (1) the educational system; (2) transportation and communication infrastructure; (3) financial institutions; (4) the legislative and economic setting, including patent laws, taxation, corporate governance rules, and trade policy; (5)

market accessibility, including market size, access, and customer relations; and (6) industry structure and the competitive environment, including the existence of supplier firms.

The *science and engineering base* provides knowledge and skills to support innovation and includes: (1) technical training systems, (2) the university system, (3) support for basic research, and (4) various R&D activities.

Figure 2.3 Innovation Policy Terrain Model



Source: OECD, 1997b

Table 2.2 Innovation Policy Terrain Model

Components	Description
Framework conditions	Basic educational system
	Communication infrastructure
	Financial institutions
	Legislative and macro-economic settings
	Market accessibility
	Industry structure and competitive environment
Innovation dynamo	Market strategy
	R&D
	Non-R&D
Science and engineering base	Technical training system
	University system
	Basic research
	Public good R&D activities
	Strategic R&D activities
	Direct innovation support
Transfer factors	Linkages between innovating units
	Technological expert
	International links
	Mobility of expert technologists
	Access to public R&D
	Spin-off company formation
	Trust and openness
	Codified knowledge

Source: Based on OECD, 1997b

Transfer factors include: (1) formal and informal linkages between firms, such as user-supplier relationships, industry clusters and networks of firms, regulatory agencies, and research institutions; (2) technological "gatekeepers," i.e. individuals who are up to date on technological innovations and facilitate the flow of knowledge; (3) networks of international experts; (4) mobility of expert technologists/scientists; (5) access to public

R&D capabilities; (6) the formation of spin-off companies; (7) ethics, value systems, and trust; and (8) codified knowledge through patents and publications in scientific journals.

The *innovation dynamo* is the set of factors that shape the firm's innovative capacity, including: (1) strategic decisions about which markets to serve or create innovation for; (2) basic research, strategic research, and product concept development; and (3) other factors, such as opportunity identification, production facility development, capital investment and technical information, patent rights, human skills, and management systems (OECD, 1997b; Speirs et al., 2007).

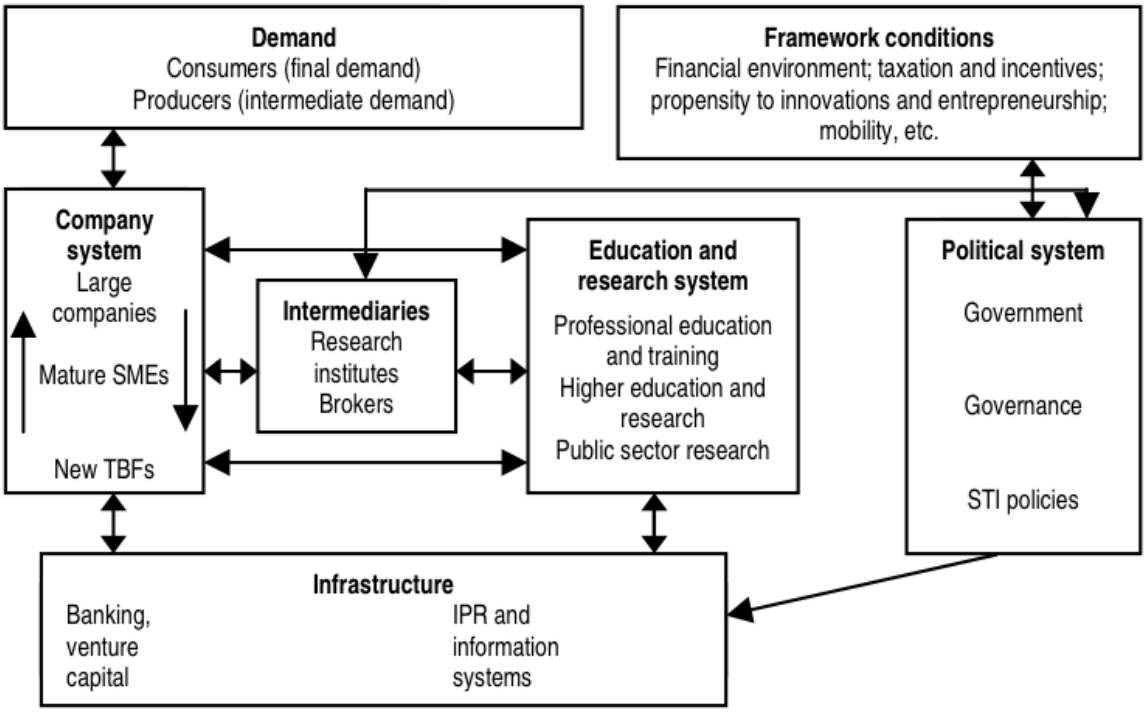
Generic Model

The OECD also presents a more specified model of system components called the *Generic Model*, focusing more on the innovating firm and its interactions in the national system of supporting institutions (Kuhlman & Arnold, 2001; OECD, 1999). The components of the model emphasize the market and non-market knowledge interactions between firms, institutions, and other human resources involved in a national system (Speirs et al., 2007). These are presented in Figure 2.4 and Table 2.3 below.

The Generic Model highlights the importance of six components necessary for innovation. *Demand* includes the need for innovations on the part of consumers and other producers in the economy. The *industrial system* is all sizes of firms in the economy, including large companies, SMEs, and new technology-based firms. *Intermediaries* are research institutes and other brokers of information or knowledge, such as government agencies. The *education and research system* includes higher education, job skills training initiatives, and also research conducted by public sector organizations. The

political system involves the government and its policies, especially those that involve science, technology, and innovation policy. *Infrastructure* includes standards and norms, venture capital, intellectual property rights, and other supporting structures for potentially innovating firms. These components all interact within broad *framework conditions*, which include fiscal and tax policy, worker mobility rules, and other incentives that affect the occurrence of firms' innovation.

Figure 2.4 Generic Model of NIS Components



Source: Kuhlman & Arnold, 2001

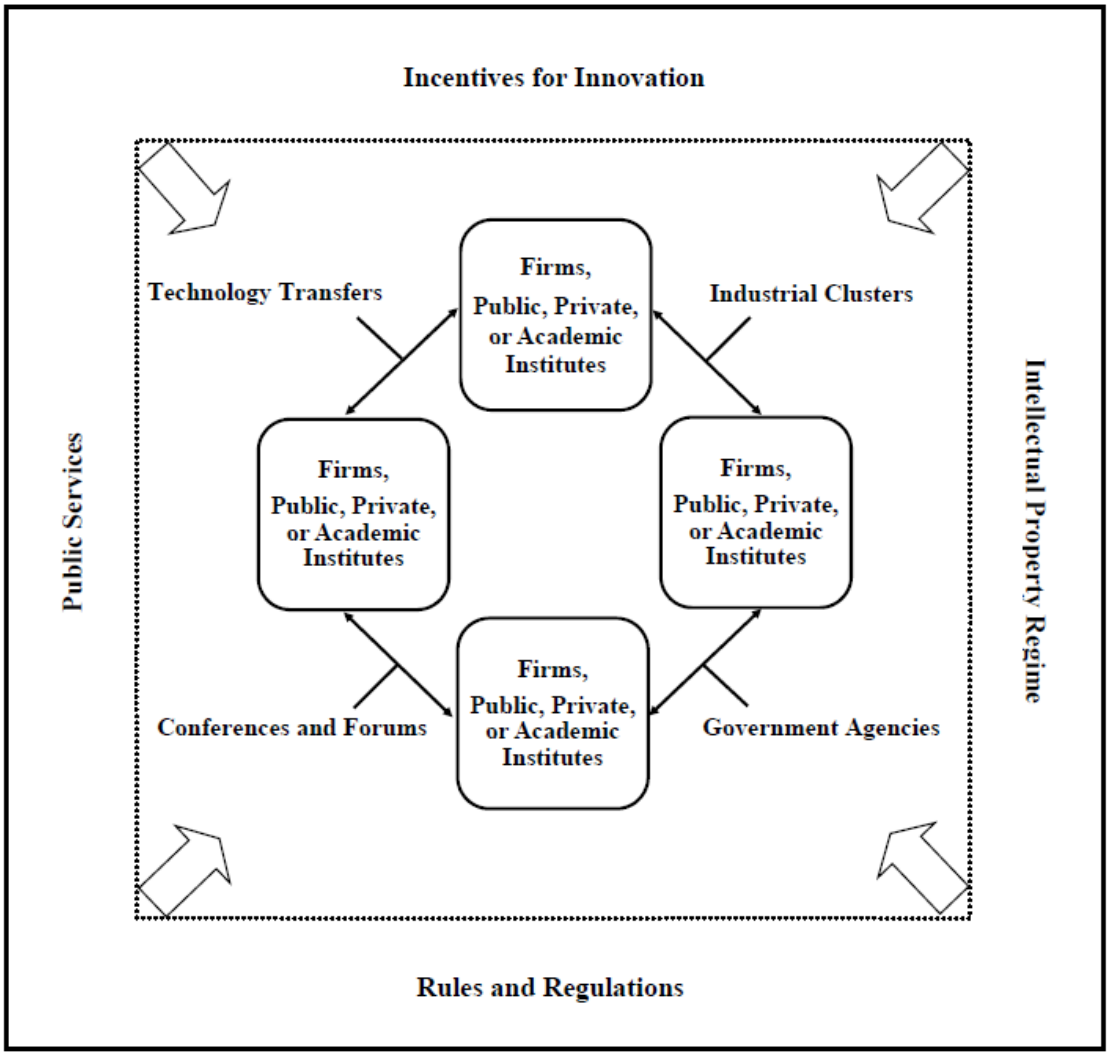
Table 2.3 Generic Model of NIS Components

Components	Description
Framework conditions	Financial environment
	Taxation and Incentives
	Propensity to innovations and entrepreneurship
	Mobility
Demand	Final consumers
	Intermediate producers
Industrial system	Large companies
	Mature SMEs
	New technology-based firms
Intermediaries	Research institutes
	Brokers
Education and research system	Professional education and training
	Higher education and research
	Public sector research
Political system	Government
	Governance
	Science, technology, and innovation policies
Infrastructure	Banking and venture capital
	Intellectual property and information
	Innovation and business support
	Standards and norms

Source: Based on Kuhlman & Arnold, 2001

The Innovation Policy Terrain Model and the Generic Model suggest the main necessary components of a well-functioning NIS that can produce many, if not all, of the desired outputs reviewed earlier. These components can be placed into three broad categories: *innovators, linkages,* and *environment* as illustrated in Figure 2.5 below as a conceptual model of NIS. Innovators in the NIS include: (1) innovating firms; and (2) public, private, and academic institutes involved in technological R&D and innovation. The linkages in the NIS include, for example: (1) industrial clusters; (2) organizations that

Figure 2.5 Conceptual Model of NIS



assist potential innovators in accessing opportunities and knowledge, such as research councils or technology transfer offices; (3) business, scientific, and academic conferences, and other forums for knowledge exchange; and (4) government agencies that set goals and directions and provide funding in support of firm innovation. The environment component refers to the playing field on which innovators interact through linkages. It includes, for example: (1) incentives for innovation such as taxes and

subsidies, (2) rules and regulations governing market access and the use and mobility of innovation capital, (3) regimes for securing intellectual property, and (4) important public services, such as a supportive educational and human resource development system.

NIS as a Means of Focusing on Innovation for Developing Countries

The NIS is seen as a framework for organizing and coordinating policies that stimulate innovation in a nation's economy. Using NIS, countries no longer use a linear input-output process to achieve innovation. The advantage of the NIS approach is the systemic view that it takes of innovators, linkages, and the environment in the economy.

The remainder of this chapter concerns developing countries and NIS. These countries were noted earlier as most in need of an assessment of NIS status and performance. Is NIS a means for developing countries to effectively participate in the global economy? And what are the benefits to developing countries of this participation?

By participating in the global economy, developing countries can take advantage of international and domestic economic opportunities. In the global economy, developing countries have the opportunity to supply goods and services to the global marketplace, which can create growth in export sectors. They also have the opportunity to acquire goods and services from the global marketplace, which can provide valued imports to producers and consumers. Finally, participation in the global economy means developing countries can attract investments of global capital, which can lead to increased employment and business development opportunities (Wolf, 2005, p. 3).

Developing countries can also create domestic opportunities for themselves by participating in the global economy. As Wolf (2004) notes ". . . the determinants of

economic success are predominantly if not overwhelmingly domestic" (p. 5). These determinants are the capacity of the state to supply the needed conditions for a market economy (Wolf, 2004, p. 5). Friedman (1999) describes this as the "hardware," "software," and "operating system" of good economic governance (p. 150-153). Effective participation in the global economy requires adjustments to economic and governing policies. For developing countries, these may include making the economy more open through structural adjustments, securing property rights, implementing appropriate regulatory oversight, and conforming to international standards.

Positive externalities are associated with these adjustments because they prepare a country for participation in the global economy, and also enhance domestic economic performance and governance. Friedman (2005) states,

> More open and competitive markets are the only sustainable vehicle for growing a nation out of poverty, because they are the only guarantee that new ideas, technologies, and best practices will easily flow into your country and that private enterprises, and even government, will have the competitive incentive and flexibility to adopt those new ideas and turn them into jobs and products (p. 399).

Friedman's comments indicate the benefits to developing countries of acquiring knowledge and technology from the global economy. Without sufficient domestic capabilities, a country is unlikely to benefit from this knowledge and runs the risk of continuously lagging behind. "Upgrading" the economy through technological innovation can better position a developing country to catch up and compete in the global economy (Aubert, 2004; Doner, 2009; Verspagen, 1991). As Juma et al. (2001) note,

> Many of the developing countries will have to move from natural resource extraction economies to knowledge-based ventures that add value to these resources. All these changes require a shift in public policy . . . Domestic innovation will not be possible without access to international markets; access to international markets will not be possible without technological innovation (p. 638).

Without innovation, developing countries can become trapped in lower growth stages, and opportunities for economic development are unlikely to emerge. Developing countries are increasingly aware of these circumstances so creating and managing technology and innovation is a prime concern. Chen and Dahlman (2005) note,

> There are many ways for developing countries to avoid reinventing the wheel and tap into, adopt, and adapt technical knowledge that was created in other developed countries. Therefore a key element of a developing country's innovation strategy is to find the best ways to tap into the growing global knowledge base and decide where and how to deploy its domestic R&D capability (p. 7).

For developing countries, the NIS could be a part of the adjustment and upgrading process described above. Moreover, the NIS can help these countries to innovate and move to higher stages of economic growth.

Finally, a study of national innovation policy in a rapidly industrializing Southeast Asian country would not be complete without a discussion of the Flying Geese model of Asian development. The Flying Geese model is a set of interconnected concepts about the pattern of national industrial and technological development that also includes spillover effects for international economic development. According to its originator, the Japanese economist Kaname Akamatsu,

> the wild-geese-flying pattern of industrial development denotes the development after the less-advanced country's economy enters into an international economic relationship with the advanced countries (Akamatsu, 1962, p. 11).

Akamatsu originally developed the theory in the 1930s to explain the process of development and "catch-up" in Japanese industry. The work was published in English in the 1960s. More recently, the Flying Geese model has been used to explain industrial development experienced in other East Asian economies during the post-war period (Kojima, 2000).

The theory includes three models of industrial and technological development: An intra-industry development model, an inter-industry development model, and a regional development model (Kojima, 2000). In the first model, intra-industry development occurs by (1) importing foreign goods from more advanced countries, (2) domestic learning and adaptation to produce similar goods to compete in local markets with the imported goods, and (3) efficient mass production of goods that can be exported to foreign markets. Government assists this process by taxing imported foreign goods during the period when domestic industries are learning to produce the goods themselves (Akamatsu, 1961, 1962). Akamatsu noticed that the growth curves for the three stages of industrial development took on an inverted V-shape and looked like a flock of geese flying in formation, so he named the theory accordingly.

In the second model, inter-industry development occurs when producers first master production in more labor-intensive, less technologically-demanding industries. After this period, producers "graduate" to higher-order industries that require more advanced skills and technology. Value is added and comparative advantage is gained with each shift to more advanced industries (Kasahara, 2004). In Japan, the inter-industry

development sequence can be seen in the progression from textiles, to chemicals, to iron and steel, to automobiles, and to electronics (Kwan, 1996).

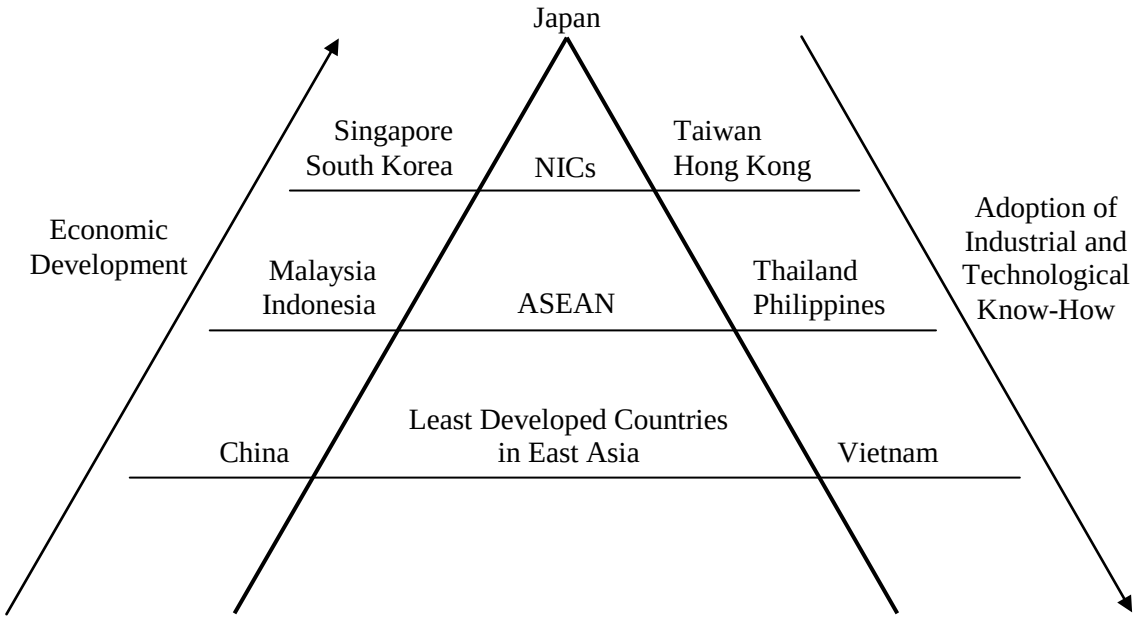
Akamatsu's third model in the Flying Geese theory focuses on regional industrial development and gained attention during the 1980s and 1990s as a conceptual framework for explaining the catching-up process in East Asia (Kasahara, 2004). The third flying geese model follows the transfer of industries from the leading economy in the region, Japan, to the lesser-developed, follower economies of the region. As Japan continued to pursue more advanced, higher value-added industrial production, it abandoned less advanced industries. However, to the follower economies, the industries Japan had left behind *were* more advanced. Adoption of these industries by the followers helped to stimulate their own industrial and technological development.

Viewed in this way, the economic development of the entire region resembled the flying geese pattern, with Japan as the "lead goose," and the "follower geese" formed into three tiers behind. The first tier behind the leader is composed of the countries referred to as the "newly-industrialized economies (NIEs)," including South Korea, Taiwan, Hong Kong, and Singapore. The next tier is composed of a core group of countries in the Association for Southeast Asian Nations (ASEAN), including Malaysia, Indonesia, the Philippines, and Thailand. Finally, the last tier is composed of the least developed countries in the region such as China, Vietnam, and others. As Akamatsu noted,

> . . . with regard to this sequence . . . the underdeveloped nations are aligned successively behind the advanced industrial nations in the order of their different stages of growth in a wild-geese-flying pattern (Akamatsu, 1961, p.208). The less advanced . . . geese are chasing those ahead of them, some gradually and others rapidly, following the course of industrial development . . . the advanced . . . geese . . . are flying in the lead onward, incessantly achieving technological innovations . . . (Akamatsu, 1962, p.17-18).

Figure 2.6 below depicts the hierarchy of the East Asian economies described in the third Flying Geese model. As this figure is based on earlier applications of the model, it is important to note that, today, China would not be considered a Fourth tier goose. At the time of this writing, China's industrial development has become increasingly more sophisticated. As such, it could be argued that China currently fits into at least the Third tier in the region.

Figure 2.6 The Third Flying Geese Model



Source: Based on Akamatsu, 1962 and Kasahara, 2006

The textile industry appears to follow the sequence of third Flying Geese model, beginning in Japan and then moving to each of the three follower tiers in succession. More recently, mass production of textiles has mainly occurred in Third and Fourth tier countries such as the Philippines, China, and Vietnam (Kwan, 1996). Japan remains the regional leader in more advanced industries such as automobiles and electronics. However, some Second Tier countries like Korea have begun to challenge the lead goose in these areas. Indeed, the third Flying Geese model suggests that as their industries and economies advanced, follower geese could move to higher tiers in the regional formation. Since the lower tier countries in the region were further behind in terms of industrial development, the adoption and adaptation of new foreign goods and technology meant that rapid rates of economic growth could be realized (Kojima, 2000). In this pattern of constantly striving to catch leading geese, all of the geese in the formation fly forward together toward higher levels of industrial, technological, and economic development.

The Flying Geese theory can have implications for public policies related to innovation in catching-up economies. These countries may direct research and development efforts toward product adaptation so that technological learning can occur. Relatively weaker intellectual property rights may also be implemented to help domestic firms to more easily adopt, reverse engineer, and modify imported foreign goods and technology. Foreign direct investment (FDI) and multinational corporations (MNCs) have been identified as the key mechanisms to transfer industrial know-how and technology between countries (Kojima, 1978). Therefore, catching-up countries may welcome foreign firms and investment to spur their economic development.

CHAPTER 3

NIS ADOPTION, IMPLEMENTATION, AND EVALUATION

In building an NIS assessment framework, this chapter examines the adoption and implementation of NIS and the evaluation of its performance. It reviews: (1) the scholarly literature on adoption, implementation, and evaluation of public policies and programs; (2) adoption, implementation, and evaluation of NIS in three innovation-leading countries, Finland, Korea, and Singapore; and (3) innovation system evaluation methods utilized by three international organizations, the OECD, the World Bank, and the World Economic Forum.

Why Organizations Adopt Policies

Policy scholars, political scientists, and sociologists have been prominent in the study of policy adoption patterns. A well-known model of policy adoption classifies adopters by their willingness to change as innovators, early adopters, early majority, late majority, and laggards (Rogers, 1995). Innovators are the first group to adopt new ideas with high motivation, needs, and expectations. They are followed by early adopters, the majority adopters, and finally laggards who are the last group to adopt new ideas, if at all.

Some other theories of policy adoption focus on adopter's motivation and resources (Mohr, 1969); position in social networks (Berry, 2008; Walker, 1969); political, social, economic, demographic, and path-dependent characteristics (Berry, 2008; Berry & Berry, 1990; Walker, 1969); and technological advancement, power and resources, and familiarity with the considered policy (Wejnert, 2002). Other theories

focus on the policy itself, including the costs and benefits of alternative policies and their public and private consequences (Wejnert, 2002). Other characteristics are considered, including relative advantage, compatibility, complexity, trialability, and observability of alternative policies (Rogers, 1995). The deciding factor is the advantage that the new policy will deliver.

Conditions in the external environment can also influence the policy adoption. These conditions include focusing events, triggering mechanisms, windows of opportunity, and punctuations of the status quo (Baumgartner & Jones, 1993; Cohen, March, & Olsen, 1972; Kingdon, 1995); policy entrepreneurs (Grinstein-Weiss, Edwards, Charles, & Wagner, 2009; Kingdon, 1995); learning from or imitating other successful adopters (Dobbin, Simmons, & Garrett, 2007; Shipan & Volden, 2008); regional diffusion (Berry & Berry, 1990; Grinstein-Weiss et al, 2009; Wejnert, 2002); economic competition (Shipan & Volden, 2008); and the growth of multinational corporations (MNCs) and global networking via ICT (Wejnert, 2002).

In these theories, policy adoption is influenced by: (1) adopter's readiness for the new policy, (2) advantages of the proposed policy, and (3) new opportunities or threats that make policy change attractive. It is possible that these influences may combine to move a policymaker to adopt a new policy. These concepts can help to understand why countries adopt NIS as a framework for innovation policymaking.

NIS Adoption in Finland, Korea, and Singapore

Shulin (1999) states that it is important to ask how innovation activities in national economies begin (p. 44). Understanding the process of identifying and

considering potential solutions to policy problems is a first step in NIS assessment. Why do countries decide to put NIS into effect? Events leading to the adoption of NIS in Finland, Korea, and Singapore are reviewed here.

Finland

The NIS in Finland has been referred to as a "showcase" and is seen as a learning example for other countries (Roos et al., 2005). According to Georghiou, Smith, Toivannen, and Ylä-Anttila (2003), the development of NIS in Finland is linked to changes in the national economy, adaptation to the policy environment, and learning from other countries. They find Finland's NIS to be an "outcome of adopting policy organizations and models from various countries and adjusting them to the national frameworks . . . Policies have also reacted to the changes in industrial structures both in the home country and internationally" (p. 56).

Innovation policy in Finland evolved through three phases: (1) creating the basic structures in the 1960s and 1970s, (2) greater technology orientation in the 1980s, and (3) developing a knowledge-based society and the NIS in the 1990s (Georghoiu et al., 2003). In the first phase, the Science Policy Council (later renamed the Science and Technology Policy Council) was established for coordinating S&T policy guidelines. New mechanisms for planning, coordinating, and financing university research were also established and development of higher education increased. Conditions also improved for industrial R&D (Georghiou et al., 2003, p. 58).

In the second phase, Finland's innovation policy was designed by OECD guidelines. During the 1980s, Finland experienced strong growth and an expanding

international market. However, exports could not keep pace with domestic demand and could not support rising living standards. Eventually there was a recession (Georghiou et al., 2003, p. 39). During this period, technology policy in Finland targeted ICT, and key programs were initiated. The Finnish Funding Agency for Technology and Innovation (TEKES) was established and took charge of R&D loans and grants. Nokia, Finland's top firm and a world leader in telecommunication, played a key role in national technology programs. Moreover, nationwide networks of science parks and centers of expertise became important for transfer, diffusion, and commercialization of research results (Georghiou et al., p. 58).

In the third phase, "NIS" and "knowledge and know-how" became important ideas for innovation policy. Four areas are emphasized: (1) knowledge creation and utilization, (2) R&D and education, (3) development and absorption of new technology, and (4) national and international cooperation (Georghiou et al., 2003, p. 59). Finland became a major exporter of electronics and high-tech products and its productivity, exports, and R&D were very strong by international comparison. Finland went from being one of the least R&D intensive countries in the OECD to one of the most. Finland leapfrogged in world exports, production, and R&D of ICT. These successes were due to changes in technology policy priorities, the role of the business sector, and decentralized decision-making (Georghiou et al., 2003, p. 47).

By the end of the 1990s, Finland had more high-skilled and high-tech industries and lower dependence on raw material and energy-intensive industries. Finland became the first country in the world to formally adopt the NIS approach, and the economy

entered the innovation-driven growth stage (Georghiou et al., 2003, p. 57, 60; Roos et al., 2005).

Korea

Korea's economic transformation has been profound,[5] and its NIS has been a key factor in the country's growth and development (Bartzokas, 2007; Kim, 1993; Suh, 2000; Wong, 1999; Yim, n.d.). Historically, Korea lacked natural resources and began its modern development with no technological base. With its NIS, the Korean government has created policies that allowed a transition to technology-based economy. The Korean NIS is characterized by active learning; restricted foreign direct investment (FDI); use and diffusion of R&D; an export orientation; and high investment in human capital (Feinson, 2003; Shulin, 1999).

Three stages of economic growth in Korea have been identified: (1) a factor-driven stage during the 1960s and the early part of the 1970s, (2) an investment-driven stage from the 1970s through the mid 1990s, and (3) an innovation-driven stage from the 1990s through the present. Three phases of S&T policy correspond to these growth stages: (1) the imitation phase in the 1960s and 1970s, (2) the transformation phase in the 1980s, and (3) the innovation phase in the 1990s (Kim, n.d, p. 3).

In the 1960s, Korea developed by a government led strategy to grow large-scale industry for export. Key industries and banks were nationalized. The government took control over credit and used a strong license and permit system. During this time, the

[5] In the 1950s, per capita income in Korea was under US$100. Between 1966 and 1996, per capita income grew by 6.8% annually. Between 1962 and 2002, GDP grew by approximately 7% annually. During parts of the 1970s, 1980s, and 1990s, GDP growth averaged approximately 19% (Bartzokas, 2007, p. 5; Choi, 2003 as cited in Yim, n.d., p. 2; World Bank, 2000, p. 1, p. 16; Yim, n.d., p. 16).

Science and Technology Promotion Act, the Ministry of Science and Technology, the Korean Institute of Science and Technology, and other government research institutes (GRIs) were all established (Kim, n.d., p. 4).

Industry grew rapidly in the 1970s and 1980s. Heavy industries and chemicals were emphasized and large family-owned conglomerates called *chaebols*[6] were the dominant type of firm. In this transformational period of S&T in Korea, industry began its own research efforts in response to the National R&D Program which provided tax incentive for private firm's R&D. Universities began to provide higher quality human resources (Yim, n.d., p. 13) and the Daedeok Science Town (later renamed Daedeok Innopolis) in Daejeon was also created (Kim, n.d., p. 6).

In the 1990s, the development goal was to promote high-tech innovation and transition to a knowledge-based economy with policies to support technology development and information infrastructure. However, due to structural weaknesses in the economy and the corporate sector and the 1997 regional financial crisis, GDP growth in Korea declined -6.7% (World Bank, 2000, p. 7). According to Chung (2003), the crisis ". . . became a driving force to increase the innovation potential of the Korean NIS" (p. 484), and overcoming the crisis and adjusting to policy shifts "prompted Korean firms to make a great leap in technological capability" (Lee, 2003, p. 233).

The economy was reformed, restructured, and liberalized (Kim, n.d.; World Bank, 2000, p. 6). Highly skilled human resources in information technology and biotechnology were developed. Highly Advanced National Projects (HAN) were undertaken, including

[6] Some of the well-known chaebols are Hyundai, Daewoo, Sumsung, and LG.

biomedical, biotechnology, electronics, next-generation vehicular, semiconductors, materials technology, and others.[7] Government also played a leading role by enhancing university research capacity, promoting cooperative research, and coordinating policy. Important S&T measures for innovation took place, including: (1) the five-year plan for innovation in 1997; (2) the creation of the National Science and Technology Council in 1999; (3) the creation of the Office of Minister of Science, Technology, and Innovation to coordinate the NIS in 2004; (4) the promotion of university-based research; (5) the formation of the Ministry of Education, Science, and Technology; and (6) the strengthening of the GRIs by placing them within a "research council" system (Kim, n.d., p. 6, 14; Lee, 2003, p. 233). Following the crisis, Korea became competitive through innovation (Kim, n.d., p. 3).

Singapore

Singapore's NIS has contributed to its status as a regional and global innovation leader (Wong, 1999). Singapore is a small city-state with a service oriented knowledge-based economy and one of the world's busiest ports. Singapore's GDP averaged 8% annual growth through the 1990s (Koh, 2006). It developed with an open economy and strong government involvement in land, labor, and industrial development (Koh, 2006, p. 143). Singapore's NIS has been based on government facilitation of technological learning from MNCs. This has resulted in a large supporting industry for MNCs and "substantial technological capability . . . among many local subcontracting . . . firms"

[7] See the list of HAN from http://park.org/Korea/Pavilions/PublicPavilions/Government/most/policye2.html

(Wong, 1999, p. 20). Over time, technological innovation capability has shifted from MNCs to local high-tech firms (Wong, 1999).

Wong (2003) refers to four stages of Singapore's growth: (1) the industrial take-off stage from 1965 through the mid 1970s, (2) the local technological deepening stage from the mid 1970s through the late 1980s, (3) the applied R&D expansion stage from the late 1980s through the late 1990s, and (4) the high-tech entrepreneurship and basic R&D stage from the late 1990s onward.

Because of a lack of natural resources, the industrial take-off stage was characterized by low cost labor-intensive manufacturing, dependence on technology transfer from MNCs, and export led growth (Wong, 2003; Wong & Singh, 2005). During the 1960s and 1970s, tax incentives and grants were offered to MNCs to locate in Singapore and produce for global markets (Koh, 2006, p. 143). The strategy successfully accelerated growth, however, local firms had no incentive to invest in indigenous innovation (Yeung, 2006). During this time, Singapore's government began to emphasize technical education (Koh, 2006).

In the technological deepening stage, MNCs operations were upgraded and local supporting industries developed. Multinational corporations provided significant investments in technology.[8] Government policy emphasized developing technological infrastructure and human resources to support innovative capacity, including the Singapore Science Park and programs for skill upgrading, high-tech start-ups, and entrepreneurialism (Koh, 2006, p. 146). After a recession in 1985, government assisted

[8] Foreign investment contributed 26% of gross domestic fixed capital formation during this period, which was one of the highest rates among Asian Newly Industrializing Economies (NIEs) (Yeung, 2006, p. 263).

the development of the venture capital industry, initiated an open-door immigration policy, and liberalized business regulations (Koh, 2006, p. 156).

In the R&D expansion stage, rapid growth of applied R&D activities by MNCs and public R&D institutions to support MNCs innovation occurred. Knowledge-intensive services and manufacturing became key drivers for growth (Wong & Singh, 2005, p. 3). A five-year national technology plan was created. It allocated US$2 billion to build R&D infrastructure, provided incentives to attract private sector R&D, and developed technical manpower to support R&D (Koh, 2006, p. 146; Yeung, 2006). The plan identified key research areas for development, including biotechnology, food and agro- technology, IT and telecommunication, microelectronics, and semiconductors. The National Science and Technology Board (NSTB) was formed and tasked with development of new research institutes in these strategic areas (Monroe, 2006). Also during time, the Ministry of Trade and Industry (MTI) coordinated economic and financial policies, tax regimes, loan regulations, and stock market rules to support of Singapore's innovation strategy. The MTI coordinates with other innovation policies from the Economic Development Agency (EDA), which engages in economic promotion, and the Agency for Science and Technology Research (ASTAR) which coordinates research programs, commercialization, and licensing (Koh, 2006, p. 155).

In the fourth stage, policy emphasized indigenous technological innovation capability, local high-tech start-ups, and science-based industry. In 1996, the Innovation Program was created to develop indigenous creative capability widely. Moreover the government created research institutes in IT, microelectronics, and life sciences to

encourage MNCs to locate their R&D activities in Singapore. The 1997 regional financial crisis caused an economic downturn in Singapore and showed that a "higher technological competitive edge" was needed (Wong & Singh, 2005, p. 21). Government increased its R&D investments to 2.6% of GDP in 1998, and the Ministry of Communications and Information Technology (MCIT), Information and Communication Development Authority (IDA), and Media Development Authority (MDA) were all formed. In 1999, the government removed regulations on high-tech entrepreneurialism and allocated US$1 billion for high-tech venture capital activities (Wong & Singh, 2005, p. 21). The One-North R&D complex was created as a S&T research "community" with research facilities, schools, amenities, and public transportation. It adopted the idea of a Silicon Valley funded at US$8.6 billion over 15 years. It focused on R&D innovation and business networking in biosciences and IT (Monroe, 2006). The National Science and Technology Plan for 1996-2001 sought to develop domestic capabilities in biomedicine to complement existing capability in electronics, chemicals, and engineering. The long-term strategy was to become a world class hub for biomedical science and a regional leader in pharmaceuticals, medical devices, healthcare services, and biotechnology R&D (Koh & Wong, 2005).

How Organizations Implement Policies

Once new policies are adopted to address problems or capitalize on opportunities, they must then be implemented. Policy implementation is the process of going from concept to end-product. It is a critical step for policy success. In developing countries, research has shown that program implementation and administration were the critical

problems influencing policy effectiveness (Patton, 1997, p. 199). Implementing a new policy may mean that the adopter has little or no experience with the policy, so assessing its design and implementation becomes important (Wholey, 1979). Examining implementation helps to understand the functioning of policy or program components, and whether the policy or program is operating as it is supposed to (Patton, 1997).

Ideally, policies are implemented rationally by putting operations in place that meet intended policy goals. Agencies that implement government policies are created and staffed by civil servants with technical expertise in relevant policy and program. This staff develops, implements, monitors, and improves programs that serve the public good. Government agencies should be apolitical, efficient, and effective policy implementers, with clear lines of hierarchy (Roth & Wittich, 1978).

Some research indicates that policy implementation may not work as smoothly as the ideal case predicts. Wholey, Scanlon, Duffy, Fukumoto, and Vogt (1970) say, "We cannot predict . . . which results will follow from particular policies, nor should we be confident that policy implementation will conform to plan" (p. 21). Implementation problems include limited resources or understanding, lack of flexibility, situational decision-making, principal-agent problem including moral hazard and adverse selection. Implementation problems can also occur because policymakers may only have a vague idea of what they want, so policies may be poorly conceptualized and infeasible before the actual implementation (Lindblom, 1959; Lipsky, 1980; Pressman & Wildavsky, 1973; Simon, 1997; Wilson, 1989; Wood & Waterman, 1994).

According to Doner (2009) effectively implementing innovation policies in developing countries requires consultation, credible commitments, and monitoring (p. 72). Consultation means actors exchange information on their preferences, capabilities, and intentions. Credible commitment means actors comply with their preferences and agreements. Monitoring means evaluating performance and outcomes and revising policies and responsibilities as needed (Doner, 2009, p. 73).

Technology, products, processes, and practices that are new to developing country firms can be complex, costly, and their benefits are uncertain (Doner, 2009, p. 74). Therefore, the role of government is to help potentially innovative firms manage expected risks and uncertainties ". . . where the agency elicits information from firms regarding key externalities and their management in an ongoing process of information exchange, goal setting and adjustment, and mutual monitoring" (Doner, 2009, p. 75). This requires consultation and credibility among all parties and monitoring of performance so that agreements can form. Therefore, developing countries will require ever-greater levels of these three institutional capacities to successfully implement innovation policy.

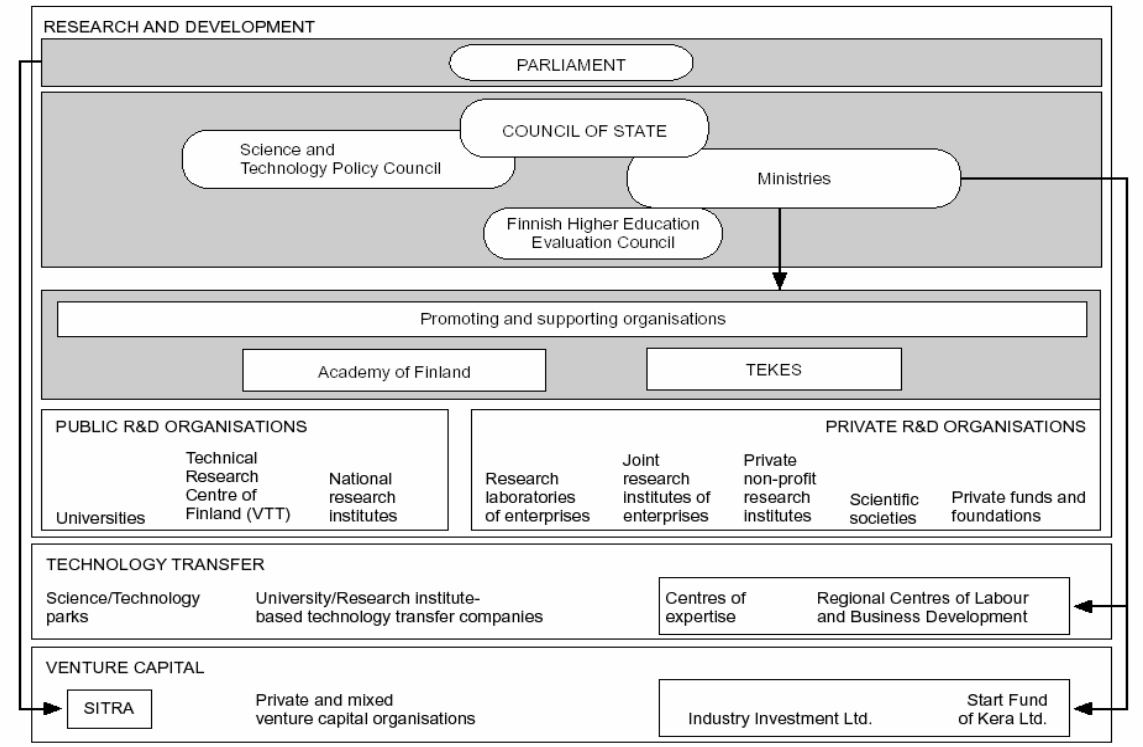
NIS Implementation in Finland, Korea, and Singapore

The components and the implementation of the Finnish, Korean, and Singaporean NIS are presented in this section. The actors, interaction, and organizational structure of each of these systems are discussed below and also depicted in Figure 3.1-3.3. The objective is to find what happens in these countries' NIS to encourage innovation, and what organizations are responsible.

Finland

A "full systems approach" is taken in Finland by examining all elements of NIS, including customers, government and regulatory bodies, technology transfer organizations and incubators, R&D bodies, financial institutions, and others (Roos et al., 2005). According to Roos et al. (2005), key organizations involved in the Finnish NIS are: (1) the Academy of Finland, (2) the Finnish Funding Agency for Technology and Innovation (TEKES), (3) public R&D organizations, (4) technology transfer agencies, and (5) capital providers. These are shown in Figure 3.1 below.

Figure 3.1 Organization of Finland's NIS



Source: Roos et al., 2005

The Academy of Finland finances scientific research in all disciplines and provides expertise in science policy development. Funding is provided for projects and programs; research centers of excellence; research positions and training; foreign visiting professors; and international networking and collaboration between universities, research institutes, and business. Annual funding for projects from the Academy accounts for 16% of government R&D spending.[9]

The Finnish Funding Agency for Technology and Innovation (TEKES) is in the Ministry of Trade and Industry and is responsible for implementing technology policy. It provides financing to universities and research institutes projects, and also to firms' product development where risk is present. It funds and coordinates joint programs implemented by firms, research institutes, and universities, and coordinates international cooperation in research and technology (Roos et al., 2005).

Universities, polytechnics, national research institutes and the Technical Research Centre of Finland (VTT) are major public R&D organizations. These organizations spend approximately 30% of the nation's budget for R&D. There are strong links between business and university R&D and other public sector R&D groups. The Finnish Innovation Fund (SITRA) provides start-up capital for technology firms and funds research projects for existing firms, training projects, and foreign venture capital, and matches SMEs with "business angels" (Roos et al., 2005).

The Science and Technology Policy Council (STPC) facilitates innovation policymaking. The council is chaired by the Prime Minister and develops guidelines for

[9] http://www.aka.fi/en-GB/A/Academy-of-Finland/

the government's R&D funding. It coordinates R&D issues among the other ministries and provides consultation between industry, funding agencies, government organizations, and universities (MEE, 2009).

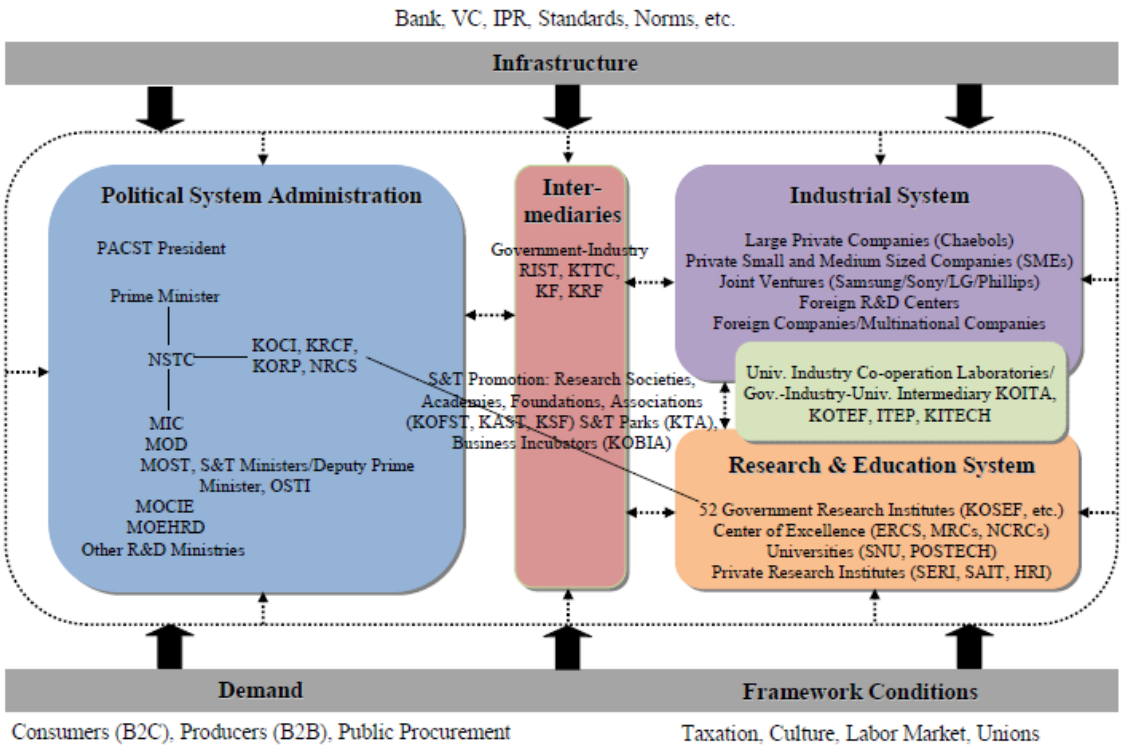
The National Innovation Strategy of 2008 identifies measures to meet the goals defined for the NIS (MEE, 2009). These measures include: (1) establishing large, modern, and flexible higher education entities; (2) supporting interaction between universities, trade, industry, and research institutes; (3) developing management training to meet world standards; (4) introducing entrepreneurship, creativity, and innovation into teaching; (5) providing incentives and opportunities for life-long learning; (6) motivating investors to commit to business growth by taxation; (7) motivating venture capital investment through public-private cooperation; and (8) using public procurement to enhance demand for innovations (Vuegelers, et al., 2008).

Universities provide two types of innovation-support structures for firms, including industry-academia research clusters and business incubators. These structures help to develop linkages with international firms and indigenous firms. Between 1995 and 2000, venture capital investments increased by 10 times. Approximately one-third of private equity investment went into ICT. Today, the venture capital market has been described as "vibrant" with "unparalleled" financing opportunities for high-tech firms (Roos et al., 2005).

Korea

Government policy and programs, government-sponsored research institutes, and private industry have played important roles in Korea's NIS (ISI, GIGA, & STIP, 2008; Yuh, 2006). Figure 3.2 below shows the organization of Korea's NIS.

Figure 3.2 Organization of Korea's NIS



Source: ISI et al., 2008

The National Science and Technology Commission (NSTC) was established in 1999 to prioritize the S&T budgets and coordinate national S&T and R&D programs. The NSTC is chaired by the Deputy Prime Minister of Science and Technology and composed

of thirteen S&T related ministers and nine representatives from the S&T community (Bartzokas, 2007, p. 31).

The Ministry of Science and Technology (MOST) is the secretariat for NSTC. It is responsible for managing and coordinating policy concerning S&T, industry, human resources, and national R&D (Bartzokas, 2007). The MOST coordinates R&D initiatives, human resource development and education, internationalization policies and activities of science-based ministries, and government supported research institutes. It is also responsible for Korea's Centers of Excellence (COE), which implement programs that encourage basic research in major universities. These centers are the Science Research Centers, the Engineering Research Centers, the Medical Science and Engineering Research Centers, and the National Core Research Centers.

The Office of Science and Technology Innovation (OSTI) within MOST forms a science and technology R&D system for future development. It promotes efficient investment and budget allocation, the development of future growth industries, and human resources in S&T. The President's Council on Science and Technology is made up of nongovernmental science experts and corporate leaders in various S&T areas. The council plays an important role in policymaking as the government has taken a more market-oriented approach. The Korean government wants "science policy to satisfy more of the private sector's needs, so it has become more open to its views" (Bartzokas, 2007, p. 31).

The role of universities in Korea's NIS has expanded.[10] Universities contributed approximately 83% of scientific publications between 1995 and 2000 (ISI et al., 2008). Recently, patenting, technology transfer, and commercialization of innovations have all improved among Korea's universities. Through the COE model, government has supported research groups with specific capabilities at universities across the country. Currently, there are 150 COEs in engineering, medicine, science, and core national objectives.

The Science and Technology Framework Law of 2001 grants authority for S&T policy and R&D coordination within the MOST. The law provides rules and regulations governing S&T, and enables the development of policies for R&D. It is the framework for 31 STI-related laws in areas such as human resource development (HRD), nuclear energy, R&D promotion, and technological development support. The S&T Framework Law is seen as fostering an "innovation-driven culture" in Korea (Bartzokas, 2007, p. 31; ISI et al., 2008, p. 259). The law has facilitated recent changes to the IP regime, and also has been helpful in supporting Korea's regional targeting policy for innovation.

The Korean Intellectual Property Office (KIPO) is the central body for patent-related policies and activities. The KIPO has streamlined innovation activities by separating patent and utility model applications. It has also accelerated commercialization and transfer of patented technology. In 2005, KIPO registered the fourth-highest number of patents in the world (ISI et al., 2008).

[10] From 1970-2004, the number of higher education institutes grew from 142 to 411 and the number of enrolled students grew from approximately 200,000 to 3.5 million.

A regional targeting policy is also used to support innovation. Free economic zones (FEZs) provide tax breaks, deregulation, financial incentives, and enhanced services in targeted regions of the country. Companies in these regions must attract a minimum amount of foreign investment to qualify for benefits. The FEZs offer an inducement for foreign companies to invest in Korean firms. Currently, FEZs exist in Busan-Jinhae, Gwangyang, and Incheon.

Since the 1970s, the Korean government has sponsored a levy-grant program to assist firms in technological HRD. The program is an inducement for firms to invest in HRD and tech-skill development (Arnold, Bell, Bressant, & Brimble, 2000, p. 110). Firms contribute a mandatory levy to a fund that can be used for HR training and skills development. Because the contribution is mandatory, firms have no reason not to invest in human resource development (Arnold et al., 2000).[11]

Singapore

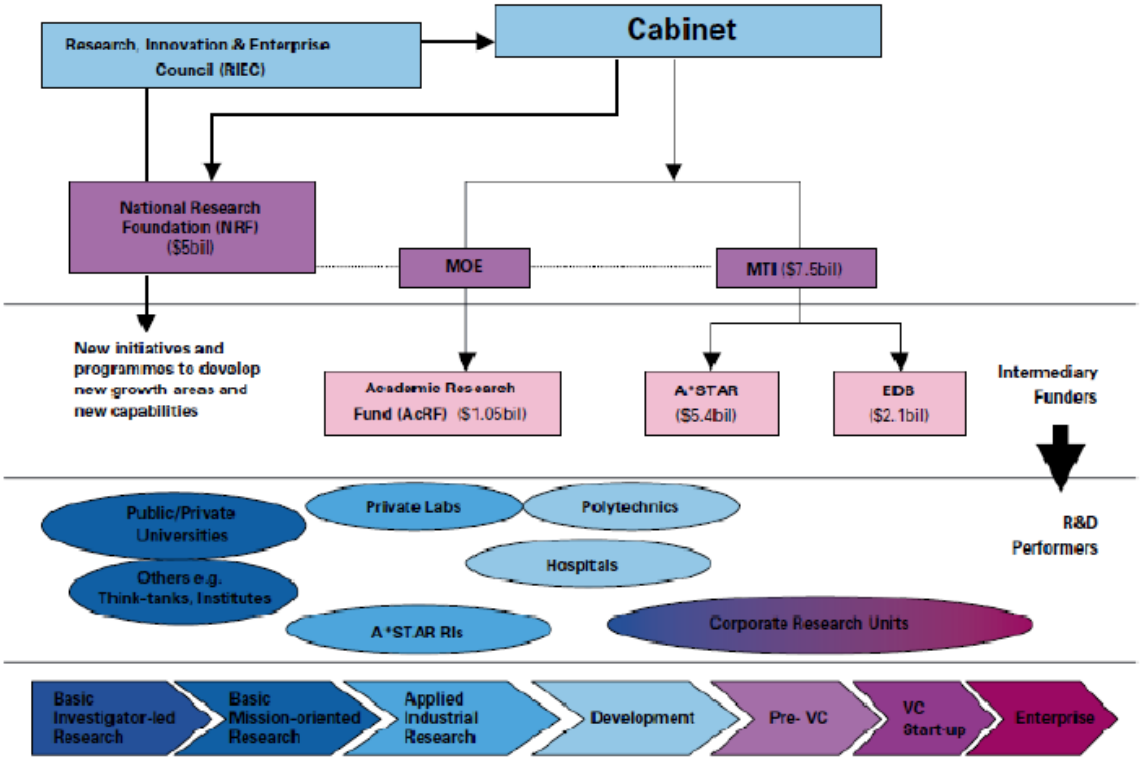
Singapore's Science and Technology Plan indicates a transformation to research-driven and knowledge-intensive economy (MTI, 2006). The plan defines the roles for organization and administration of Singapore's NIS. Figure 3.3 below shows the organizational structure of Singapore's NIS.

The Research, Innovation, and Enterprise Council (RIEC) is chaired by the Prime Minister and includes other ministers, industry leaders, and scientists and academics. It advises the government on research, innovation and enterprise strategies. The RIEC

[11] Levy and grant amounts, firm size for program exemption, and sponsored training activities, have varied over time. The levy is typically some predetermined proportion of the wage bill. Firms with less than a minimum number of employees are exempted. If grants to firms for HRD activities exceed their contribution level, government makes up the difference (Arnold et al., 2000, p. 110-112).

promotes these functions with new initiatives in S&T and knowledge-based economic growth. These functions are implemented by the National Research Foundation (NRF). NRF funds programs that meet the objectives of these strategies, coordinates national research efforts, and develops policies for implementing the national R&D agenda (MTI, 2006).

Figure 3.3 Organization of Singapore's NIS



Source: MTI, 2006

The Agency for Science, Technology, and Research (ASTAR) and the Economic Development Board (EDB) are located in the Ministry of Trade and Industry (MTI). The ASTAR fosters scientific research and talent by setting priorities for public research and

developing the research labor force. It enables commercialization of research outputs, attracts research-intensive projects from MNCs, and enhances capabilities of industry clusters and local enterprises. The EDB identifies technologies and growth areas, promotes private sector R&D in local enterprises, and attracts MNCs to locate R&D activities in Singapore (MTI, 2006).

The Ministry of Education (MOE) oversees and funds basic research for knowledge creation in universities. Universities are primarily engaged in independent and collaborative research projects to create new knowledge for future innovations. Polytechnic institutes perform developmental research and joint projects with industry and local enterprises. This will strengthen domestic private sector innovation. The Academic Research Fund (AcRF) also funds basic research in universities and strategic research for independent researchers. The AcRF attempts to attract world-class researchers to Singapore who can "seed ideas and new breakthroughs" and enhance graduate education (MTI, 2006).

The Science and Technology Plan attempts to develop an "open platform that allows the free flow of ideas among the players in the research landscape" (MTI, 2006, p. 29). The plan emphasizes collaboration among the performers of R&D. Linkages between research institutes, universities, public research agencies, and disease centers and hospitals facilitate the flow of research from basic to applied research and then to commercialization. These linkages are formed through joint programs, seminars, conferences, project supervision, and appointments, and facilitated by ASTAR and NRF. The NIS also supports linkages to the private sector through two programs. One is a

government incentive for MNCs to help local engineers acquire new technical skills. The other is the Local Industry Upgrading Program (LIUP) which encourages MNCs to help local suppliers to upgrade their procedures and technologies (Wong & Singh, 2005).

Singapore has three science parks that provide infrastructure for R&D. The first two parks include government agencies, several private firms involved in IT and telecommunications, and high-tech R&D institutes. The third one is One-North as mentioned above (Finegold, Wong, & Cheah, 2004; Wong & Singh, 2005). Besides the science parks, there are seven technopreneur incubation centers that facilitate networking for over 400 technology-related firms. The program is managed by a group of public and private sector operators (Wong & Singh, 2005, p. 41).

Singapore funds firm-level human resource development with a levy-grant program called the Skill Development Fund.[12] The training provision comes from in-house, local training organizations, and foreign providers of specialized training. The training and skill types have focused on ICT fields and the needs of SMEs (Arnold et al., 2006, p. 109-112).

Multinational corporations (MNCs) provided finance in the early stage of Singapore's high-tech development. In 1999, the government provided the US$1 billion Technopreneurship Fund to induce venture capitals to Singapore. The fund attracted several leading venture capitalists from the United States. The requirements on the national stock exchange were simplified for new ventures to access market funding. The

[12] The program has used a levy rate between 1-4% of the wage bill, depending on firms' needs for technological skill upgrading.

Start-up Enterprise Development Scheme (SEEDS) was also created to fund early stage business development over 100 new start-ups (Wong & Singh, 2005).

How Organizations Evaluate Policies

Policymakers must evaluate the performance of policies after implementation. They need to know how the policy is performing to meet the goal. Policy evaluation is the way to provide this important information. Evaluation measures the effects of a policy against the goals where the analysis of performance data indicates when policies work well, when improvements are needed, or when a policy should be discontinued. It also contributes to subsequent decision-making about programs (Shadish, Cook, & Leviton, 1991).

Evaluations have been developed for assessing the utility, the feasibility, and other missions of policies and programs in a wide range of fields. Many different types of evaluations exist. The generic "program outcome" evaluation model, for example, analyzes: (1) inputs, which are the resources put into a program; (2) activities, which are the things the program actually does; (3) outputs, which are the products that are produced; (4) outcomes, which are the results of the activities and outputs; and (5) impacts, which are the program's long term consequences (World Bank, 2007, p. 161). Another well-known evaluation framework is the CIPP model, which investigates four elements, including context, inputs, process, and products (Stufflebeam, 1971).[13]

[13] See Stufflebeam (1971), the model was originally designed for evaluating the utility of educational curricula.

Nowadays, performance measurement is seen as a necessary tool for the evaluation of public policies (Thomas, 2006). The policy evaluation has become increasingly popular in the public sector in recent years with ideas of re-inventing government, total quality management (TQM), performance-based management and others (Thomas, 2006, p. 1). However, evaluating the performance of public policies through formal evaluations can be difficult. According to Thomas (2006), the problem is ". . . measurement . . . in terms of linking outcomes in society to programs" (p. 21).

Performance indicators can be both quantitative and qualitative and vary in terms of validity and reliability (Patton, 1997). Choice of indicators can be affected by availability of resources for data collection, and the time frame associated with the interest (Patton, 1997, p. 159-160). Patton (1997) says, "some kind of indicator is necessary . . . to measure the degree of outcome attainment . . . the key is to make sure that the indicator is a reasonable, useful, and a meaningful measure of the intended client outcome" (p. 160-161).

International Organizations Evaluation of NIS Performance

Some international organizations regularly evaluate nations' innovation performance, including the OECD, the World Bank, and the World Economic Forum. They use proxy variables referred to as "innovation indicators," to evaluate and rank national innovation performance. The evaluation practices of these organizations are discussed below.

The OECD

The OECD is comprised of 34 member countries.[14] It has established many guidelines on the measurement of science, technology, and innovation activities at national and regional level. Some of these include: (1) *Frascati Manual* for surveys of research and experimental development, (2) *TBP Manual* for the measurement and interpretation of technology balance of payments (TBP) data, (3) *Oslo Manual* for collecting and interpreting technological innovation data,[15] (4) *Patent Manual* for using patent data as science and technology indicators, and (5) *Canberra Manual* for the measurement of human resources devoted to science and technology (OECD, 2002). This section discusses the Oslo manual, which identify innovation indicators and best practices for NIS.

The Oslo Manual is a series of works produced in 1992, 1997, and 2005, by the OECD which serves as a methodological reference for the analysis of innovation impacts in national economies. The Oslo Manual "provides guidelines for collecting and interpreting innovation data in an internationally comparable manner" (OECD, 2005, p. 10). It recommends using firm-level surveys and provides guidelines for developing survey instruments (OECD, 2005).

[14] Current members are advanced and emerging countries including Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States.

[15] The Oslo Manual also inspired the development of the manual for the standardization of technological innovation indicators in Latin American and Caribbean countries, called the "Bogota Manual" produced by many institutions including Organization of American States (OAS), Ibero-American Network of Science and Technology Indicators (RICYT), Ibero-American Program of Science and Technology for Development (CYTED), Andrés Bello Convention (SECAB), and Colombian Observatory of Science and Technology (OCYT). The manual focuses on specific characteristics of innovation systems and firms in less developed countries.

Firm surveys provide qualitative data on innovation activities. Surveys collect data on the source of knowledge relevant to firms' innovation activities, firms' R&D expenditure and performance, inter-industry collaboration, numbers of innovative products, return on investment on innovation effort, the presence of linkage between public and private research sectors, personnel movements, and other innovation-relevant data (OECD, 2005; Stahl-Rolf & Hamann, n.d.). The manual recommends collecting quantitative data on firm expenditures for innovative activities for a given period (rather than expenditure data for a specific innovation) (OECD, 2005, p. 98). The manual also recommends collecting information on how firms protect their innovations, such as patents, copyrights, registration of designs, trademarks, or confidentiality agreements (OECD, 2005).

The World Bank

Currently, the World Bank evaluates 146 countries' innovation systems in terms of their readiness for the knowledge economy. The Knowledge Assessment Methodology (KAM)[16] was developed by the World Bank as a "knowledge economy benchmarking tool." The KAM uses 148 structural and qualitative variables to evaluate performance in the knowledge economy. Each variable is ranked on an ordinal scale and serves as an indicator. These variables are grouped into four pillars: (1) the economic and institutional regime, (2) education and skills, (3) information and communication infrastructure, and

[16] The KAM uses data from World Bank databases and also UNCTAD, UNESCO, and WEF. The World Bank continuously updates the KAM data and expands coverage when possible. The details of KAM can be retrieved from http://web.worldbank.org/WBSITE/EXTERNAL/WBI/WBIPROGRAMS/KFDLP/EXTUNIKAM/0,,menuPK:1414738~pagePK:64168427~piPK:64168435~theSitePK:1414721,00.html

(4) the innovation system. The innovation system pillar of the KAM has 29 variables, as shown in Table 3.1 below. The KAM evaluates the innovation system for countries by using data on these variables.

Table 3.1 KAM Innovation System Pillar

Pillar 4 The Innovation System	
FDI outflows as % of GDP	S&E journal articles
FDI inflows as % of GDP	S&E journal articles/mil. people
Royalty and license fees payments (US$ mil.)	Availability of venture capital
Royalty and license fees payments (US$/pop.)	Patents granted by the USPTO
Royalty and license fees receipts (US$ mil.)	Patents granted by the USPTO/mil. people
Royalty and license fees receipts (US$/pop.)	High-technology exports as % of manuf. exports
Royalty payments and receipts (US$ mil.)	Private sector spending on R&D
Royalty payments and receipts (US$/pop.)	Firm-level technology absorption
Science and Engineering enrollment ratio (%)	Value chain presence
Science enrollment ratio (%)	Capital goods gross imports (US$ mil.)
Researchers in R&D	Capital goods gross exports (US$ mil.)
Researchers in R&D/mil. people	S&E articles with foreign coauthorship (%)
Total expenditure for R&D as % of GDP	Avg. Number of citations per S&E article
Manuf. trade as % of GDP	Intellectual property protection
University-company research collaboration	

Source: Based on World Bank, 2012

However, of these 29 indicators, only 3 are used by the KAM to develop innovation rankings for countries: (1) total royalty and license fees payments and receipts in million USD, (2) patent applications granted by United States Patent and Trademark Office (USPTO), and (3) scientific and technical journal articles.[17]

[17] http://info.worldbank.org/etools/kam2/KAM_page5.asp

The World Economic Forum

The World Economic Forum (WEF) evaluates countries' innovation capacity in relation to their competitiveness in the global economy. It annually publishes these results in the Global Competitiveness Report (GCR). The report examines factors leading to sustained economic growth and prosperity, and provides "benchmarking tools for business leaders and policymakers to identify obstacles to improved competitiveness thus stimulating discussion on the best strategies and policies to overcome them" (WEF, 2010, p. 3).

The GCR uses an extensive set of indicators which are grouped into 12 pillars, and "innovation" is one of them (WEF, 2012, p. 4).[18] The competitiveness of countries was evaluated using these indicators and pillars, and countries are ranked accordingly. The 2012-2013 GCR measures competitiveness using surveys distributed by the WEF to business leaders in 144 countries. Survey questions ask them to evaluate various aspects of the operating environment in their country on an ordinal scale (WEF, 2012).

According to the WEF, to enhance living standards in a country for the long term requires improvements to the innovation pillar (WEF, 2012). It is comprised of the following indicators: (1) capacity for innovation, (2) quality of scientific research institutions, (3) company spending on R&D, (4) university-industry collaboration on R&D, (5) government procurement of advanced technology products, (6) availability of

[18] The other pillars are institutions, infrastructure, macroeconomic environment, health and primary education, higher education training, goods market efficiency, labor market efficiency, financial market development, technological readiness, market size, and business sophistication.

scientists and engineers, (7) utility patents, and (8) intellectual property protection. Survey questions correspond to these indicators, and are shown in Table 3.2 below.

Table 3.2 GCR Questions Corresponding to Innovation Indicators

Question	How to Answer
In your country, how do companies obtain technology?	1 = exclusively from licensing or imitating foreign companies 7 = by conducting formal research and pioneering their own new products and processes
How would you assess the quality of scientific research institutions in your country,?	1 = very poor 7 = best in their field internationally
To what extent do companies in your country spend on R&D?	1 = not at all 7 = heavily
To what extent do business and universities collaborate on R&D in your country?	1 = not at all 7 = extensively
Do government procurement decisions foster technological innovation in your country?	1 = not at all 7 = extremely effectively
To what extent are scientists and engineers available in your country?	1 = not at all 7 = widely available
How would you rate intellectual property protection, including anti-counterfeiting measures, in your country?	1 = very weak 7 = very strong

Source: Based on WEF, 2012 (Global Competitiveness Report 2012-2013)
Note: Besides these above questions, the GCR also used the number of patents for inventions per millions of population in 2009 as an additional innovation indicator.

The GCR notes that less advanced countries can improve productivity by adopting existing innovation or making incremental improvements. However, countries in an innovation-driven stage of growth; such as Finland, Korea, and Singapore; must innovate new products and processes to be competitive (WEF, 2012, p. 7). The GCR recommends that countries create an environment that is conducive to innovation and supported by the public and private sectors. This environment includes high levels of investment in R&D,

especially by the private sector; high quality scientific research institutions; extensive research collaboration between university and industry; and secured property rights.

NIS Evaluation in Finland, Korea and Singapore

Below are three tables presenting the results of innovation performance evaluation for Finland, Korea, and Singapore from the Knowledge Assessment Methodology (KAM) and the Global Competitiveness Report (GCR). These countries' scores and rankings on innovation performance are among the best in the world and reflect positively on the NIS in each country.

Table 3.3 Innovation Rankings and Scores for Innovation-Leading Countries

Country	KAM		GCR	
	Innovation Rank	Innovation Score	Innovation Rank	Innovation Score
Finland	3	9.66	2	5.75
Korea	21	8.80	16	4.94
Singapore	4	9.49	8	5.39

Source: Based on World Bank, 2012 and WEF, 2012

Table 3.4 GCR Innovation Indicator Rankings for Innovation-Leading Countries

Indicator	Finland	Korea	Singapore
Capacity for innovation	4	19	20
Quality of scientific research institutions	13	24	12
Company spending on R&D	3	11	8
University-industry collaboration in R&D	4	25	5
Government procurement of advanced technology products	14	33	2
Availability of scientists and engineers	1	23	13
PCT patents, applications/mil pop.*	3	9	13
Intellectual property protection	1	40	2

Source: Based on WEF, 2012 (values on 7-scale for 146 countries except PCT*)

Table 3.5 KAM Innovation Indicator Scores for Innovation-Leading Countries

Indicator	Finland	Korea	Singapore
FDI outflows as % of GDP, 2004-2008	6.95	6.41	9.53
FDI inflows as % of GDP, 2004-2008	2.64	0.79	9.64
Royalty and license fees payments (US$ mil.), 2009	7.92	9.36	9.68
Royalty and license fees payments (US$/pop.), 2009	9.68	9.04	9.92
Royalty and license fees receipts (US$ mil.), 2009	9.21	9.37	9.05
Royalty and license fees receipts (US$/pop.), 2009	9.60	8.57	9.44
Royalty payments and receipts(US$ mil.), 2009	8.72	9.28	9.52
Royalty payments and receipts(US$/pop.), 2009	9.60	8.48	9.92
Science and engineering enrollment ratio (%), 2009	9.55	9.44	10.00
Science enrollment ratio (%), 2009	6.44	4.89	9.00
Researchers in R&D, 2009	6.71	9.18	5.89
Researchers in R&D/mil. people, 2009	10.00	8.08	8.77
Total expenditure for R&D as % of GDP, 2008	9.90	9.60	8.91
Manuf. trade as % of GDP, 2009	5.95	8.83	9.91
University-company research collaboration (1-7), 2010	9.85	8.40	9.62
S&E journal articles, 2007	8.41	9.38	8.00
S&E journal articles/mil. people, 2007	9.79	8.28	9.38
Availability of venture capital (1-7), 2010	9.85	3.21	9.85
Patents granted by USPTO, avg. 2005-2009	8.97	9.73	8.56
Patents granted by USPTO/mil. people, avg. 2005-2009	9.59	9.66	9.18
High-tech exports as % of manuf. exports, 2009	8.02	9.47	9.92
Private sector spending on R&D (1-7), 2010	9.69	9.24	9.47
Firm-level technology absorption (1-7), 2010	9.24	9.54	9.24
Value chain presence (1-7), 2010	9.39	9.01	9.39
Capital goods gross imports(US$ mil.), 2005-2009	5.67	7.16	9.93
Capital goods gross exports (US$ mil.), 2005-2009	8.73	9.40	10.00
S&E articles with foreign coauthorship (%), 2008	2.29	0.49	2.01
Avg. number of citations per S&E article, 2008	8.96	6.88	8.54
Intellectual property protection (1-7), 2010	10.00	6.87	9.85

Source: Based on World Bank, 2012 (scores on 10-scale for 146 countries)

Besides international surveys and indicators discussed above, there are other ways in evaluating NIS performance such as in-house evaluation, as in the case of Finland; or independent observations and secondary data, as in the case of Korea and Singapore. These are discussed below.

Finland

Finland is a continuing global leader in innovation, however, a new innovation strategy was adopted in 2008 to redirect the NIS and focus on problems of the system (Vuegelers et al., 2009, p. 21). In 2009, a panel of domestic and international experts was assembled by Finland's Ministry of Education and Ministry of Employment and Economy to evaluate the performance of the NIS and its future prospects.

The panel commissioned several in-depth studies including a firm-level survey, and concluded that Finland's NIS "has an admirable track record and its current performance is still good" (Vuegelers et al., 2009, p. 88). According to the panel, however, "good is not enough" (Vuegelers et al., 2009, p. 9). The system is too complex and not user friendly. Private firms require too much time and effort in dealing with NIS actors, related policies, and initiatives (Vuegelers et al., 2009, p. 17-18). Therefore, the NIS should be simplified. The number of policy instruments should be reduced by 90% and the number of public innovation policy organizations should also be reduced (Vuegelers et al., 2009, p. 88).

The panel also found there is a shortage of educated labor in Finland's high-tech companies (ISI et al., 2008; Vuegelers et al., 2009, p. 18). It therefore recommended several changes to the higher education system, including redefined tasks for

polytechnics and universities; financial incentives for high-quality research, education, and internationalization; and repositioning academically-oriented research into the universities and commercially-oriented research into a small number of public R&D organizations (Vuegelers et al., 2009, p. 88).

Korea

Evaluation of firm-level innovation shows that Korea is restructuring from a manufacturing-led economy to a knowledge-intensive one and transitioning from imitation to innovation (Lee, 2003, p. 221). A firm survey in 2002 showed that 43% are technologically innovative (Intarakumnerd, Chairatana, & Tangchitpaiboon, 2002). In 2003, the International Institute for Management Development (IMD) ranked Korea first in the world for IT infrastructure and third for S&T achievement (Yim, n.d., p. 2). The long-term innovation vision plans for 2025 and 2030 continue current NIS policies and targeted sectors, including a shift to private sector driven innovation and international competitiveness and openness.

However, several challenges for Korea's NIS have been identified; including enhancing efficiency and interactions through strengthened links among R&D institutes both domestic and foreign ones; more joint research and manpower exchange; more technical cooperation between foreign and domestic firms; and implementing enhanced FDI regimes, cross-licensing, and strategic alliances (Bartzokas, 2007, p. 7-8).

In 2008, the Institute for Systems and Innovation (ISI), the German Institute of Global and Area Studies (GIGA), and the Georgia Tech Program in Science, Technology and Innovation Policy (STIP) also identified strengths and weaknesses in Korea's NIS.

The performance of S&T administration, the GRIs, and the educational system was seen as critical. Korea's tax incentive system was described as complex with many elements. Patent registration adjustments, the creation of spinoff firms, and improved university efforts have resulted in better technology diffusion, patenting, and commercialization. However, innovation linkages through science parks have not been achieved and chaebols have not reached the desired innovation capacity (ISI et al., 2008).

Singapore

Singapore has scored highly on key innovation indicators in international evaluations (Wong, 2003). However, Wong and Singh (2005) claim that insufficient attention has been given to promoting innovation collaboration among local enterprises. They find that despite some examples of promoting R&D consortia, inter-firm collaboration in Singapore lags behind countries such as Finland and Taiwan. This situation is identified as a major weakness in Singapore's NIS (Wong & Singh, 2005, p. 34).

Moreover, venture capital deals are lagging despite government initiatives to establish Singapore as the preferred venture capital location in Southeast Asia (Wong, 2003). Approximately US$13 billion (S$16 billion) in venture funds were managed in 2004, but there was weak high-tech start-up formation in the country (Wong & Singh, 2005, p. 43).

CHAPTER 4

METHODS FOR NIS ASSESSMENT

This chapter presents a framework that could be used by policymakers for assessing the status and performance of national innovation systems in fostering technological innovations in a given country, especially a developing one. The framework is based on a few fundamental questions that would likely be of interest to policymakers and policy analysts. In this way, the framework enables a broad-based examination of NIS as an approach for organizing policies and institutions in multiple domains as they are brought into the production of technological innovation.

A Conceptual Framework for NIS Assessment

The findings of the previous two chapters are synthesized into this framework. The framework calls for an understanding of, first, what the NIS is, i.e. its theoretical conceptualization and its basic system components; second, why the NIS approach is adopted, i.e. the rationale for incorporating the approach in encouraging innovation; third, its implementation in terms of the organizational structures and functions in place; and fourth, potential methods by which the performance of the NIS can be evaluated. Put simply, the assessment framework asks: What is NIS? Why is NIS adopted? How is NIS implemented? And how can NIS performance be evaluated? Table 4.1 presents these four questions as well as the responses that have been uncovered so far through the reviews of NIS and public policy-related theory and the NIS practices of innovation-leading countries.

Table 4.1 NIS Assessment Framework

Question	Explanation	Theory	Best Practice	Criteria
What is NIS?	Concepts of NIS; basic components of the system	A system for stimulating technological innovation in the private sector of a national economy; innovators, linkages, environment	Private firms innovate, R&D institutes, universities and government agencies support; funding, clusters, science parks, rules, regulations, and institutions enable innovation	Presence/absence of necessary system components
Why is NIS adopted?	Rationale and goals	Adopter predisposition; motivation/ obstacles; Costs and benefits; Threats and opportunities; Imitation; Learning	Global competitiveness, economic crisis, learning from/replicating successful practices of others	Historical details of policy development
How is NIS implemented?	Structure and function to achieve intended outputs; organization of the system and the instruments that make it work	Rational bureaucracy; muddling through; consultation, monitoring, credibility	Government agencies/private organizations fund and link innovators; government rules incentivize innovators; institutions provide technical and capital resources to innovators	Organizational and institutional structures and capacities
How can NIS performance be evaluated?	Means of understanding how well the policy or program is doing in terms of meeting intended goals	Measurement of actual vs. expected performance to aid in decision-making; can be vague in respect to public agencies and policies	Quantitatively using international and domestic indicators; qualitatively using expert opinion	R&D expenditures and manpower, patents and publications, new to the world products and processes; commentary and experience of local system experts

The framework presents three dimensions that build on each other and lead to criteria for answering these questions. The dimensions include explanation, theory, and best practice. The *explanation dimension* provides a brief concept of each question and indicates what to look for. Understanding the questions points policymakers in the right direction for finding criteria for an answer. Each question has a unique concept that requires background or theories related to NIS. The *theory dimension* provides policymakers an empirical basis for understanding the concepts, evolution, and components of the NIS; the adoption and diffusion of public policy; and policy and program implementation and evaluation. Theories can be used to develop guiding principles which can help to translate NIS concepts into practice. The *best practice dimension* reflects real-world NISs using short cases of three innovation-leading countries: Finland, Korea, and Singapore. It examines their NIS adoption, implementation and evaluation against the theory. The selection of these three countries is based on their success in applying the NIS approach and stage of economic development as innovation-driven economies. Finland was the first country to adopt NIS and that led to positive changes to its economy up to present, Korea turned crisis into opportunity in the transition to a technology-based economy using NIS and has become competitive in the global economy, and Singapore is a regional and global innovation leader. Additionally, the evaluations of NIS by the OECD, the World Bank, and the World Economic Forum are also reviewed to provide policymakers techniques and measurements for evaluating their countries' innovative performance.

Criteria bring together these dimensions. Understanding the questions, the theories behind them, and real-world experiences provides guidance for policymakers in acquiring relevant data to create their own indicators for NIS assessment. Some criteria could be based on presence or absence of necessary system components, while other criteria could be based on organizational and institutional structures and capacities. This study does not attempt to create uniform sets of indicators for a given country's NIS assessment. Instead, it gives policymakers a framework for finding their own indicators that are "made to measure" their specific system.

Application of the Framework: A Case Study and Interviews

The remainder of this study demonstrates how the NIS framework can be applied to assess the status and performance of an individual country's NIS. In the next chapter, the case study of Thailand's NIS is presented, including a background of the country, an overview of recent socioeconomic trends and STI policy developments, and the details of its NIS. Thailand is in the efficiency-driven stage of economic growth and is in the process of structuring its NIS. History, size and endowments, and economic development stage have shaped Thailand with a different set of institutions, various government roles, and the relations among them as well as different national focuses. These make Thailand a suitable candidate among developing countries for an in-depth review of the NIS.

In addition to reviewing the Thailand case, the interview method is used to obtain insightful information about Thailand's NIS. Individuals with knowledge and experience in Thailand's NIS were asked for their evaluations of the system. These individuals are officials from different departments of Thailand's national government; including Mr.

Alongkorn Ponlaboot, Deputy Minister of Commerce (MOC); Prof. Dr. Soottiporn Chittmittrapap, Secretary General of National Research Council of Thailand (NRCT); and Dr. Yada Mukdapitak, Deputy Secretary General of National Science Technology and Innovation Policy Office (STI). Open-ended interviews were conducted and based on the following questions:

1. In your view, is the NIS approach being implemented effectively?
2. How can NIS be improved?
3. What is your agency's role in this system?
4. How would you evaluate the status and the overall performance of NIS?

CHAPTER 5

A CASE STUDY OF THAILAND'S NIS

This chapter presents an in-depth case study of Thailand's NIS. It includes a brief background of the country itself, a discussion of its stages of economic growth and technological developments. It examines preconditions to Thailand's NIS, provides a broad description of the NIS, and notes some important outputs of the system.

Thailand's shift from an agricultural-based to a higher-technology path stemmed in part from a conscious national development strategy. Thailand, like many other developing nations, has recognized that facilitating the transition to an innovation-based economy is an important public policy priority. A brief overview of the nation's path to economic development and technological progress helps to contextualize this case study's review of the NIS.

Background

Thailand (Figure 5.1 below) is centered on the Chaophraya River basin, where an agrarian and feudalistic society originally developed. Bangkok is the capital of Thailand and is the largest city with a population of 9.6 million in 2009 (USAID, 2011). It is a modern, international city experiencing rapid growth and is the center of government, business, finance, industry and culture in the country.

After World War II, Thailand became a modernizing democratic nation with a market-based economy and strengthening international cooperation (Baker & Phongpaichit, 2005; Chairatana, 2006; Krishna, n.d.; USAID, 2011). Today, Thailand is a

newly industrialized country with a population of 67.8 million. Most of the population is employed in agriculture. However in recent decades, industrial manufacturing has also contributed significantly to GDP and has become an engine of growth and investment (CIA, 2010).

Figure 5.1 Map of Thailand

Source: CIA, 2011

Government in Thailand

Thailand became a constitutional monarchy in 1932. The current king, His Majesty Bhumibol Adulyadej, assumed the throne in 1946 and is the world's longest reigning monarch. The king, prime minister, and the cabinet compose the executive branch of government. The prime minister is typically the leader of the party which gains a majority in parliament from direct elections. The prime minister forms a government by nominating 35 ministers and deputy ministers to compose the cabinet.

The prime minister and the cabinet formulate government policy and agencies translate policies into action. Thailand's parliament is bicameral with five hundred members in the House of Representatives and one hundred fifty members in the Senate. The House of Representatives has the main legislative, appropriations, and constitutional amendment powers, while the Senate has primary advisory with appointment powers. The House can also remove ministers and prime ministers with a vote. The judiciary in Thailand is composed of three systems: a Court of Justice, an Administrative Court, and the Constitutional Court. Thailand has had seventeen constitutions since 1932 and has also experienced several military coups during this time (Baker & Phongphaichit, 2005; Girling, 1981; Library of Congress, 1987; US Department of State, 2011). There are 77 provinces in Thailand, including Bangkok. Provincial governors are appointed by the Minister of the Interior, except for the governor of Bangkok who is directly elected.

Stages of Economic Growth

Industrialization in Thailand began in the late 1950s. Government promoted private investment, the role of state enterprises was reduced, and investment in

infrastructure increased. The first national social and economic development plan was drafted in 1961 and resulted in economic growth driven by private sector capitalism (Baker & Phongpaichit, 2005, p. 150-151). The Board of Investment (BOI) was created to promote investment by providing tax and non-tax incentives and other privileges, the Industrial Finance Corporation of Thailand (IFCT) was created to provide financing for industrial investments, the Small Industry Finance Corporation (SIFC) provided finance to SMEs, and the Thailand Institute of Scientific and Technological Research (TISTR) began conducting R&D (Brimble, 2003, p. 337; Chairatana, 2006, p. 120).

During the 1960s, Thailand employed an import-substitution strategy with tariffs on imports to stimulate domestic industries. By the early 1970s, a major shift in policy to promote export was undertaken; however, some barriers and control on many products, imports, and industrial activities remained (Brimble, 2003, p. 339).

During the 1970s and 1980s, policy favored export industries and also small-scale and regional industries. After 1980, the contribution of agriculture to Thailand's GDP began to decline, and industry's share began to rise (Chairatana, 2006, p. 121). In this period, Thailand positioned itself as an attractive place for labor-intensive manufacturing by combining imported capital and technology with local human and natural resources. Products were marketed and exported through foreign partner networks (Chairatana, 2006). Rapid growth had begun and lasted through the 1980s and into the 1990s. The economy grew at approximately 10% by the middle of the 1980s. Thailand was viewed as an attractive investment location in the Asia-Pacific region. The BOI removed obstacles and provided more incentives for private investment in key sectors. It promoted regional

areas and infrastructure development, with private sector investment becoming increasingly important.

In the late 1980s and the early 1990s, Thailand took steps toward more openness and competitiveness in the economy. The economy grew by more than 8% a year between 1991 and 1995, per capita incomes rose, and poverty decreased dramatically (Brimble, 2003, p. 336). For the period 1985-1994, Thailand's per capita GNP grew by 8.2% (Brimble, 2003, p. 336; Chairatana, 2006, p. 120-122).

In 1995, Thailand joined the World Trade Organization. Foreign direct investment and exports of manufactured products were the main drivers of growth, and the share of GDP from manufacturing reached approximately 30% (Brimble, 2003, p. 336). The rapid growth put pressure on infrastructure and resources causing production costs to rise. There was also intensifying competition from low-wage countries, such as India, China, and Indonesia. In response, Thai manufacturers shifted to higher value-added and more sophisticated products and moved up the value added ladder (Brimble, 2003, p. 336).

In 1997, however, the Thai economy went into a deep recession due to the failure of the financial sector. This economic crisis lasted the remainder of the decade. As a result, the currency collapsed, over 2 million people lost their jobs, consumers stopped buying, and creditors stopped paying their loans. The economy had become fragile due to cheap credit, weak financial controls, and excessive foreign investment. Between 1997 and 1998, the economy declined by 11%. GDP growth in 1998 was -8.3%, and inflation rose to 8% (Baker & Pongphaichit, 2005; Bosworth, 2005, p. 2; Brimble, 2003, p. 336-339; Chairatana, 2006).

The crisis in Thailand triggered similar crises in several other East Asian countries because of the level of integration of the regional economies. This phenomenon was referred to as "contagion." The IMF intervened in Thailand and some of the other affected countries to help stabilize the situation. Friedman (1999) has referred to the Asian Economic Crisis as the "first global financial crisis of the new era of globalization" (p. 1).

Investment was also affected by the crisis. In the first half of the 1990s, investment averaged 40% of GDP; however after the crisis, investment has been reduced to only 20% (Bosworth, 2005, p. 2). The crisis caused financial and corporate restructuring, and the government implemented reform to the financial sector (Brimble, 2003, p. 339). By the early 2000s, economic output had bounced back to the pre-crisis level; however, economic growth was on a lower trajectory. At this point, Thailand required "significant increases in competitiveness in the major export sectors" (Brimble, 2003, p. 337).

Thailand's growth has been described as relatively capital intensive because the growth of the capital stock has been greater than the growth of the output (Bosworth, 2005, p. 2). Studies conducted by domestic institutions indicate strong rates of capital formation. Moreover, the largest improvement in total factor production (TFP) has occurred in agriculture while TFP growth in the service sector has frequently been negative (Bosworth, 2005, p. 16).

Current Economic Status

Thailand is transitioning into a middle-income country. It is seen as a business-friendly manufacturing hub, and an investment, industry, and tourism destination in the Asia-Pacific region. Thailand's GDP in 2010 was approximately US$153.19 billion, and its GDP per capita was US$2,276.28 (ADB, 2012).[19] Tables 5.1 and 5.2 below show the structure and trends of economic output and exports for Thailand in recent years. For the period of 1990-2010, overall, Thailand's GDP and its GDP per capita have increased during this period. Moreover, the output of the agricultural, industrial and service sectors of the economy have remained consistent during this period (ADB, 2012).

Exports are critical to the economy, accounting for about two-thirds of GDP (USAID, 2011). In 2010, exports grow by 26.8% and in 2011 by 15.5% (ADB, 2012). Export activities are concentrated along the Eastern Seaboard, where port facilities and major industrial estates are located. Major export industries include electronics, automotive, chemicals and heavy industry.[20] The electronics industry is the country's largest source of manufacturing export, particularly hard disk drives. Most electronics firms are original equipment manufacturers (OEMs) for foreign multinational corporations (MNCs). Automobiles and automotive parts exports account for 12% of GDP. Thailand has become an important base of production for automotive firms from Japan, the United States, and Europe. It is predicted that Thailand will be one of the top 10 motor vehicle producing countries in the world by 2015 (Intarakumnerd, 2010).

[19] GDP and GDP per capita in constant 1988 dollars
[20] Business Report Thailand, issue 5, February 2011

Table 5.1 Thailand's Output in Constant Prices 1990-2010

Indicator	1990	1995	2000	2005	2010
National Accounts					
GDP per capita (USD)	1,359.21	1,930.74	1,418.37	1,446.14	2,276.28
GDP (billion USD, at constant prices)	75.84	114.69	88.22	94.14	153.19
GDP by industrial origin at constant prices (billion USD)					
Agriculture	10.28	10.78	9.09	8.49	12.72
Mining	1.21	1.74	1.88	2.15	3.37
Manufacturing	21.09	37.36	32.15	36.60	62.44
Electricity, gas, and water	1.82	3.08	2.86	3.15	5.46
Construction	4.55	7.16	2.24	2.29	3.40
Trade	13.18	20.14	13.92	13.22	20.36
Transport and communications	5.72	9.33	8.52	9.37	14.34
Finance	4.21	12.48	5.99	7.02	11.92
Public administration	2.39	3.02	2.79	2.84	4.24
Others	11.38	9.59	8.78	9.02	14.94
Structure of output (% of GDP)					
Agriculture	10.0	9.1	8.5	9.2	10.9
Industry	37.2	37.6	36.9	38.8	40.1
Services	52.8	53.3	54.6	52.0	49.0

Source: Based on ADB, 2012
Note: The base year for constant prices is 1988; Services includes banking, finance, and tourism.

Agricultural products are also a major export. Approximately 42% of the working population is engaged in agriculture (USAID, 2011). Thailand is the largest exporter of rice in the Southeast Asian region and one of the largest in the world. It is also the world's largest exporter of shrimp and natural rubber. Besides electronics, automotive, and agricultural products, other important exported products include gems and jewelry, chemicals, and polymers. Currently, the United States is Thailand's largest export market, followed by China (ADB, 2010; ADB, 2012).

Tourism is also a major component of the economy with approximately 15% annual growth in numbers of tourists in 2010 (Durongkaveroj, 2010; MFA, 2010). Typically, tourism accounts for about 6% of Thailand's annual GDP. Tourism is more important to Thailand's economy than to any other Southeast Asian country.

Table 5.2 Thailand Exports 2000-2011

Indicator	2000	2005	2008	2009	2010	2011
Exports						
Exports value (billion USD)	62.2	110.9	177.8	152.4	193.3	222.6
Exports growth (%)	19.9	14.9	15.54	-14.3	26.8	15.5
Key Exported Products, growth rate (%)						
Automatic data processing machines parts and accessories	7.6	28.6	1.4	-9.9	9.4	-13.9
Motor cars, parts, and accessories	27.2	40.5	14.8	-26.3	48.3	-8.8
Electronic integrated circuits	52.3	21.4	-18.0	-7.8	16.3	-6.7
Rubber	31.5	8.2	15.1	-34.6	70.5	59.3
Precious stones and jewelry	-1.4	21.7	48.0	21.8	9.9	1.2
Polymers of ethylene, propylene, etc. in primary forms	53.5	34.6	0.9	-16.1	31.8	32.4
Iron, steel and their products	n/a	16.0	12.2	-4.4	n/a	n/a
Machinery and parts thereof	n/a	26.0	-7.0	-18.7	36.3	19.4
Refine fuels	n/a	33.7	84.6	-27.6	14.9	23.5
Rice	-15.8	n/a	70.5	-15.3	n/a	-2.3
Rubber products	n/a	n/a	19.0	1.9	33.1	24.4
Chemical products	n/a	27.7	4.9	7.4	19.9	37.0

Source: Based on MOC, 2012 (Exports) and NSO, 2012 (Key Exported Products)
Note: n/a means the product is not in the top 10 exported items.

In 2009, Thailand's "Creative Economy" became the focus of a new economic development strategy. The Director of the National Innovation Agency, Dr. Supachai Lorlowhakarn said,

> The emergence of the 'creative economy' concept in recent years is closely linked to innovation. In essence, a creative economy is deeply anchored in continuous innovation wherein not only technological advancements, but also business factors and social factors provide a foundation for such development.[21]

The Creative Economy policy as defined by the National Economic and Social Development Board (NESDB) covers four industry clusters.[22] These are: (1) cultural heritage industries, which include crafts, historical and cultural tourism, Thai foods, and traditional medicine; (2) performing and visual arts; (3) media, including film, publishing, broadcasting, and music, and (4) functional creation industries, which include design, fashion, architecture, advertising, and software. These clusters comprise "creative" domestic industries which are less dependent on foreign capital and technology (PRD, 2011). The new strategy is referred to as "Creative Thailand." The goals of the Creative Thailand policy are to promote Thailand as a hub of creative industries in South East Asia, and to boost the economic contribution of national creative industries from the 12% to 20% of GDP by 2012 (PRD, 2011).

The Thai government has identified several measures to achieve the goals of the Creative Thailand policy, including: (1) establishing a dedicated agency to oversee policy implementation; (2) enhancing the efficiency of the nation's intellectual property management system; (3) developing a next-generation ICT infrastructure to support creative industries; (4) updating the national curriculum with courses and textbooks on

[21] http://www.thailand-innovativecompanies.com/ttd_bizenterprise/Indprof/TTIC/TTIC_2010_IP04.pdf
[22] The National Economic and Social Development Board (NESDB) describes the creative economy as a way to drive a balanced and sustainable production restructuring strategy under the 10th National Economic and Social Development Plan (2007-2011). The major principle is the creation of value by applying knowledge and innovation, together with strength from the diversity of natural resources, culture, and Thai ways of life (http://thailand.prd.go.th/ebook/review/content.php?chapterID=76).

the Creative Economy and intellectual property; (5) promoting the value of traditional knowledge and creativity at the regional and community levels; (6) establishing new sources of funding and new investment measures to support creative industries and businesses, especially SMEs; and (7) allocating approximately US$670 million from 2010-2012 to lay the groundwork for the Creative Economy agenda.[23]

Science, Technology, and Innovation

From the late 1950s to about 1980s, science and technology policy development started to take shape in Thailand. In 1959, the National Research Council of Thailand (NRCT) was created to formulate and implement national research policy and strategies.[24] In 1963 the Thailand Institute of Scientific and Technological Research (TISTR) was created for implementing special S&T policies of the Thai government.[25]

The First (1963-1966) and then the Second (1967-1971) National Economic and Social Development Plans were launched during this period.[26] In 1979, the Ministry of Science and Technology (MOST) was created to formulate national policy for S&T, the environment, and energy, and to implement these policies efficiently to bring about the most socio-economic benefits and national stability.[27] Four universities offering degrees in engineering, computing, and other technological fields opened during 1970s: the Asian Institute of Technology (AIT), King Mongkut's University of Technology North

[23] http://thailand.prd.go.th/ebook/review/content.php?chapterID=77
[24] http://nrct.go.th/index.php?mod=contents&req=view&id=88
[25] http://www.tistr.or.th/tistr_en/index_en.php?pages=us_history
[26] http://www.nesdb.go.th/Default.aspx?tabid=84
[27] http://www.most.go.th/eng/index.php/about-the-ministry/background

Bangkok (KMUTNB), King Mongkut's University of Technology Ladkrabang (KMITL), and Mahidol University (MU) (Inarakumnerd & Brimble, 2007).

During the 1980s, technology plans were developed and two key public technology research institutes opened. The Fifth National Economic and Social Development Plan (1982-1986) called for promoting S&T to raise output and productivity and conserve factors of production for agriculture, manufacturing, and energy. [28] The development of the 20-year S&T master plan (1990-2011) also began at this time. The National Science and Technology Development Board (NSTDB) was established during this period to conduct, support, coordinate, and promote efforts in scientific and technological development in the public and the private sectors. The National Center for Genetic Engineering and Biotechnology (BIOTEC) and the National Electronics and Computer Technology Center (NECTEC) were also created. BIOTEC supports the creation and transfer of technology for industry, agriculture, natural resources, and the environment.[29] NECTEC undertakes and promotes the development of electronics and computer technologies through R&D activities, and serves as a linkage between research communities and industries through established industrial clusters.[30]

Between 1987 and 1997, 103 scientists and engineers and 39 technicians per million persons were engaged in R&D in Thailand, and science and engineering students accounted for 18% of college and university enrollments. Suranari University of Technology opened, and planning for the Thailand Science Park (TSP) began in 1989.

[28] http://www.nesdb.go.th/Default.aspx?tabid=87
[29] http://www.biotec.or.th/biotechnology-en/en/About-Us.asp
[30] http://www.nectec.or.th/en/index.php?option=com_content&view=article&id=46&Itemid=63

TSP would become a major hub for technological innovation in the country (Intarakumnerd et al., 2002).

In the 1990s, the Seventh National Economic and Social Development Plan (1992-1997) called for a sectoral approach to technology development and initiated several instruments to encourage innovation.[31] The National Science and Technology Development Agency (NSTDA) was established in 1991 with an annual budget of US$50 million. Its task was to promote a knowledge-based society through R&D, technology transfer, human resources development, and infrastructure development and research.[32] The Thailand Research Fund (TRF) was set up to strengthen Thailand's research infrastructure through grants provision.[33] The National Synchrotron Research Center (NSRC) was also established to conduct nationwide research in basic science, chemistry, and biochemistry for industrial adaptation.[34]

In 1996, the First National Information Technology Policy, called IT 2000, was developed. It identified three key areas necessary for IT development in Thailand: (1) an equitable national information infrastructure, (2) human resources, and (3) enhancement of government service. The Thailand Graduate Institute of Science and Technology (TGIST) was established to develop human resources in S&T, and link industry and academia.[35] King Mongkut's University of Technology Thonburi (KMUTT),

[31] http://www.nesdb.go.th/Default.aspx?tabid=89
[32] http://www.nstda.or.th/eng/index.php/at-a-glance
[33] http://www.trf.or.th/en/visions.asp
[34] http://www.most.go.th/eng/index.php/agencies-under-most/75-national-synchrotron-research-center
[35] http://www.nstda.or.th/tgist/general.html

Mahanakorn University of Technology (MUT), and the National Science Museum (NSM), also opened during the decade.

The Asian economic crisis that struck Thailand in the late 1990s has been called a "blessing in disguise," because the country then became aware of the importance of learning processes and linkage creation for supporting industries (Intarakumnerd & Brimble, 2007, p. 263). After the crisis, the idea of "competitiveness" gained more attention in Thailand and throughout the region. It triggered science, technology, and innovation policy reform (Brimble, 2003, p. 340; Intarakumnerd & Brimble, 2007, p. 263).

Immediately following the crisis, Thailand re-examined its approach to economic growth and development, led by the government of Prime Minister Thaksin Shinwatra, who emphasized the country's economic competitiveness. Support for innovation-oriented policy in the government also took shape at this critical time. Dr. Yada Mukdapitak, the deputy secretary general of Thailand's Science, Technology and Innovation Policy Office, states that NIS was recognized in Thailand around 1998 by NSTDA (discussed below). During the 1990s, Dr. Yongyut Yuthavong, the first President of NSTDA, was searching for a way to manage the country's S&T development in a more systemic approach and also to understand international trends in technology transfer and technological innovation. A two-year research project was initiated to uncover details about systemic approaches to S&T development. Dr. Mukdapitak was one of three NSTDA's researchers assigned to the project. NIS came to the researchers' attention

because of the global trend of innovation thinking at that time (personal communication, April 7, 2011).

Research on NIS in Thailand had begun. Its aim was to understand the concept of NIS itself and determine how it could bring changes to the country's S&T development approach. Dr. Mukdapitak and her colleagues investigated what other countries were doing with NIS, including Finland, Japan, Korea, Taiwan, the United Kingdom, and the United States. Interviews with key people that studied NIS and innovation policy in those countries were conducted (personal communication, April 7, 2011).

The NSTDA study resulted in a report on innovation systems, and recommendations to the government for a change in national direction for R&D and S&T development. The Research and Policy department at NSTDA also invited Bengt-Åke Lundvall, a leading NIS expert from Aalborg University in Denmark, to help explain the NIS idea to the Thai government. The NIS concept was initially applied. NSTDA supported the NIS approach to prioritize what needed to be done, and to direct key system actors to accomplish innovation-related tasks (Y. Mukdapitak, personal communication, April 7, 2011).

Description of Thailand's NIS

The rationale for NIS adoption in Thailand is based on three main factors: the environmental context, competition, and learning. The environmental context refers to outward influences that cause changes in making decisions (e.g. system shocks, crisis). Competition means that adoption occurs when the adopter enters into economic competition. Adoption is more likely when positive economic spillovers are present.

Negative economic spillovers discourage adoption. Learning can incorporate the adopter's own experiences as well as the experiences of others. Learning also involves the processing of information which can be obtained from internal and external sources.

The Asian economic crisis of 1997 raised the awareness of competitiveness of the country and triggered science, technology, and innovation policy reform. Concerted learning and research efforts at this time in Thailand focused on a more systemic approach to manage the country's innovation development. NIS came to the country's attention because of the global trend of innovation system thinking at that time. Adoption of the NIS approach was a good fit with the historic and continuing build-up of science and technology infrastructure and capacity in the country. A long-term view of growth and development was emphasized by both NIS and S&T build-up.

Different reasons for adopting a policy or program leads to different responses and means of implementation, and most importantly, this can lead to different levels of success. If the adopters are forced to adopt something into use without background knowledge and experiences, they may not be ready and find it difficult. Similarly, when the adopters voluntarily adopt something without learning it thoroughly, it may not be well conceived and fail. Will different adoption types affect the performance? For Thailand, the factors that triggered NIS adoption are the environmental context from financial crisis, competition in global economy, and learning from experiences of NIS leading countries. This gives us understanding of the way Thailand adopted the NIS and why it does what it does. Is Thailand doing the thing right or is Thailand doing the right thing?

Implementation of the NIS is proceeding in Thailand, affected by the wider policy environment discussed above. National Innovation Agency (NIA) and the National Science, Technology and Innovation Policy Office (STI) have both shown capacity in planning for and fostering innovation. Foreign-based firms and investors are transferring capital and some necessary technology to suit their operations to the local affiliate firms. This transfer takes place through the conventional branch plant arrangement. Most domestic firms in Thailand appear to lack the resources, technical sophistication, and stimulus to be real participants in the implementation of the NIS. Institutional structures to facilitate innovation are taking shape; however, weak or missing linkages among innovation actors persist in the system. Most notably, the critical linkage between industry and universities appears to be underdeveloped. Rationalizing the system and enhancing the credibility of actors and their incentives can have a positive impact on policy implementation. These issues will be described in more detail and addressed through policy recommendations in the sections below.

In Thailand, the NIS is intended to assist the innovative efforts of targeted firms in private industry. These firms undertake R&D and innovative activities to produce products and processes that embody technological innovation. Public organizations, including key government agencies and research institutions are integral to facilitate the innovative efforts of firms. Key political and social institutions create "framework conditions" (OECD, 1997b) that also help to promote a climate for innovation in the economy. These aspects of Thailand's NIS are described below.

The Private Sector

Industry accounted for approximately 45% of Thailand's GDP in 2010 (CIA, 2010). Major industries include textiles and garments, agricultural processing, food and beverages, cement, jewelry, electric appliances, machinery and equipment, computers and computer parts, integrated circuits, communications equipment, furniture, rubber and plastics, automobiles and automotive parts. The industrial production growth rate was 14.5% in 2010, which was the ninth-highest in the world. Manufacturing exports accounted for approximately 50% of GDP in 2010, especially machinery and electronic components (CIA, 2010; NSO, 2007). Table 5.3 below is based on Thailand's last census of industry in 2007. [36] It shows output from major industrial divisions in terms of value added production. Communication equipment, food and beverages, motor vehicles, and fabricated metals are the leading industries in terms of value added.

Large multinational corporations (MNCs) and large state-owned enterprises dominate the economy and are the most important contributors to GDP (Intarakumnerd, 2010). The automotive and electronics manufacturing sectors include important Japanese firms, such as Honda, Toyota, Hitachi, and Matsushita (Andrews, Chompusri, & Baldwin, 2003).[37] Between 1995 and 2004, transportation machinery and electronics including hard-disk drive (HDD) were the top two manufacturing subsectors in terms of FDI (Brimble & Urata, 2006).

[36] The National Statistical Office conducts the census of industry every 10 years.
[37] http://www.bangkokcompanies.com/categories/thai_companies_p252.htm

Table 5.3 Industrial Value Added Production 2007

Industrial Division	Value added	
	(million USD)	%
Food and beverages	7571.0	14.0
Textiles, apparel, leather products	4784.0	8.8
Wood and wood products, paper and paper products, printing	2519.4	4.6
Chemicals and chemical products	3431.1	6.3
Rubber and plastic products	3783.6	7.0
Non-metallic, basic metals and fabricated metallic products	6596.2	12.2
Machinery and equipment	2971.8	5.5
Radio, television, and communication equipment and apparatus	7990.5	14.7
Motor vehicles, trailers, and semi-trailers	6661.8	12.3
Furniture manufacturing	1925.8	3.5
Others	6047.1	11.1
Total	**54,282.6**	**100.0**

Source: Based on NSO, 2007
Note: Value added equals gross output less production expenses

The R&D activities of most MNCs appear disconnected from local affiliates and institutions (Brimble & Urata, 2006). In the HDD subsector, however, Seagate Technology appears to be the only MNCs in Thailand to acknowledge the values of innovation linkages. It is the country's largest employer and has developed mutual technology, human resources, and R&D connections with several of Thailand's universities (Brimble & Doner, 2007, p. 1029-1030; Doner, 2009, p. 136). Seagate has taken the initiative on: (1) developing a consortium of five universities to deliver a customized curriculum for producing engineers to manage the company's high-tech facilities, (2) participating in a government cooperative training program hosting 20-40 students per year, and (3) establishing joint R&D centers at Khon Kaen and Suranaree

Universities. These have been successful efforts with benefits for both partners (Brimble & Doner, 2007). However, Thai authorities have been unable to transfer lessons from the Seagate example into initiatives for related industries (Brimble & Doner, 2007; Doner, 2009).

In 2006, Thailand's small and medium sized enterprises (SMEs) contributed nearly 40% of GDP. Thailand's BOI estimates that 99% of the companies operating in the country in 2010 were SMEs. SMEs are defined as having no more than 200 employees and no more than US$200,000 of capital. Thailand has many SMEs which account for 78% of employment. However, Thailand has fewer medium-sized enterprises and more small enterprises than other Asian countries. The many small enterprises in the country employ relatively small numbers of workers. This suggests that barriers to growth exist in the economy (Intarakumnerd, 2010). Some SMEs, many large local firms, and most MNCs, possess little higher order technological capabilities, as shown in Table 5.4 below (Arnold et al., 2000). Perhaps because of the lack of technological skills in SMEs, the Office of Small and Medium Enterprise Promotion's (OSMEP) set up the SMEs promotion plan (2007-2011) as a strategy for upgrading their productivity and innovative capability (Hoang, 2008).

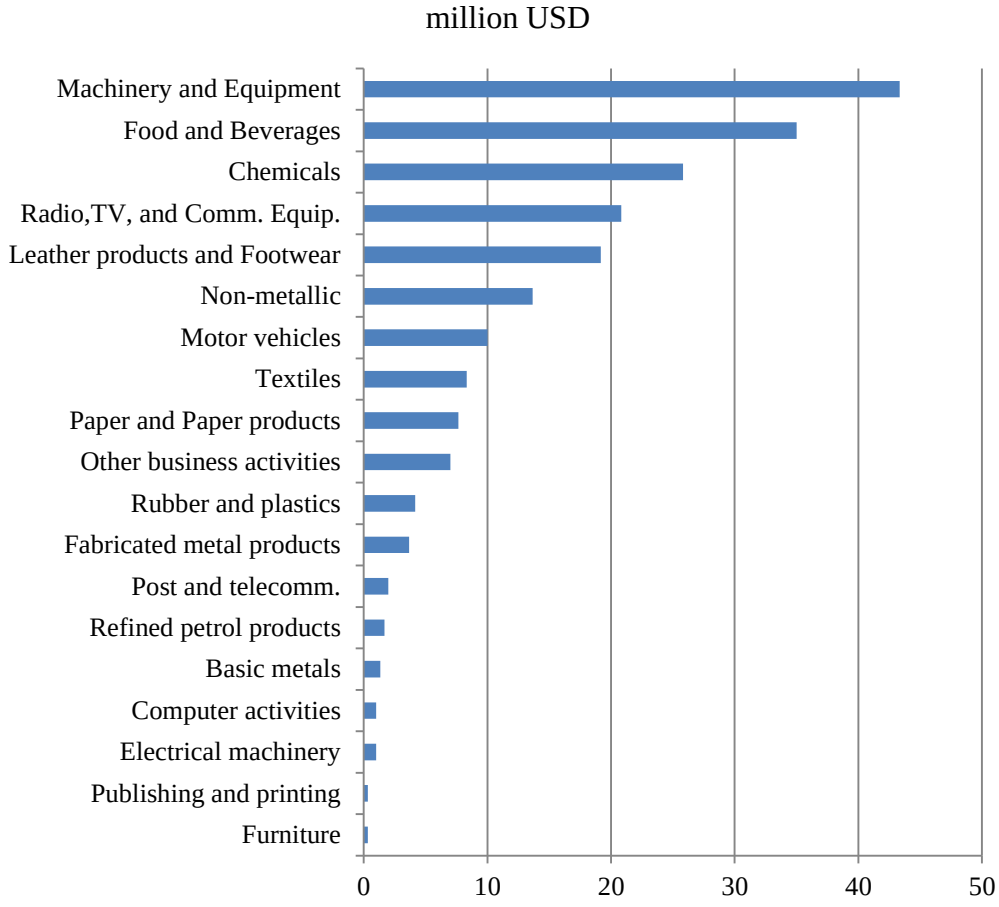
Table 5.4 Technological Activities and Capabilities in Thai Firms

Activity	Firm Type	
	Some SMEs, Many Large Local Firms, Most MNCs	**Most SMEs**
Research and technological development	Occasionally present, limited in scale, depleted by 1997 crisis in some cases, strengthened by pressures in many cases	Very rarely present
Design and engineering	Capabilities limited but growing, when present play a limited technological development role but this is likely changing	Rarely present though emerging in some firms
Technician and craft skills and capabilities	Usually present, often the focus of training efforts, selected key skills sometimes weak	Strong skills sometimes present, though key skills often weak or absent
Basic operating skills and capabilities	Present, often strong, and regularly upgraded	Often weak with limited and irregular upgrading

Source: Based on Arnold et al., 2000

Many Thai firms have shown slow and passive technological learning, a lack of R&D capabilities, and long-term technological development (Arnold et al., 2000; TDRI, 1992). However, there are some business sectors in Thailand that are investing relatively more in R&D, as shown in Figure 5.2 below. These include some key manufacturing subsectors, such as machinery and equipment, food and beverages, and chemicals subsectors.

Figure 5.2 Business Sector R&D Expenditures in 2005 for High-Ranking Sectors



Source: Based on Vanichseni & Suvalai, 2009

There are two main organizations that are active in promoting innovative capacity and diffusing innovation knowledge among domestic firms (Intarakumnerd & Brimble, 2007, p. 255). These are the Technology Promotion Agency (TPA) and the Kenan Institute Asia (KI Asia). They serve as "bridging agents" by providing education, training, technical services, and technology transfer to industry partners. The TPA and KI

Asia have also become involved in government policies to enhance the capacity and entrepreneurship of Thai SMEs (Intarakumnerd & Brimble, 2007, p. 256).

Cluster development is seen to enhance the competitive advantages of industries. Porter (2003) notes the progression of national economies in cluster development, including manufacturing, service, and regional assembly. An important step is to upgrade the sophistication of clusters to more advanced activities, such as Silicon Valley. The Thai government has taken policy steps over the years to encourage cluster formation for industrial development, and Thailand industrial clusters have been recognized internationally (WEF, 2010). The greater Bangkok area has become a favorable base for world-leading firms to produce for regional and global markets. Currently in the Bangkok area, there is an electronic industry cluster and an automobile industry that are particularly active and worthy of attention.

Thailand is the largest hard-disk drive (HDD) assembler in the world (Intarakumnerd & Brimble, 2007, p. 249). Major manufacturing facilities in the Greater Bangkok region are operated by world-leading firms, including Seagate, Maxtor, Western Digital, Hitachi-IBM, and Fujitsu (Yeung, 2008). Thai firms typically import high-tech components, and then export the assembled product worldwide, therefore local content is low. Technology is transferred from foreign affiliates, and marketing and production decisions are made by MNCs headquarters (Intarakumnerd & Brimble, 2007, p. 249). Thai HDD firms have shown strong capabilities in investment, process development, and industrial engineering, but weak capabilities in product engineering and innovation and linkage development. Firms have expressed interest in strengthening linkages to other

industry stakeholders through joint efforts by industry and government (Intarakumnerd & Brimble, 2007, p. 249).

Since 1999, NSTDA has supported cluster development programs for the HDD industry. Representatives from the storage technology industry, the Thai government, academia, and public research institutes have created a collective management committee to help guide the development of the industry in Thailand. In 2004, the committee planned several joint activities utilizing public-private partnerships. Projects were designed to further develop human resources, industry automation, investment opportunities, and technology "road mapping and to create a Disk Storage Institute." As of 2005, most of these projects are underway using public and private financing, with NECTEC and MOST playing a supportive (Intarakumnerd & Brimble, 2007).

In the automobile manufacturing industry, the Greater Bangkok and eastern seaboard region of Thailand is now Southeast Asia's leading production center. More than 20 world-leading assembly firms and hundreds of suppliers are active (Yeung, 2008). The automobile industry is now Thailand's second largest export industry after electronics and electrical products (Yeung, 2008, p. 27).

In the automobile cluster, both foreign and Thai-owned assemblers and suppliers gain the benefits of lower transport and logistics costs, increased certainty in inter-firm transactions, reduced time-to-market, and just-in-time production flexibility. These advantages come from the geographic proximity of firms in the cluster. The Thai government has played an important role in facilitating cluster development by creating sector-specific industrial estates, and securing regional economic cooperation. The

National Innovation Agency (NIA, discussed below) has become increasingly involved in the automobile cluster. These efforts have helped to connect Thailand's automobile cluster with global automobile production networks.

Yeung (2008) investigated the emergence of industrial clusters in Thailand, Malaysia, and Singapore, including the HDD and automobile clusters. He describes three models for the existence of industrial clusters: (1) an "agglomeration economies model" which results from local specialized labor, local provision of non-traded inputs, and the flow of product and market knowledge; (2) an "industrial complex model" which results from lower transport and logistics costs and greater certainty in transactions; and (3) a "social network model" which results from localized trust and interpersonal relationships, institutionalized practices, conventions, and norms. Yeung finds that aspects of the HDD and automobile clusters in Thailand can be explained by the agglomeration economies and industrial complex models, but not the social network model.

Public Sector Organizations

In Thailand's NIS, several public organizations help to create a supportive climate for innovation by connecting potential innovators with resources and with each other. As noted above, there are few linking organizations in the private sector; therefore public institutions serve as the main linkages in Thailand's NIS. These include: the Ministry of Science and Technology, the National Science and Technology Development Agency, the National Science Technology and Innovation Policy Office, the National Innovation Agency, the National Research Council of Thailand, the Thailand Research Fund, four public research institutes, and the Thailand Science Park.

The Ministry of Science and Technology (MOST) was established in 1979. Its responsibilities are formulating, coordinating, and implementing national policy for S&T, the environment, and energy. It oversees the work of fourteen agencies and enterprises, including the National Science and Technology Development Agency, the National Science Technology and Innovation Policy Office, and the National Innovation Agency).[38] The Permanent Secretary of MOST Pornchai Rujiprapha states,

> We must capitalize on our competitive advantages by investing in R&D. It is our goal that we invest in research and innovation in the advanced-industrial clusters . . .We realize that to escape the middle-income trap, Thailand must invest in research to stay ahead in the international economy. We plan to become an innovation hub in Southeast Asia, capitalizing on a well-trained science-and-technology workforce, science-and-technology training services, cost effectiveness in R&D, a foreign-direct-investment-friendly policy, government support and incentives for investment and our well-known hospitable culture.[39]

The National Science and Technology Development Agency of Thailand (NSTDA) is an autonomous agency within the MOST. It was created by the Science and Technology Development Act of 1991 and tasked with conducting, supporting, coordinating, and promoting efforts in scientific and technological development in the public and the private sectors.[40] NSTDA enables scientists and experts to meet and work on scientific and technological issues of national and international priority. NSTDA is the home of the four national research centers discussed below: BIOTEC, MTEC, NECTEC, and NANOTEC. In 2008, NSTDA's R&D budget was approximately US$64 million (1,910 million baht) (Vanichseni & Suvalai, 2009).

[38] http://www.most.go.th/eng/index.php/executive-ministry-of-science-and-technology/history-of-most
[39] http://www.nationmultimedia.com/2011/03/01/technology/Ministry-pushes-R&D-investment-30149798.html
[40] http://www.nstda.or.th/eng/index.php/about/nstda-in-brief

The Technology Management Center (TMC) is the commercial department of NSTDA and facilitates the growth of high-tech industry in Thailand.[41] It encourages researchers to transform their results into SMEs and other firms commercial applications in assisting them toward knowledge-based, higher value-added operations. The TMC offers financial assistance to firms through research grants, R&D loans and tax incentives (in conjunction with the Revenue Department), and loans for company start-ups and new technology. It also co-invests in pioneering or high priority national projects. Other programs operated by TMC include the Industrial Technology Assistance Program (ITAP), which helps firms overcome technical obstacles, and the Support for Technology Acquisition and Mastery Program (STAMP), which helps firms acquire and utilize new technology.

The National Science Technology and Innovation Policy Office (STI) is under the MOST and was created by the National Science, Technology, and Innovation Act of 2008 (discussed below).[42] Its objective is to develop science, technology, and innovations for national economic and social development. STI's major responsibilities are: (1) formulating national STI policies and plans; (2) developing standard measurements, indicators, and databases, and conducting research on science, technology and innovation policy; (3) providing support and advice to other government agencies in formulating their own STI implementation plans; (4) coordinating and monitoring the development of

[41] http://library.stks.or.th:8080/dspace/bitstream/123456789/1067/1/Summary%20Biotecnology%20in%20Thailand_Book-01.pdf
[42] http://www.sti.or.th/th/index.php?option=com_content&view=article&id=224&Itemid=105

a national S&T workforce; and (5) monitoring and evaluating national STI implementation actions.

The STI sees three elements important for innovation: (1) Thailand's NIS; (2) technical requirements, including hardware, software, engineering technology, and basic science; and (3) the goals of innovation, including new and emerging industries and businesses, economic growth, and social development (Durongkaveroj, 2010). It enacted a 10-year Science and Technology Action Plan (2004-2013) to strengthen industrial clusters and innovation capabilities. The plan includes targets for measuring innovation progress which concern levels of R&D expenditure and manpower. Indicators, databases, indexes, reports, and research on comparative STI policies are also provided. STI coordinates and monitors the development of human STI resources in the country, and ensures consistency between other innovation-oriented agencies and the STI policy and plan.

The National Innovation Agency (NIA)[43] was established by the Ministry of Science and Technology in 2003 as an autonomous organization. NIA was tasked with enhancing the national innovation system through a broad-based approach. The establishment of the NIA combined the Innovation Development Fund, previously under the NSTDA, and the Revolving Fund for Research and Technology Development, previously under the MOST. The intention is to set up a single agency to undertake and support national innovation development.

[43] http://www.most.go.th/engCMS/index.php?option=com_content&task=view&id=74&Itemid=84

NIA serves as a central coordinator in the innovation system by linking different organizations from the fields of education, technology, finance, manufacturing and management. It provides technical advice, financing and investment, industry and innovation markets assessment, post-R&D support for commercialization. NIA uses knowledge management and promotes a cluster format for achieving three objectives: (1) inducing innovations in economic units, (2) creating a supportive atmosphere for innovation culture, and (3) strengthening organizations in innovation direction. Five innovation cluster projects are ongoing in NIA: (1) food and herbs, (2) indigenous rubber and derived products, (3) software and mechatronics, (4) automotives and parts, and (5) engineering and industrial designs.

The NIA is implementing the STI Policy goals at firm level. Acting as a "match-maker and integrator" (Lorlowhakarn & Ellis, 2005), it supports research in areas that meet business needs, and encourages development of start-up companies, especially SMEs. NIA has initiated and partnered in several schemes to manage the risks of investing in innovative businesses and facilitate the emergence of new companies involved in knowledge-based R&D. For example, with one scheme, NIA bears the interest payments incurred on behalf of the recipient for the first three years (Lorlowhakarn & Ellis, 2005).

The NIA has performed these activities on a variety of recent projects. These include: (1) the University Business Incubator program with the Commission on Higher Education and several universities, (2) the Innovation Management for Executives (IME) training course supported by 17 universities and companies; (3) five-minute diagnostic

test kits for H5N1 Avian Influenza and Salmonella; (4) R&D, commercialization, and cluster building for native herbal extracts with five universities, eight suppliers, and the spa industry; (5) the Design and Branding Innovation Project of the Ceramics Development Cluster in Lampang province, which seeks to establish *CeraLampang* as a world-renowned Thai national brand; (6) the National Organic Agriculture Model to stimulate the organic sector's product and process-based innovations; (7) consortium building between four software companies and shrimp producers and exporters for a computer-based traceability system to verify product safety and quality for the Thai shrimp industry; and (8) introduction of new technologies, funding, and strategic innovation projects for the natural rubber industry in order to increase the international competitiveness of the sector and stimulate private sector investment (Lorlowhakarn & Ellis, 2005).

Recently, NIA is granting approximately US$10 million (300 million baht) to Thai companies to set up a pilot plant for bioplastic production. This is part of NIA's plan to offer 30% funding support for investments in bioplastic production. The manager of the NIA's Innovation Strategy Department, Sura-at Supachatturat said, "Without the NIA sharing the risks, it would be very difficult to persuade companies to set up the plant in Thailand due to the relatively high cost." Moreover, NIA director, Supachai Lorlowhakarn said, "If the project succeeded, it could also help to promote efforts to restructure Thailand's agricultural system."[44]

[44] NIA hopes to kickstart new industry with B300m (2011, April, 18). *Bangkok Post.*

The National Research Council of Thailand (NRCT)[45] was established in 1959 as the government's highest council on issues of scientific research relating to national development. To carry out this mission, NRCT: (1) formulates the national research policy and strategy; (2) develops research standards, research systems, and conducts research monitoring and evaluation; (3) promotes local and international research cooperation; (4) promotes and supports research, inventions, innovation, and technology transfer to social, industrial, and commercial sectors; (5) reports on national research status and research indicators; and (6) serves as a knowledge center for research.

In 2009, the NRCT initiated Thailand's research system reform to establish linkages among domestic and foreign research agencies, stakeholders, researchers, and other related parties. In the process of the research system reform, NRCT has been working closely with other research agencies, including National Science and Technology Agency (STI), Thailand Research Fund (TRF), National Science and Technology Development Agency (NSTDA), Health System Research Institute (HSRI), Agricultural Research Development Agency (ARDA), National Economic and Social Development Board (NESDB), and Office of Educational Council (OEC). The reform program intended to bring clarity and more efficient administration to Thailand's research system. In 2009, NRCT had an R&D budget allocation approximately US$23 million (677 million baht) (NRCT, 2009).

[45] http://www.nrct.go.th

The Thailand Research Fund (TRF) was established by the 1992 Research Endowment Act to enable greater efficiency in research support.[46] Its objectives are to: (1) build up professional researchers and strengthen the research community, (2) support basic and applied research significant to national development, (3) promote the dissemination and use of research findings, and (4) raise funds for national R&D efforts. In 2008, TRF had an R&D budget allocation of approximately US$43 million (1.3 billion baht) (Vanichseni & Suvalai, 2009).

There are four major public research institutes in Thailand that innovate new technological products and processes: The National Center for Genetic Engineering and Biotechnology, The National Metal and Materials Technology Center, The National Electronics and Computer Technology Center, and The National Nanotechnology Center. These centers are administered by NSTDA.

The National Center for Genetic Engineering and Biotechnology (BIOTEC) was first set up under the Ministry of Science, Technology and Energy (discussed below) in 1983. The BIOTEC became one of the NSTDA centers in 1991. Operating outside the framework of civil service and state enterprises allows BIOTEC to better support and transfer technology to users. BIOTEC operates research units at Thailand Science Park (discussed below) and also at specialized university laboratories. It develops biotechnology innovations for industry, agriculture, natural resources, and the environment. It conducts research in genetic and biotechnology applications in

[46] http://www.trf.or.th/index.php?option=com_content&view=article&id=47&Itemid=122

agricultural science, biomedical science, and environmental science; and also conducts policy-related research, and outreach, training, and international relations activities.[47]

The National Metal and Materials Technology Center (MTEC) was established in 1986 as a project under the Office of the Permanent-Secretary of the then Ministry of Science and Technology. Its main objective is to support R&D in metals and materials instrumental for the industrial sector and the overall development of the country. The MTEC became one of the NSTDA centers in 1991. Its research became more integrated with all of Thailand's major industrial clusters: food and agro; medical and public health; automotive and transportation; software, microchips, and electronics; energy and environment, and textiles and chemicals.[48]

The National Electronics and Computer Technology Center (NECTEC) was established in 1986 and became a specialized national center under NSTDA in 1991. NECTEC's responsibilities are to undertake and promote the development of electronics and computer technology innovations. These responsibilities carry out R&D activities; design and engineering; technology transfer to industries and communities; human resource development; and policy research, industrial intelligence, and knowledge infrastructure. NECTEC also provides a linkage between research communities and industries through established industrial clusters.[49]

The National Nanotechnology Center (NANOTEC) was established in 2003 as an autonomous research agency under NSTDA and the Ministry of Science and Technology.

[47] http://www.biotec.or.th/EN/index.php/about-us
[48] http://www.mtec.or.th/en/index.php?option=com_content&task=view&id=567&Itemid=155
[49] http://www.nectec.or.th/en/index.php?option=com_content&view=article&id=46&Itemid=63

Its mission is to design and conduct R&D and support technology transfer for nanotechnology applications to Thailand's industrial sector. Its goals are to strengthen the nation's global competitiveness, promote public awareness of nanotechnology development trends, and protect the environment.[50]

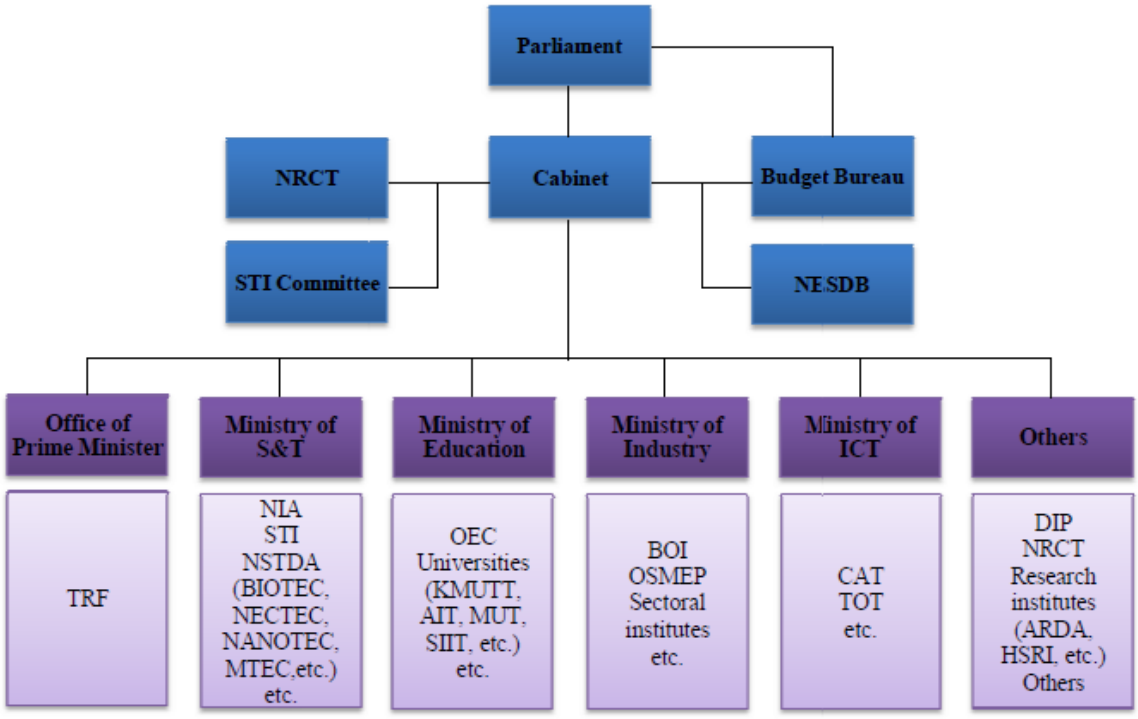
The Thailand Science Park (TSP) came into operation in 2002 with 140,000 square meters of space, outside of Bangkok. A new phase of development, called Innovation Clusters 2, adds a further 127,000 square meters of space for private companies.[51] The TSP is an important component in Thailand's in research and innovation system. Currently it hosts NSTDA headquarters, TMC, BIOTEC, MTEC, NECTEC, and NANOTEC, and over fifty-nine corporate tenants. The park is also located close to three of Thailand's leading universities: the Asian Institute of Technology (AIT), Thammasat University (TU), and Sirindhorn International Institute of Technology (SIIT).

The park offers state-of-the-art facilities and business space and value-added services, including subsidized facility rates, technology and technical support, human and legal resources, financial support, intellectual property and licensing services, contract research and collaborative research support, and participation in a joint investment fund administered by the NSTDA Investment Center (NIC). Tenants of the park also enjoy the most attractive BOI incentives. The Thailand Science Park-Incubator (TSP-I) programs help start-up companies and entrepreneurs transfer product ideas into businesses. Successful start-ups may become fulltime tenants of the park.

[50] http://www.nanotec.or.th/en/?page_id=1899
[51] http://www.sciencepark.or.th/index.php?option=com_frontpage&Itemid=1

From the above discussion, Figure 5.3 illustrates the public organizations in Thailand's NIS.

Figure 5.3 Public Organizations of Thailand's NIS



Source: Author

Framework Conditions

Some key political and social institutions surround Thailand's private and public organizations involved in the NIS. These institutions help to create "framework conditions" (OECD, 1997b) that are conducive to innovation by providing rules and resources, and creating incentives and expectations. In Thailand, framework conditions include laws, plans, and policy statements directed at science, technology, and innovation; rules and regulations governing capital investments and intellectual property;

the ICT infrastructure; and the higher education system, which provides human resources with the capacity for innovation.

Laws, Plans, and Policies

The National Science, Technology and Innovation Act was created in 2008 to guide the formulation of policy and plans for STI in Thailand, as well as strengthening S&T manpower and infrastructure (Intarakumnerd, 2010). The Act addresses: (1) production, development, and mobility of STI human resources; (2) collaboration among research institutes and educational institutions; (3) protection of intellectual property rights; (4) use of public fiscal, financial, and procurement mechanisms to expand the market for innovation; (5) collaboration among state agencies, the private sector and the civil sector for technology transfer; (6) development of STI infrastructure for knowledge dissemination and exploitation; (7) revision of relevant laws, by-laws, rules, or regulations; and (8) recognition of distinguished STI organizations or persons.[52] The Act created a supra-ministerial body called the National Science, Technology and Innovation Policy Committee which is chaired by the Prime Minister. The committee is tasked with monitoring and reporting the results of the national STI Plan (discussed below) including the performance of government agencies (Intarakumnerd, 2010). The Act also established the National Science, Technology and Innovation Policy Office to implement the law.[53]

The current 10-year Science and Technology Strategic Plan (2004-2013) is focused on enhancing the NIS and industrial clusters. The plan emphasizes the strength of

[52] http://www.sti.or.th/th/files/National20Science_Tech_Inno_Act.pdf
[53] Ibid.

human resources; an encouraging environment for S&T development; and the capacities of four core technologies for the future, including information and communications technology, biotechnology, material technology, and nanotechnology. The Strategic Plan also sets three targets for increasing Thailand's innovation competitiveness by the year 2017. These targets are: (1) approaching 1% of GDP on R&D expenditure, (2) creating 10 R&D personnel (full-time equivalent: FTE) for every 10,000 persons, and (3) achieving a ratio of 50:50 private sector to government expenditure on R&D (Durongkaveroj, 2010).

Thailand's National Science, Technology and Innovation Policy expands the Strategic Plan. It covers the 10-year period from 2012 through 2021. The policy sets goals, strategies, and measures for guiding innovation. These concern the innovative capability of localities and communities, industrial sectors, STI human resources, financial instruments, markets and infrastructure, and laws and regulations to encourage STI development.[54]

Investment Rules

Industrial development in Thailand is primarily financed by banks. However, banks are relatively risk-averse therefore entrepreneurial start-ups have been less likely to obtain funding. Some industrial development banks exist, but reportedly they are inefficient, not well known, and have misevaluated past innovation projects. Instead, industrial development banks have contributed through innovation awards, public

[54] http://www.sti.or.th/th/images/stories/files/Draft_Plan_ST.PDF

relations, and training programs (Intarakumenrd, 2010; Intarakumnerd & Brimble, 2007, p. 256-257).

The Market for Alternative Investment (MAI) is a subunit of the Thailand stock exchange (SET) for trading technology and SMEs shares. However, start-up companies and most SMEs have difficulty participating because of required capitalization levels. Several venture capital funds have been supported by the Thai government with a combined value of over US$500 million. Tax incentives to promote more venture capital investment have been considered, however, the venture capital industry and its effect on innovation in Thailand remains underdeveloped. As a result, SMEs seek loans from informal sources where they can get credit more quickly (Intarakumnerd, 2010; Intarakumnerd & Brimble, 2007, p. 256-257).

Foreign direct investment (FDI) has played a significant role in the Thai economy, which contributed to GDP growth and employment through capital formation, exports, and imports (Montreevat, 2006). Most FDI has been attracted by industrial manufacturing, however, in recent years the service sector's share of FDI has been increasing. In 2004, 41% of total FDI came from Singapore, 20% from Japan, 13% from the EU, and 9% from the US (Montreevat, 2006).

The Board of Investment (BOI) has authority to grant tax incentives to promote investment. Its "investment zones" policy supports government goals of decentralizing Thailand's industrial base away from the Bangkok metropolitan area. Three investment zones exist: Zone 1, including Bangkok and the five surrounding provinces; Zone 2, including the 12 provinces surrounding Zone 1; and Zone 3, including the remaining 58

provinces, many of which are under-developed. To encourage projects in the less developed areas, projects located in Zone 3 receive the most generous tax privileges, while those in Zone 1 receive the least.

The BOI has identified priority projects in basic transportation systems, public utilities, environmental protection, technological development, machinery and equipment, vehicle parts, electronic appliances, and computers. These projects are automatically entitled to a corporate income tax exemption for eight years, and an import duty exemption on machinery, regardless of project location. Strategic industries are also targeted with a customized incentive scheme to promote cluster-based investment. Customized incentives are also granted to skills, technology, and innovation industries, such as the HDD industry, semi-conductors, software, the automotive industry, mold and die, iron and steel, alternative energy, business process outsourcing, and regional operating headquarters (ROH).

The standard company tax rate in Thailand is 30% of net profits, which is relatively high compared to other countries in the region. However, concerning FDI and innovation, there is a 10% corporate tax rate for Regional Operating Headquarters (ROH) and SMEs. Venture capital investment in SMEs is also incentivized through tax exemptions (Rochananonda, 2006). Table 5.5 below outlines these incentives.

Table 5.5 Investment Incentives

Types of Companies	Tax Incentives
Regional operating headquarters	10% corporate income tax on net profits, interest and royalties for ROH
SMEs companies	Reduced company tax rates for small and medium enterprises (SMEs) are as follows: - 15% on net profits up to 1 million baht - 25% on net profits of 1 to 3 million baht - 30% on net profits above 3 million baht
Listed companies	Reduced tax rates for companies listed on the Stock Exchange of Thailand (SET) and the Market for Alternative Investment (MAI) are as follows: - 25% for companies listed on the SET from September 6, 2001 to December 31, 2005 - 20% for companies listed on the MAI from September 6, 2001
	The reduced rate will applied for 5 consecutive accounting periods only
Venture capital companies investing in SMEs	Corporate tax exemptions are granted to venture capital companies that invest in SMEs.
	Dividends received from SMEs and gains arising from the transfer of shares in SMEs are granted exemption from corporate tax.

Source: Rochananonda, 2006

Intellectual Property Rights

In Thailand, intellectual property rights have been often abused, particularly through copyright infringement (Kelly & Chuenjaipanich, 2002).[55] Despite aggressive legislation to facilitate enforcement, there is still an excessive amount of infringing goods in the Thai marketplace. Actually, there is less patent infringement issues (Kelly & Chuenjaipanich, 2002). The Thai Patent Act of 1979 allows applicants to file for patent for inventions, designs, and petty patents. The criteria for patents are novelty, inventive step, and industrial applicability. There is no business method patent in Thailand and computer programs are not patentable subject matter. Thailand is not a member of the

[55] Thailand "top IP pirate," Bangkok Post 3/05/2011

Patent Cooperation Treaty but it is bringing its examination procedures in line with international standards (DIP, 2009; Kelly & Chuenjaipanich, 2002).

In Thai culture, intellectual property infringement has not been viewed as criminal. Therefore there is less public sentiment to protect IPRs. Moreover, IPR protection is often seen as imposed by western standards and disrespectful to Thai culture. The Thai Department of Intellectual Property (DIP) has attempted to raise awareness that counterfeiting has damaged Thailand's ability to compete in the global marketplace (Kelly & Chuenjaipanich, 2002).

The Thai government has continued to increase efforts on prevention and suppression of intellectual property violation. Intellectual property issues were raised by the Abhisit Vejjajiva government as a part of the strategy to achieve a creative and knowledge driven economy. As a WTO member, Thailand has taken steps to comply with international intellectual property standards (DIP, 2009).

ICT Infrastructure

In 1987, the National Information Technology Committee (NITC) was formed to oversee policy aspects of IT development and usage in Thailand. In 1997, NITC created six laws to facilitate and regulate IT:[56] (1) the Data Protection Law, (2) the Computer Crime Law, (3) the Electronic Data Interchange Law, (4) the Electronic Transaction Law, (5) the Electronic Funds Transfer Law, and (6) the Universal Access Law. This legal framework reduces the risks to individuals and private firms in using ICT.

[56] http://www.nectec.or.th/users/htk/e-commerce/e-commerce-escap

National policies also aid the development of ICT in Thailand. Following IT 2000 policy (discussed above), IT 2010 was created to cover the period 2001-2010 and help Thailand transition into the Knowledge-Based Economy (KBE)/Knowledge-Based Society (KBS) (NECTEC, 2003). The IT 2010 policy seeks to: (1) raise the capability of the country from a technology adopter to a technology leader, (2) increase the proportion of "knowledge workers" in the country to 30%, and (3) increase the share of "knowledge-based industries" within the overall economy to 50%. IT 2010 noted that organizational reforms and inter and intra sectoral partnerships would be required to implement these goals.

In 2006, the Ministry of Information and Communication Technology conducted an assessment of IT 2010's progress toward its three goals. In terms of the goal of becoming a technology leader, Thailand had moved up from "dynamic adopter" to "potential leader" status.[57] In terms of the goal of increasing Thailand's knowledge workers, the assessment noted that based on National Statistics Office figures, 21.1% of the country's labor force could be considered "knowledge workers." In terms of the goal of increasing the share of knowledge industries in the country, the assessment found that this percentage had remained relatively consistent between 2004 and 2006 at 25% (MICT, 2009). These results show that midway through IT 2010's time horizon, Thailand had made important gains in fulfilling its information technology goals (MICT, 2009).

[57] The MICT assessment used the United Nations Development Program's Technology Achievement Index (TAI) for 2005 to evaluate Thailand's progress towards the technology leader goal. The TAI groups countries into four categories based on their capacity to create new technology, diffuse the adoption of new technology, diffuse long-existing technologies, and build human skills for technology creation and adoption. The four categories are leaders, potential leaders, dynamic adopters, and marginalized (Desai et al., 2002, http://hdr.undp.org/en/reports/global/hdr2002/papers/ip_desai-2.pdf).

The first ICT Master Plans (2002-2006) were created to further develop ICT in Thailand for R&D, expansion into international markets, utilization by SMEs, and provision of government administration and services (Kaonantakool, 2006). The second ICT Master Plan (2009-2013) established "a fair and competent regulatory body for telecommunications and broadcasting, bridging the digital divide, and building confidence in e-commerce" (Koanantakool, Udomvitid, & Thuvasethakul, 2010, p. 342). The Strategic Master Plan on Electronic, Computing, Telecommunication, and Information (ECTI) Technologies (2000-2009)[58] was also developed to strengthen R&D in ECTI and transfer ECTI technologies and products to the industrial sector.

Several studies have reported the progress of ICT development in Thailand. These include IT legal and regulatory infrastructure; network infrastructure in schools and universities; increased telephone penetration, fiber-optic cable, and microwave communication services; networking government agencies and delivering e-Government services; development of the Thailand Software Park and the Electronic Commerce Resource Center; and increased numbers and funding of IT-related research projects submitted by government agencies, universities, and private sectors (Koanantakul, 2006; NECTEC, 2003; UNESCAP, 2009).

Higher Education

Currently Thailand's higher educational system is composed of 78 public universities, including 11 autonomous universities, 34 private universities, and 34 private

[58] http://www.nectec.or.th/intro/e_rd.php

colleges, with approximately 2 million students.[59] The number of public universities has increased dramatically because public institutes were upgraded to universities in 2004.

In the 1960s and 1970s, the higher educational system was expanded with the creation of provincial, open, vocational, and agricultural universities, and teacher training colleges. Between 1970 and 2000, 3.4 million Thais earned a tertiary education. This is 20-fold increase. Most of these became professionals, technicians, executives, and managers in the growing economy (Baker & Phongpaichit, 2005, p. 207).

In 2002, Thai public universities became "semi-autonomous" meaning that while still subsidized by the government, they gained more financial freedom. The universities were expected to generate more income from other sources, especially the private sector. While public funding would mainly cover teaching expenses, research agencies supported collaboration with industry and commercialization. These changes helped to promote R&D, however, difficulties remained because academic promotion is more dependent on teaching than research (Doner, 2009; Schiller & Liefner, 2007). There is a lack of high quality research transferable to industry, and universities' rules do not encourage conducting personal projects with industry (Schiller & Leifner, 2007). By 2007, only six universities had become autonomous, and university-industry linkages (UILs) remained weak.

Thai universities' primary concern is educating students. Private firms have little interest in linking with universities, except for a few cases such as Seagate (Doner, 2009, p. 135; Termpittayapaisith, 2006). In the early 2000s there was

[59] http://inter.mua.go.th/main2/article.php?id=55

> . . . a consensus that Thai universities performed poorly in training personnel and exposing companies to new ideas . . . overall research output was low, research topics were inconsistent with industrial needs, and faculty ties with business were individual and temporary. These weaknesses were in part the result of low demand: in most sectors, local firms' technological and absorptive capacities were insufficient to stimulate much demand for university inputs. More technologically advanced foreign firms were either uninterested or sceptical as to the institutions' capacities to provide needed service. But the incentives and structure of the universities themselves were also a key part of the problem . . . their funding has been largely unrelated to research productivity, teaching-effectiveness, or market-related services . . . (Doner, 2009, 134-135, 138).

In closing, it is important to consider how Thailand's overarching science and technology policy framework compares with the recent creative economy effort mentioned above. There are key elements of the nation's science and technology policy that match up well with components of the creative economy agenda. Where the science and technology policy offers support for industrial clusters and collaborative efforts, the creative economy identifies which industries: the "creative" ones involved with culture, art, media, design, software development, and related. It also identifies which collaborators: university centers of excellence, SMEs, local- and community-level actors, and the Ministry of Commerce. Thailand's science and technology policy advocates enhanced intellectual property protection and improved ICT infrastructure for the nation. The creative economy acknowledges that improvements in both of these areas can encourage innovation and creativity among emerging, targeted industries and among traditional knowledge-holders at local levels. With 99% of the business sector in Thailand composed of small, medium, micro, and informal enterprises in 2010, accounting for approximately 39% of GDP, the S&T policy and the creative economy agenda are right

to encourage the innovation potential at this level (Durongkaveroj, 2010). In this sense, some objectives of the creative economy are compatible with the broader directions provided by Thailand's science and technology policy.

CHAPTER 6

ASSESSMENT OF THAILAND'S NIS PERFORMANCE

Formally evaluating the performance of Thailand's NIS can help to make decisions about improving it. Evaluation provides critical feedback in the policy assessment process, and there are a variety of ways to evaluate the NIS, both quantitative and qualitative. In this chapter, evidence for the performance of the Thai NIS is presented. It discusses innovation effectiveness in terms of both international and domestic quantitative indicators and the opinions of government officials with knowledge of the system. It also discusses the performance of Thailand's NIS in terms of the outcomes of innovation. Innovation outcomes are the long-term, broad-scale effects of innovation on the economy. With an idea of the effectiveness of the NIS, barriers to innovation performance are identified, and policy recommendations to improve the performance of the NIS are made.

International Indicators

In the World Bank's Knowledge Assessment Methodology (KAM) for 2012, Thailand received an innovation system score of 5.95 on 10-scale, ranking 55th out of 146 countries. This was up four places from the 2009 KAM ranking. The KAM collects data on 80 variables which serve as proxy measurements for a country's innovation system, its educational system including training, its information infrastructure, and its institutional and economic incentives regime. The 29 innovation system indicators collected in the KAM and their scores for Thailand are shown in Table 6.1 below.

Table 6.1 KAM for Thailand Innovation System Indicators

Indictor	Score
FDI outflows as % of GDP, 2004-2008	4.92
FDI inflows as % of GDP, 2004-2008	5.14
Royalty and license fees payments (US$ mil.), 2009	8.80
Royalty and license fees payments (US$/pop.), 2009	7.12
Royalty and license fees receipts (US$ mil.), 2009	7.38
Royalty and license fees receipts (US$/pop.), 2009	5.95
Royalty payments and receipts (US$ mil.), 2009	8.48
Royalty payments and receipts (US$/pop.) 2009	6.80
Science and engineering enrollment ratio (%), 2009	n/a
Science enrollment ratio (%), 2009	n/a
Researchers in R&D, 2009	6.30
Researchers in R&D/mil. People, 2009	3.42
Total expenditure for R&D as % of GDP, 2008	2.38
Manuf. trade as % of GDP, 2009	9.28
University-company research collaboration (1-7), 2010	7.10
S&E journal articles, 2007	7.24
S&E journal articles/mil. People, 2007	5.17
Availability of venture capital (1-7), 2010	7.02
Patents granted by USPTO, avg. 2005-2009	7.53
Patents granted by USPTO/mil. People, avg. 2005-2009	5.89
High-tech exports as % of manuf. exports, 2009	8.93
Private sector spending on R&D (1-7), 2010	6.56
Firm-level technology absorption (1-7), 2010	5.50
Value chain presence (1-7), 2010	7.48
Capital goods gross imports (% of GDP), avg. 2005-2009	9.48
Capital goods gross exports (% of GDP), 2005-2009	9.48
S&E articles with foreign coauthorship (%), 2008	3.68
Avg. number of citations per S&E article, 2008	7.29
Intellectual property protection (1-7), 2010	4.05

Source: Based on World Bank, 2012

Although the KAM collects data for 29 indicators, it assesses the innovation system performance for a given country using only three of them: (1) total royalty payments and receipts, (2) patent applications granted by US Patent and Trademark Office, and (3) scientific and technical journal articles.[60] Its score for total royalty payments and receipts was 8.48 (on a 10-scale), 7.53 (on a 10-scale) for patent applications granted by USPTO, and 7.24 (on a 10-scale) for scientific and technical journal articles.

The WEF's Global Competitiveness Report (GCR) 2012-2013 ranks Thailand's innovation system 68th out of 144 countries, with a score of 3.19 on the 1-7 scale. The Table 6.2 below shows Thailand's ranking on the seven innovation indicators. According to the report, Thailand has little competitive advantage on any of these innovation indicators. Its mid-range rankings for the indicators in Table 6.3 make sense for a middle income country that is attempting to advance from the efficiency-driven growth stage and close the gap with innovation leaders. There is clearly room for improvement on all of the GCR indicators, however. The intellectual property protection indicator shows the most potential for improvement. As a technology and innovation adopter and adapter, it may not be surprising that weak intellectual property protection exists. However, strengthening institutions that govern IP is one measure that can help Thailand to advance to higher innovation, growth, and development stages.

[60] The innovation system is the simple average of the normalized scores on these three variables. Retrieved from http://info.worldbank.org/etools/kam2/KAM_page5.asp

Table 6.2 GCR for Thailand Innovation Indicators

Indicator	Rank
Capacity for innovation	79
Quality of scientific research institutes	60
Company spending on R&D	74
University-industry collaboration in R&D	46
Government procurement of advanced technological products	98
Availability of scientists and engineers	57
Patents per million population	72
Intellectual property protection	101

Source: Based on WEF, 2012

Both the KAM and GCR collect data for an extensive set of innovation system and other relevant indicators, as discussed in Chapter 3. They provide quantitative measurements and rankings determined through scientific research. The full breakdown of Thailand's KAM and GCR entries are included in Appendix A and B, respectively. By analyzing data on internationally accepted innovation indicators, the World Bank and the WEF give Thailand's NIS a fair rating. Thailand's NIS is not as good as that of innovation-leading countries such as Finland, Korea, or Singapore, but it is also not as bad as with innovation laggard countries, particularly ones in least developed countries (LDCs), such as Angola and Bangladesh and ones in the Southeast Asian region, such as Laos and Myanmar.

Table 6.3 below compares Thailand's KAM innovation system rank to several least developed countries (LDCs). The table shows that Thailand, a middle-income country in the efficiency-driven growth stage, has a better-performing innovation system than the poorer, lesser-developed countries in the KAM. From the table, the closest LDC

to Thailand is Senegal, whose innovation system rank is 111th. Contrary, the GCR ranks Senegal (62nd) higher than Thailand (68th) along with Rwanda (51st), Gambia (52nd), Liberia (54th), Zambia (61st), and Cambodia (67th).[61]

Table 6.3 KAM and GCR Innovation Rank
for Least Developed Countries (LDCs) versus Thailand

Country	Innovation Rank		Country	Innovation Rank	
	KAM	GCR		KAM	GCR
Angola	146	n/a	**Madagascar**	119	106
Bangladesh	135	130	**Malawi**	114	99
Benin	112	84	**Mali**	130	88
Burkina Faso	123	107	**Mauritania**	137	121
Burundi	n/a	140	**Mozambique**	133	122
Cambodia	124	67	**Myanmar**	145	n/a
Chad	n/a	113	**Nepal**	121	133
Djibouti	143	n/a	**Rwanda**	134	51
Eritrea	128	n/a	**Senegal**	111	62
Ethiopia	129	114	**Sierra Leone**	140	139
Gambia	n/a	52	**Sudan**	142	n/a
Guinea	144	125	**Tanzania**	n/a	75
Haiti	139	143	**Thailand**	55	68
Lao PDR	136	n/a	**Uganda**	118	82
Lesotho	131	138	**Yemen, Rep.**	127	144
Liberia	n/a	54	**Zambia**	125	61

Source: Based on World Bank, 2012 and WEF, 2012
Note: KAM rank out of 146 countries, GCR rank out of 144 countries, n/a denotes data not available

Table 6.4 below shows how Thailand's innovation rankings compare with those of the other countries in the region. Among the other eight Southeast Asian countries in

[61] The following LDCs do not appear in both KAM and GCR – Afghanistan, Bhutan, Central African Rep., Comoros, Dem. Rep. of the Congo, Equatorial Guinea, Guinea-Bissau, Kiribati, Niger, Samoa, Sao Tome and Principe, Solomon Islands, Somalia, Togo, Tuvalu,and Vanuatu.

the KAM, only Singapore's (4th) and Malaysia's (42nd) innovation rank is higher than Thailand's (55th). Among the other eight Southeast Asian countries in the GCR, Singapore's (8th), Malaysia's (25th), Indonesia's (39th), Brunei's (59th) and Cambodia's (67th) innovation rank is higher than Thailand's (68th). Table 6.4 below supports the notion that Singapore is Southeast Asia's innovation leader. Using the KAM, Thailand fits into a second tier of innovation in the region with Malaysia as its peer. Using the GCR, Thailand is in a third tier of innovation with Brunei and Cambodia, behind Malaysia and Indonesia in the second tier. Overall, Thailand's innovation is in the middle range for the region. It is not in the lead position but also not in a lagging position.

Table 6.4 Innovation Rankings for Southeast Asian Countries

Country	Innovation Rank	
	KAM	GCR
Brunei	n/a	59
Cambodia	124	67
Indonesia	103	39
Laos	136	n/a
Malaysia	42	25
Myanmar	145	n/a
Philippines	93	94
Singapore	4	8
Thailand	55	68
Timor-Leste	n/a	134
Vietnam	113	81

Source: Based on World Bank, 2012 and WEF, 2012
Note: KAM rank out of 146 countries, GCR rank out of 144 countries, n/a denotes data not available

These international indicators can be useful for countries to identify strengths and weaknesses in their innovation systems. Policymakers can use these to benchmark their country's NIS performance with other countries. Thailand has scored well on several internationally-accepted innovation indicators including availability of scientists and engineers, manufacturing trade, high-tech exports, imports and exports of capital goods, and royalty and license fees payments and receipts (WEF, 2012; World Bank, 2012). These represent Thailand's strengths; areas in which Thailand has some comparative advantage. Relatively strong performance on these indicators could be expected for a newly-industrialized country with a favorable business climate that is a key base of production in global assembly and manufacturing chains.

Thailand has scored poorly on other innovation indicators, however, including government procurement of advanced technology, intellectual property protection, numbers of researchers in R&D, expenditures on R&D as a percentage of GDP, and co-authored science and engineering publications (WEF, 2012; World Bank, 2012). These represent Thailand's weaknesses; areas in which Thailand needs to improve so that it can continue to close innovation and development gaps. Weaker performance on these indicators could be expected for a developing country with a less-than-robust educational system that has relatively recently transitioned into an efficiency-driven stage of growth and is trying to catch up with innovation leaders.

While policymakers in Thailand will want to continue to play to the country's innovation strengths, greater gains may be available by focusing on its innovation weakness. In terms of benchmarking, policymakers can take note of innovation-leading

countries' performance in areas where Thailand is weak, for instance Finland, Korea, and Singapore. Thailand's policymakers should ask: "What have innovation leaders done in the areas where we are weak?" With this knowledge in hand, Thailand can then attempt to emulate these "innovation best practices" with adjustments to its own policies.

Although these international indicators of innovation performance can be useful, they must be viewed appropriately and caution is advised. The KAM uses only secondary data that is self-reported by firms and national governments, which could introduce distortions. The World Economic Forum's Global Competitiveness Report also uses self-reported data, and its rankings can be confusing for innovation benchmarking. The report indicates that innovation is the most important of all factors for improving economic competitiveness (WEF, 2010, p. 8). However, countries' performance on innovation indicators and their innovation ranking are not used to determine their stage of economic growth, either factor-driven, efficiency-driven, or innovation-driven (WEF, 2010, p. 10). Therefore a country can be in the "innovation-driven" stage of growth regardless of its "innovation" performance.

Furthermore, some countries' innovation rankings in the KAM and the GCR are very similar, for example Sierra Leone (140th in the KAM and 139th in the GCR) and Philippines (93rd in the KAM and 94th in the GCR). However, other countries have very different innovation rankings between the KAM and the GCR, for example Rwanda (134th in the KAM and 51st in the GCR) and Indonesia (103rd in the KAM and 39th in the GCR). These inconsistencies appear even though the KAM and the GCR have a similar

sample size and use much of the same data.[62] The different indicators used to measure innovation appear to account for these inconsistencies. The KAM uses three innovation indicators: royalty payments, patents, and science and technology articles published. The GCR uses eight: Innovation capacity, quality of science/research institutes, company R&D spending, university-industry linkage, government procurement, availability of scientists and engineers, patents per million persons, and intellectual property protection. NIS policymakers should therefore be aware of the different methods and indicators used in international innovation measurement and their implications for NIS evaluation.

Domestic Indicators

The performance of Thailand's NIS can also be evaluated with domestically-produced indicators, including innovation goals recommended by STI, the output of R&D institutions including the higher education system, and the firm-level innovation survey conducted in Thailand in 2003.

STI Goals

The National Science Technology and Innovation Policy Office (STI) set three goals for improving Thailand's science, technology, and innovation competitiveness, to be achieved by the year 2017. These are: (1) total expenditure for R&D as 1% of GDP, (2) a ratio of 50:50 private sector to government expenditure on R&D, and (3) 10 R&D personnel (FTE) for every 10,000 persons. Progress toward these goals is shown in Table 6.5 below.

[62] KAM sample size = 146 countries, GCR sample size = 144 countries

Table 6.5 Improvement of Thailand's
Science, Technology, and Innovation Competitiveness

Strategic Plan	Performance			Goals
	2005	2007	2010	2017
Total expenditure on R&D as % of GDP	0.24	0.21	0.24	1
Ratio of private sector to government R&D expenditure	49:46	48:52	40:60	50:50
R&D personnel (FTE) per 10,000 persons	3.29	6.76	9.01	10

Source: Based on Durongkaveraj, 2010; NRCT, 2010; and Vanichseni & Suvalai, 2009

With respect to the goal of total expenditure for R&D as 1% of GDP, STI notes improvements in government, private, and state enterprise R&D spending. Yet, as Table 6.5 above shows, R&D expenditures as a percentage of GDP have not grown in the five year period from 2005 through 2010 but have remained stable at around 0.25%. Private sector investment in R&D comes mainly from a relatively few large MNCs (Intarakumnerd, 2010). The numerous SMEs and microenterprises in Thailand likely have few resources to devote to R&D. Moreover, government tax incentives and subsidies for firms' R&D investment are too narrowly defined and most firms do not take advantage of these incentives (Intarakumnerd, 2010). In terms of expenditures on R&D as a percentage of GDP, it is known that Thailand lags well behind the region's leaders Singapore (2.61% in 2007) and Malaysia (0.64% in 2006) (Intarakumnerd, 2010). To meet the 1% R&D expenditure goal shown in the table above, STI recommends enhanced use of venture capital, FDI, and research centers (Durongkaveraj, 2010). However, these options may not be enough, given their current status as reviewed in this study. R&D expenditure is an area where government has the capacity to channel significant

resources. To meet the 1% of GDP target set for 2017, Thailand's government should increase its financial commitment to the national R&D effort.

The public and private shares of R&D expenditure are a related issue. Table 6.5 above shows the strategic plan goal of a 50:50 contribution for R&D spending from the public and private sectors for 2017. The table also shows a decline in the share of private investment (from 49% to 40%) and an increase in the share of government investment (from 46% to 60%) in R&D between 2005 and 2010. Since we know that overall expenditures on R&D in Thailand lag behind neighboring countries, we cannot be certain that increased government expenditure accounts for the increase in the government's share. A more likely explanation for the imbalance may be continued disinvestment in R&D on the part of the private sector. Some of that decline may be tied to the recent recession although, STI found a 9% decline in R&D expenditures in Thailand's manufacturing and service sectors between 2006 and 2008 as the recession was just beginning to surface (STI, 2009). To balance public and private investments in R&D, STI notes the incentives offered for R&D investment, including BOI tax and non-tax incentives and projects undertaken by NSTDA and NIA, discussed earlier. The STI further recommends other alternatives, including personal income tax exemptions or reductions, enhanced venture capital, improved IP management, and enhancing the competitiveness of SMEs. Some of these recommendations have also been discussed above (Durongkaveraj, 2010). It should be noted that measures to encourage a greater share of private sector investment in R&D such as enhanced venture capital availability and SME competitiveness will likely require still many more years before taking effect.

Thailand's government should be prepared to shoulder a greater share of R&D expenditure in the near term and perhaps reconsider its 2017 goal of a 50:50 public-private ratio.

Concerning the goal of R&D personnel, Table 6.5 above shows that R&D personnel have increased dramatically between 2005 and 2010 and has almost reached the target of 10 researchers per 10,000 persons set for 2017 by the Strategic Plan. STI finds that no policy measures exist for developing R&D human resources, so perhaps the increase in researchers is due to market forces alone. According to NRCT, between 2005 and 2009, while the number of lead researchers on R&D projects remained stable, research assistants and technical support personnel grew (NRCT, 2010). Including support staff in official counts could also account for the growth experienced in R&D personnel. Thailand is within reach of its R&D personnel goal for 2017. To better ensure the realization of this goal, STI recommends improving university-industry linkages (UILs); science, technology, engineering, and mathematics (STEM) education; labor mobility; and scholarships/outstanding student programs (Durongkaveraj, 2010). These suggestions should be followed, especially in the face of an increasingly competitive regional market for R&D and innovation talent (Intarakumnerd, 2010).

The Strategic Plan developed by STI can be useful for evaluating R&D aspects of Thailand's NIS. The plan identifies future benchmarks for R&D expenditures and human resources, including percent of GDP devoted to R&D, the ratio of private to government R&D expenditure, and numbers of R&D personnel per 10,000 persons. Between 2005 and 2010, personnel numbers had improved, while the expenditure ratio became more

unbalanced and the percent of Thailand's GDP on R&D had declined. It is important to note that NRCT is only now clarifying what activities can be formally classified as R&D in Thailand. Also, with relatively few Thai firms innovating, the ratio of public to private R&D expenditure must be viewed with caution. Most importantly, the combined level of R&D expenditures by both the public and private sectors is far behind leading Southeast Asian countries. Since innovation policy in Thailand has only been formalized for a few years (with the creation of STI in 2008), more time may be needed before clear trends in the Strategic Plan benchmarks and the effect of the STI can be seen. Still, the Strategic Plan's 2017 goals can be helpful to evaluate Thailand's innovation performance.

R&D Output

STI human resource development is another indicator for evaluating Thailand's NIS. Thailand's R&D output grew between 1998 and 2008. Specifically, scientific publications grew by over 300% and patents granted grew by 12% (Intarakumnerd, 2010). Furthermore, Intarakumnerd (2010) reports that in the ten year period 2001-2010, approximately 56% published scientific articles were published with international co-authorship, showing Thai researchers' integration into global research networks. Performance on these R&D output indicators suggests that Thailand's R&D institutions contributing toward the development of STI human resources.

However, there is evidence that Thai universities have underperformed in developing STI capacity. Thailand's universities have been described as relatively weak, with research that is less relevant to industry and publication that is less internationally recognized (Intarakumnerd et al., 2002; Krishna, n.d.; Sakunsriprasert, 2009; Schiller,

2006). Formal university-industry linkages are in the early stage of development, with few activities and less-developed institutional mechanisms (Krishna, n.d.). University-industry linkages have been based on personal connections between researchers and companies, not long-term organizational commitments. These linkages primarily involve short-term training, consulting, or research activities in low levels of technology. There appears to be little incentive within the universities to encourage linkages with industry (Brimble & Doner, 2007; Sakunsriprasert, 2009).

From the other side of the university-industry linkages, Thai firms appear to value innovation information gathered from parent or associate companies much more. Table 6.6 below shows that, on a 100 point-scale, internal sources of information are more important for innovation activities in Thai firms than external ones.

Table 6.6 Importance of Innovation Information Sources

Source		Result
Internal	Sources within the enterprise (unspecified)	82.0
External	Patent disclosures	32.0
	Exhibitions	53.1
	Internet	63.0
	Universities, educational institutions	35.8
	Research institutes	35.8
	Clients	77.4
	Competitors	42.1
	Parent/associate company	61.2
	Business service providers	33.1
	Technical service providers	40.2
	Specialist literature	56.6
	Professional conferences and meetings	55.2

Source: Based on Intarakumnerd, 2007

This result could indicate: (1) a lack of absorptive capacity necessary to interact with and learn from universities and R&D institutes, (2) universities and public research institutes are of limited quality, and uninteresting to firms as an innovation information source, (3) a mismatch between what universities and public research institutes can provide and what firms want, or (4) communication between the two are underdeveloped (Intarakumnerd, 2007, p. 11-13). Overall, the evidence from both sides indicates university-industry linkages are weak.

Firm-Level Innovation Surveys

A firm-level Innovation Survey was conducted by NSTDA in 2003 to assess the innovation activities and capabilities of private firms in Thailand (Intarakumnerd, 2007). The survey serves as a useful NIS evaluation instrument. It adopted definitions and methods used by OECD in the Oslo and Frascati Manuals, as well as those used by other Asian countries, including Korea and Singapore. In the 2003 survey, 6,031 firms were surveyed, with a response rate of 42.8%. Of these firms, 6% reported that they performed R&D activities and 5.8% reported that they carried out innovation activities. These innovation activities included detailed design work and reengineering, which are catch-up actions (Intarakumnerd, 2007). Large companies are more likely to be innovative than SMEs. The chemicals, machinery, electronics, and food sectors appear to be more innovative than others, but still at small percentages. These results correspond to the R&D investments in these sectors, shown in Figure 5.2 above (see p. 94).

Overall, the survey shows a relatively small percentage of firms in Thailand performing innovation activities. According to the firm-level innovation survey of 2002,

in Korea, 42% of firms were innovating (Intarakumnerd, 2007, p. 8). Table 6.7 below contains key results from the survey.

Firm-level evaluations show Thai firms' absorption and diffusion of technology, their output of innovative products and processes, and their awareness and utilization of innovation partnerships and resources. Comparative analysis indicates that Thai firms can improve their innovativeness. Although many firms in Thailand now work in high-tech manufacturing industries, surveys show that most firms are not involved in globally-competitive innovation activities (Intarakumnerd, 2007).

Table 6.7 Selected Results of Thailand's Innovation Survey in 2003

Firm Indicators	Result
No. of manufacturing and service firms	21,653
Sample size	6,031
Response rate	42.8%
R&D performing firms	6.0%
Innovating firms	5.8%
Innovating firms, SME	7.3%
Innovating firms, large company	14.4%
Innovating firms, Thai-owned	10.2%
Innovating firms, partial MNC-owned	12.2%
Share of innovating firms by sector	
Food, beverage, tobacco	18%
Wood, wood products, furniture	10%
Paper, paper products, printing/publishing	10%
Chemicals, chemical products, coal, petroleum, rubber and plastic products	11%
Fabricated metal products, machinery and equipment	13%
Jewelry, diamond, gem and ornament	10%

Source: Based on Intarakumnerd, 2007

Thailand NIS Government Official Interviews

Finally, individuals with knowledge and experience in Thailand's NIS were asked for their evaluations of the system. These government officials discussed implementation and measurement issues, coordination and linkages, and the role of the Creative Economy in Thailand's NIS. Their comments are summarized below. The interview questions are presented in Appendix C.

Dr. Yada Mukdapitak, Deputy Secretary General of STI

Dr. Yada Mukdapitak is the Deputy Secretary General of National Science Technology and Innovation Policy Office (STI). Dr. Mukdapitak notes that the NIS cannot be set out with a single rule or policy. Instead, NIS is a new paradigm for stimulating many policies related to STI development. Dr. Mudapitak says the term "NIS" may not be commonly known but it is embedded in all dimensions of STI policy in Thailand. It is known that an NIS for one country may be different from that of other countries. This implies that an NIS for one sector may be different from the others from the same country. This idea can be applied when implementing NIS and measuring its performance (personal communication, April 7, 2011).

Dr. Mudapitak believes that implementing the NIS requires understanding the roles and characters of each system component. Implementation means unique and creative application of the NIS scheme to each system component and on a sector, subsector, or even product basis. Effective implementation means recognizing what is the most appropriate in the context of Thailand such as components, sectors, or products. In

Thailand, innovation can be something that already exists; the key issue is to use what you have. The usage may be from your own R&D or someone else's which you extend.

The mechanism in building innovation is the linkages among private business, educational institutions, financial institutions, and government. Implementing the NIS framework means identifying and matching key players, but when players are approached, they must become the most important, rather than the system itself (personal communication, April 7, 2011).

In terms of NIS performance measurement, Dr. Mukdapitak states that the whole system cannot be measured effectively because of its scale and complexity. The more effective way in NIS performance measurement is focusing on each component, sector, or product, and building up its own indicators based on its roles and characters. The macro picture will be completed by integrating several pieces of micro ones. Dr. Mukdapitak uses the term "chain links" to describe the relationship among components in the system, meaning that missing one link will shorten the life of the whole system (personal communication, April 7, 2011).

Prof. Dr. Soottiporn Chittmittrapap, Secretary General of NRCT

Prof. Dr. Soottiporn Chittmittrapap, the Secretary General of National Research Council of Thailand (NRCT) states that the main reason for the use of the NIS strategy is to further the utilization of research results and innovation for commercialization. Increasing innovation activities can help Thailand leapfrog in terms of social and economic development, therefore the NIS is significant. However, the NIS has not been as successful as it could be due to the poor performance and lack of cooperation among

relevant organizations in the system. Adopting the innovation system strategy for promoting innovation in Thailand led to the formation of the NIA. To this point, however, NIA has had limited success in connecting industries and universities in innovating partnerships. Also public-private partnerships do not get support from the funding system, and producers of research results and innovation have weak IPRs. Cooperation is the main factor for successfully implementing the innovation system. In Thailand, coordination between innovation laws, public-private partnerships, and readiness can be improved (personal communication, September 22, 2011).

An NIS consists of three things: (1) innovation creation or value creation, (2) innovation protection, and (3) innovation utilization. Currently in Thailand, relevant stakeholders are forming an NIS that fits the Thai context and puts organizations in charge of each of these three areas. In terms of innovation creation, NRCT motivates and promotes research and innovation. It has been studying international practices in innovation promotion; collecting inputs from relevant stakeholders, including research institutes, funding agencies, and research users; and promoting laws and regulations related to innovation activities. NRCT stimulates SMEs' innovation activities by matching SMEs and research institutes; the result of these collaborations is intended to meet the needs of markets and end users. NRCT is addressing the issue of commercialization of research results and innovation, which is in need of reform. Based on past research projects that NRCT has overseen; it can serve as an innovation database or clearinghouse. It has a stock of knowledge that could be tapped into for innovation and

commercialization purposes (S. Chittmittrapap, personal communication, September 22, 2011).

In terms of the protection of innovative works, DIP acts as an IPR protector. Industry is reluctant to fully invest in R&D because the ownership of the research result would belong to the financial supporter, i.e. the government. There are risks in further investing in product lines derived from R&D so industry is unlikely to put money into R&D. Firms may be willing to invest more in R&D if ownership of the R&D results funded by the government belong to the firm. Creating this motivation comes through giving ownership of the innovation to the innovator. When firms receive benefits from R&D and innovation, the country gains too (S. Chittmittrapap, personal communication, September 22, 2011).

The protection of IPRs and related issues for the benefit of innovators are being improved. However, DIP is more of an innovation regulator than an innovation supporter that makes linkages between innovation and utilization. This situation creates obstacles for researchers and innovators. It is up to DIP, in particular, to determine how to be more flexible in terms of IPR management. If government acts as a partner with firms instead of a regulator, for example, it can more easily monitor financial flows within those firms (S. Chittmittrapap, personal communication, September 22, 2011).

Promoting the utilization of innovation can come from, for example, creating "pilot plants" for innovators by organizations like NSTDA, changing the mindset of researchers, and adjusting the promotional method for universities' professors from producing papers for publication to creating innovations that can be commercialized.

NRCT also acts to help with innovation utilization, but there should be a separate organization acting as a linkage between the market and R&D performers to help proof of technology, technology licensing, and negotiating between researchers and innovators. Currently, universities have been creating their own technology licensing offices (TLOs). However, the volume of research in Thailand is relatively small and these offices create additional transaction costs, so it may not be worth the investment (S. Chittmittrapap, personal communication, September 22, 2011).

To be successful with the NIS approach, integration and a comprehensive process are needed. The relevant organizations in Thailand need to adjust and adapt to serve the system. A change in understanding of the roles of actors in the system, including researchers, innovation producers, and funding agencies, is needed. All sectors and stakeholders involved with the NIS need to realize their role and make changes so that the system can perform better. Mindset is important. How to change the mindset of researchers to realize the importance of R&D for social and economic development as a whole, rather than focusing on their own benefits? How to make individuals realize that they are part of the system, not just an isolated mind? (S. Chittmittrapap, personal communication, September 22, 2011).

Mr. Alongkorn Ponlaboot, Deputy Minister of Commerce

Mr. Alongkorn Ponlaboot is Thailand's Deputy Minister of Commerce. He notes that the only results that have come from the present innovation infrastructure are reports and books, nothing tangible. The same problems continue to occur. The Creative Economy is the new trend focused on ideas or innovations in the country. It goes back to

basics by asking "what is the research for?" The Creative Economy's surrounding organizations and clusters constitute another mechanism to drive innovations to commercialization, in addition to the conventional R&D structure in Thailand. Patenting is low in Thailand, and the Creative Economy can help to improve this. (personal communication, April 27, 2011).

In the Creative Economy, the focus is on applied research and commercializable research for value creation. In working with intellectual property, there are patent and prototype holders who cannot reach the market. Part of the reason for the Creative Economy is because some "local wisdom" innovations will not be funded by banks, so the Ministry of Commerce has grants and loans available. Investment is the most important aspect. The creative academy or institute will act like a funding agency, but also make recommendations to the Budget Bureau to allocate funds for "creative organizations." Also a "creative bank" will be able to do memorandum of understandings (MOUs) with industry (A. Ponlaboot, personal communication, April 27, 2011).

Deputy Minister Ponlaboot indicates that basic research is good but eventually you have to commercialize it, that's the key issue. Research may conform to the Creative Economy by putting 50% to creative industries, 25% to basic research, and 25% to researchers' preferences. The business man is the most important person that can tell you what research to do and what to innovate. If the private sector wants R&D, they need to cooperate with universities to meet their demands since they may not have their own facilities. Instead of doing research or innovating from your own idea you "place an order" and there is no worry that the innovation will be commercialized as the private

sector has already targeted the market. This is the bottom line of the Creative Economy strategy (personal communication, April 27, 2011).

The strategy is somewhat like the triple helix model of the private sector, government, and universities. Fifteen creative industries have been identified and an organization has been created to assist them. Ten "creative academies" will also be developed from the existing universities to act as a coordinator and the core of a creative industry, like in a Center of Excellence model. Other universities will also be in the network. Government helps in this process as it can, for example, creative partnerships where investors and innovators are brought together in a virtual market (A. Ponlaboot, personal communication, April 27, 2011).

The Ministry is trying now to make links between trade associations, industrial clusters, and the Industrial Council and connect them with the Creative Economy infrastructure. Deputy Minister Ponlaboot says that Thailand does not lack resources, but needs to do a better job of coordinating them (personal communication, April 27, 2011).

The opinion of government officials who actually work in Thailand's NIS is useful for assessing NIS performance. In one view, a well-performing NIS is one which creates and commercializes tangible products. It uses basic and applied research from universities and R&D institutes to meet the innovation demands of the private sector. In this view, 50% of the research effort should be directed to "creative industries," 25% to basic research, and 25% to the preference of the individual researcher (A. Ponlaboot, personal communication, April 27, 2011). In another view, NIS effectiveness requires linking business, educational institutions, financial institutions, and government. It also

requires recognizing the appropriate components, sectors, and products in the system. Therefore, individual performance measurement for system components, sectors, and products is advised (Y. Mukdapitak, personal communication, April 7, 2011). Another view sees that linkages and cooperation are the main factors for successfully implementing the innovation system. These linkages extend beyond partnerships of innovators to the wider environment including policy and laws. Technological readiness as well as the cooperation between innovators and organizations can be improved in Thailand. A successful NIS approach in Thailand requires integration and a comprehensive process (S. Chittmittrapap, personal communication, September 22, 2011).

Outcomes of Innovation

The performance of Thailand's NIS can also be evaluated in terms of the outcomes of innovation. Innovation outcomes are the longer-term, broader-scale effects of innovation on the economy. What is the system delivering in terms of socioeconomic results?

Indicators for assessing Thailand's innovation outcomes are shown in Table 6.8 below. Some of these indicators, such as those concerning new business creation and royalty and license payments, give us an idea of how innovation in Thailand is impacting business and industry. Other indicators, such as those concerning high-tech products exported to foreign markets and the competitiveness of the Thai economy on a global scale, give an idea of how Thailand's innovation is impacting the larger economy. The

last indicator in Table 6.8, Thailand's ranking on the Human Development Index, can give an idea of how innovation in its broadest sense affects social welfare.

Some of these indicators have appeared earlier in this study and are presented again here because they are helpful measures of innovation outcomes. The indicators dealing with competitiveness from the World Economic Forum (WEF) and the International Institute for Management Development (IMD) have not appeared to this point. As the global competitiveness of an economy is an important outcome of innovation, these well-known indices were selected. The Human Development Index score also has not appeared to this point. Economic and technological innovation can effect improvements in the socioeconomic development of a country generally; therefore the widely-used United Nations Development Program (UNDP)'s Human Development Index was a logical choice to capture these trends in Thailand.

The table shows that during the period of available data, business creation was relatively flat while receipts for royalties and licenses rose considerably. High-tech exports as a percentage of all exports have declined slightly but their value in real US dollars has risen. The global competitiveness of Thailand's economy has remained relatively stable. The World Economic Forum typically ranks Thailand's competitiveness just within the upper third of all countries in the study while the International Institute for Management Development typically ranks it in the middle of its study group. Finally, Thailand's Human Development Index score has remained stable since 2001, with a slight decline in 2010 and 2011.

Overall, indicators such as these can be used to represent prosperity and societal well-being in Thailand. Table 6.8 below shows that some positive outcomes have resulted from innovation efforts in Thailand. By continuing to improve the NIS, even greater positive outcomes can be achieved. Continuing to monitor the outcomes of innovation in Thailand using these and other indicators will be important to understand the full impact of the NIS and related public policies.

Royalty and license fees and the value of high-tech exports have risen over the past decade. This is likely due to Thailand's increasing participation in higher value added global supply chains, such as automobiles and electronics. However, other indicators of innovation outcomes are falling over the past decade. New businesses created and the percent of high-tech exports both have declined. This trend may reveal the barriers to business development and lack of technological learning and development in firms noted by Intarakumnerd (2010) and Arnold et al. (2000) (see p. 92). While Thailand's World Competitiveness Yearbook ranking is stable, there has been a slight decline in its Global Competitiveness Index ranking in the last few years. Several new countries entered the Global Competitiveness Report study during this time including Angola, Belize, Cape Verde, Haiti, Iran, Lebanon, Rwanda, and Yemen. However, since this decline coincides with the formalization of innovation policy in Thailand and the creation of the National Science Technology and Innovation Policy Office (STI), it may be of some concern. As noted in Chapter 1 above, the drive for a globally competitive economy is an important reason for innovation policy. Thailand's ranking in the Human development Index had been relatively stable until 2009 when a noticeable decline

occurred. While recent political instability in Thailand may account for this, some losses in innovation and competitiveness may as well.

The outcomes from economic and technological innovation take time before their impact can be known. The indicators presented in Table 6.8 should be revisited in five or ten years' time to take note of changes to these trends. Overall, attention to innovation outcomes demonstrates that Thailand's NIS needs to be proactive to promote development, enhance global competitiveness, and serve as a means to keep the country from falling behind in the evolving global economy.

Table 6.8 Selected Indicators of Innovation Outcomes

Indicators	2002	2004	2006	2008	2010	2011
New business registered (number)[a]	n/a	31,013	30,119	27,654	n/a	n/a
New business density (new registrations per 1,000 people ages 15-64)[a]	n/a	0.70	0.67	0.60	n/a	n/a
Royalty and license fees, receipts (current US$mil.)[a]	n/a	14.3	46.4	100.8	153.1	n/a
High-technology exports (% of manufactured exports)[a]	30.78	28.13	27.39	24.55	24.02	n/a
High-technology exports (current US$bil.)[a]	15.69	20.61	27.05	31. 30	34.16	n/a
World ranking by the Human Development Index (rank/no. of countries)[b]	76/177	74/177	73/177	77/177	92/169	103/173
World ranking by the Global Competitiveness Index (rank/no. of countries)[c]	31/80	34/104	35/117	34/134	38/139	39/142
World ranking by the World Competitiveness Yearbook (rank/no. of countries)[d]	n/a	26/51	29/53	27/55	26/59	27/59

Source: Based on World Bank, 2012[a]; UNDP, 2012[b]; WEF, 2012 [c]; and IMD, 2012[d]

Synthesis of Evidence from the Thailand NIS Case

Table 6.9 below presents the assessment framework seen in Chapter 4, with evidence from the Thailand case now included. The table reveals some key information about Thailand's NIS. NIS theory identifies private firms as the primary *innovators* in a national economy. The intent of the NIS is to facilitate firms' innovative efforts. Currently in Thailand there appears to be relatively few private firms performing innovation activities. Technology absorption among firms is low (WEF, 2012). Among most large multinational corporations (MNCs), many large local firms, and most small and medium enterprises (SMEs), research and technological development is infrequent (Arnold et al., 2000). In a survey of private manufacturing and service firms in Thailand, only 5.8% were determined to be "innovating" in contrast with 42% in Korea (Intarakumnerd, 2007).

Several government agencies, research institutes, and the Thailand Science Park actively work to facilitate innovation in the private sector through *linkages* between firms and innovation resources. Industrial clusters are one form of innovation system linkage that is working well in Thailand. The booming electronics and automobile industries in Thailand have clearly benefitted from the cluster approach, and government agencies have played a key role in cluster development.

The Thailand Science Park hosts technology-based firms and the nation's four public research institutes, provides ready access to major universities, and helps to incubate start-up companies. The National Innovation Agency (NIA) has become a lead agency in working to connect firms in strategic sectors. It provides funding, shares

financial risks, and offers technical advice and other partnering services. It works to further develop partnerships between universities, R&D institutes, and firms in the targeted sectors. Some innovative products, discussed above, have resulted from NIA-enabled linkages.

Table 6.9 NIS Assessment Framework: Thailand Case

Question	Evidence from Thailand NIS Case
What is NIS?	Few private firms are innovating; some public research institutes are innovating; some links between firms, institutes, and universities, but typically weak; industry clusters provide some linkages in some sectors; public organizations work to promote innovation and are linked to each other and possibly overlap; institutional environment for innovation is improving; output of higher education and IPRs are concerns
Why is NIS adopted?	Regional economic crisis/Thailand's financial crisis of 1997; desire to compete in global economy; concerted learning and research efforts focused on other NIS/innovative countries to find suitable policy alternative
How is NIS implemented?	The 2008 Innovation Law, the Strategic Plan, and the STI Policy create a framework of goals and allocation of resources; NIA and STI are leading policy implementation agencies; key capital investment and technology from foreign sources
How can NIS performance be evaluated?	Conventional quantitative indicators used by OECD, WEF, and World Bank; firm-level innovation surveys; measures of success offered in Strategic Plan; evaluation of key government officials; socioeconomic outcomes of the system

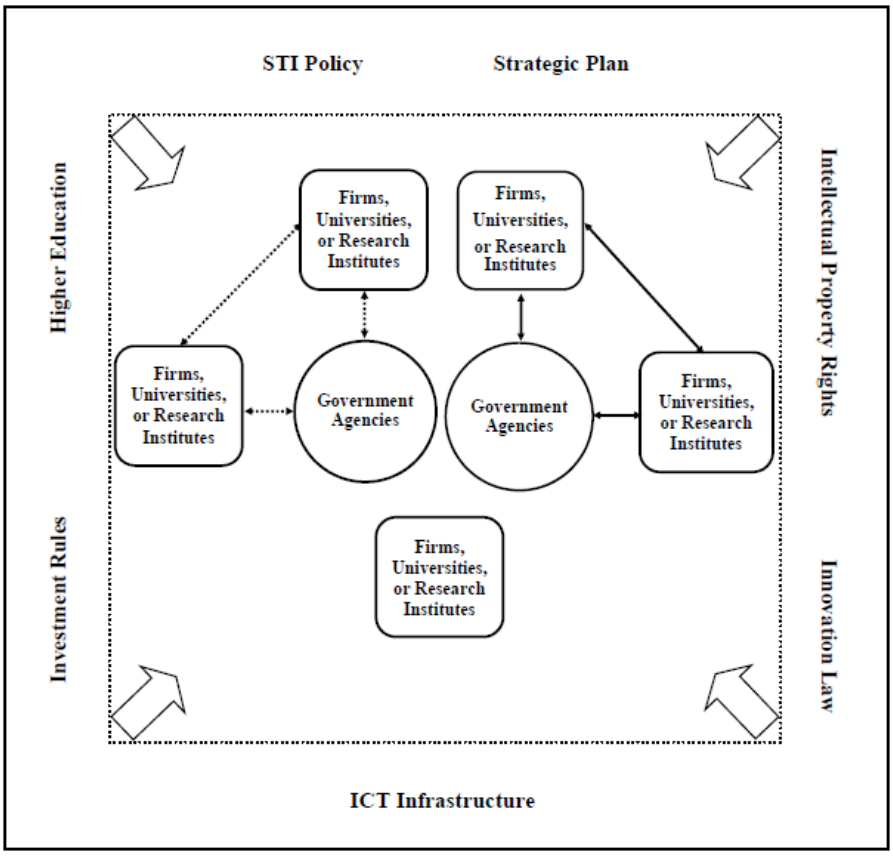
Incompatibilities and past disappointments between industry and universities cause these linkages to remain weak. Despite some autonomy among universities and

growing research outputs, universities' research does not appear to be significant for firms. Many firms do not have a strong demand for STI human resources. There are only two organizations in the private sector that can facilitate innovation in firms, which do not appear to be very active. Based on firm surveys, there is an interest in innovation linkages. But these firms are either unaware of existing linkage opportunities, or unwilling to participate. Thailand's industrial clusters provide benefits for the firms involved. However, the advantages of Thailand's industrial clusters are related to efficiency rather than innovation gains. These clusters do not appear to link firms together for enabling "knowledge spillovers," as NIS theory predicts. Links between firms and domestic investors to allow financial resources for innovation to flow also appear to be weak or absent.

Social institutions and infrastructure in Thailand create an *environment* that can be conducive for firms' innovation. Physical infrastructure in Thailand, including ICT and industrial estates, and the investment regime for foreign capital, are viewed favorably. However, the regime governing intellectual property rights, the investment regime for domestic capital, and the provision of innovation-oriented human resources from higher education are lagging (WEF, 2010). Thailand's recent innovation law and the corresponding innovation policies and plans help to guide private sector, public sector, and academic innovation activities. The law and supportive policies set goals and expectations for innovation outcomes, target strategically important industries and sectors, and channel resources to innovation actors.

Figure 6.1 below presents a conceptual model of the structure of Thailand's current NIS. It shows relationships between innovators and supporting actors in the system including firms, universities, research institutes, and government agencies. Some of these relationships involve strong linkages between actors in the system portrayed with a bold connecting line. However, in other cases the linkages between actors in the system

Figure 6.1 Conceptual Model of Thailand's NIS



Note: ◄——► = Strong Linkage; ◄·····► = Weak Linkage; No Line = Absent Linkage

are weak shown with a dashed connecting line. Some actors in the system may not be linked to the others at all; these isolated actors in the system are portrayed with no

connecting line. Surrounding these actors and linkages is Thailand's innovation environment composed of the nation's innovation laws, plans, and policies; rules governing investment and intellectual property; the higher education system; and the nation's ICT infrastructure. This institutional environment guides and also constrains the interactions of the actors in Thailand's innovation system.

Barriers to Innovation in Thailand

Synthesizing the details of the Thailand NIS case within the assessment framework is very useful because it helps to identify the major barriers to innovation in the country. With this knowledge, problem areas that Thailand's NIS must address become clear. There are four critical barriers to innovation in Thailand related to the overall direction and rationale of the country's innovation policy, and the organization and functioning of key system components and processes. More specifically, these barriers concern resource allocation, the nature of industry in Thailand, the integration of R&D into the innovation system, and the organization of the public sector component.

Strategic Allocation of Resources

Thailand's current innovation policy creates obstacles instead of advantages in moving the country toward innovation-based growth and competitiveness. Currently, a two-track innovation policy is pursued. One track is focused on science and technology. It is outward looking and recognizing the importance of global trends and participation. It has been building for decades with many important successes along the way. This track takes a long-term view. The other track is the "Creative Economy" approach which is

focused partially on cultural arts and local cuisine rather than high technology, the more common focus in terms of innovation. Some elements of the Creative Economy agenda look inward to "local wisdom" and heritage and turn back from the global technology frontier mentioned in Chapter 2 towards a more factor-driven stage. Other elements of the Creative Economy however emphasize contemporary, cutting edge fields such as film, software design, and fashion. The problem with a two-track policy is that it can misallocate resources. For a country like Thailand, with relatively limited resources, it must be strategic in the way that it allocates resources for innovation. Pursuing both of these tracks simultaneously and independently means there are relatively fewer resources available to either.

Firms' Incentives for Innovation

Chapter 5 showed that private industry in Thailand is not oriented toward R&D and technological learning, and therefore not conducive to innovation. This fact is demonstrated by Table 5.4 above which plainly shows that most Thai firms do not possess higher-order technical capacity. Most firms in Thailand are SMEs, and most of these SMEs are small. Furthermore, though the rise of industry brought significant economic benefits to Thailand, many successful industrial firms in the country are foreign-owned ones with large global operations. Thai affiliates in this arrangement are "branches" of larger MNCs.

SMEs do not conduct R&D for innovation purposes because, very simply, they cannot afford it. SMEs often function to meet more immediate needs of larger firms in a

wider supply or value chain. They do not have the capital and resources to devote to higher-order, skill-intensive, technology-intensive activities like R&D.

The branch plant organization of industry that exists in Thailand means that as "host" country for a parent MNC, relatively simpler technical work will be performed in Thailand. Simpler technology will be present in the local affiliate firms and relatively less-advanced skills will be required in the work force. At the headquarters of these MNCs, which reside in the "home" countries, higher-order work is conducted, including executive-level functions, marketing, design, engineering, and R&D. The branch plant arrangement means innovation occurs in MNCs' R&D institutions in Japan, Europe, and America, not in Thailand. Little local learning occurs, little indigenous innovation emerges.

Size and structure explain the lack of R&D orientation in Thai firms. They further explain why Thailand performs well on some internationally-accepted innovation indicators, such as foreign investment and technology transfer, imports of capital goods, value chain presence, manufacturing trade, high-tech exports, and royalty and license fees payments, but not others, such as higher education and training, firms' technology absorption, venture capital access, intellectual property protection, numbers of researchers in R&D, expenditures on R&D as a percentage of GDP, science and engineering publications, and royalty and license fee receipts. Performing well on the former set of indicators makes perfect sense for a newly-industrialized country with a favorable business climate that is a key base of production in global assembly and manufacturing chains. Performing worse on the latter set of indicators makes perfect

sense for a developing country with a less-than-robust educational system that has relatively recently transitioned into an efficiency-driven stage of growth.

Several steps can facilitate a move to the next stage of development for Thailand's firms: allocating more capital to R&D and innovation activities from government; improving university-industry links; and overcoming disincentives for innovation in firms by broadly defining tax incentives and subsidies for R&D, strengthening intellectual property rights, reducing barriers to labor mobility and business development, and attracting a portion of MNCs' R&D facilities to Thailand. However, this is not very likely except in subareas where there is a large concentration of activity. These are the types of measures taken by global and regional innovation leaders as their private sectors advanced to higher stages of development.

Isolated University Research

Industrially oriented applied research can be conducted in university R&D facilities in close collaboration with firms. Firms can identify their needs to university labs and contract with them to undertake the innovative activities. In this way, the demand from industry pulls innovation from R&D institutions into the market place. As Chapter 5 showed, industry in Thailand is not supportive of university research and this "innovation pull" does not occur. This is because industry does not need university R&D. As mentioned above, the branch plant structure means R&D activities occur in the home country not the host country, and with predominantly small supporting firms, the need and resources for innovation is absent.

This scenario becomes a self-reinforcing, vicious circle. Industry does not need university innovation, so universities are not incentivized to provide it; universities have no need to produce innovation, so there is none available to industry. Innovation-capable human resources are not demanded by industry, so universities supply fewer of them. If those that exist cannot find jobs, "brain drain" occurs as they relocate to other countries where their qualifications are in demand.

Complicated Public Sector Component

Thailand's NIS has several policy statements, plans, objectives, initiatives, and agencies. There are several plans with a five-year time frame that require coordination within the government to follow the plan. However, the coordination issues were not considered a significant threat. With most agencies working on their own innovation efforts independently, this resulted in significant policy and program overlap across agencies as well as bureaucratic in-fighting against what they saw as interference from one another.

Like Finland, Korea, and Singapore, Thailand also created a single agency, the NIA, to lead innovation efforts. NIA has shown itself to be a dynamic agency in implementing various project-based linkages between innovators and resources. In this manner, NIA plays a similar role as TEKES and ASTAR do in the Finnish and Singaporean NIS. However, NSTDA and STI are also key agencies in Thailand's NIS. In Thailand's NIS, an excessive amount of initiatives by different agencies can lead to overlap, unclear bureaucratic boundaries, and conflict in the public sector component of

the NIS, and too much "red tape" for the private sector. Potentially-innovative firms may become overwhelmed by a complicated system.

The NIS evaluation in Finland showed the NIS was seen as too complicated by firms. The transaction costs with the system were too high and firms decided not to participate. Thailand's NIS policymakers must make sure the system is coordinated so firms do not ignore innovation linkages and opportunities. It is important for clearly defined organizational responsibilities and boundaries to be imposed on the system. So-called "lean government" principles can be used to reduce public sector waste by eliminating unneeded approval cycles, reporting, and other processes and simplifying and streamlining needed processes. Its aim should be increasing efficiency and effectiveness of the NIS.

Policy Recommendations to Improve Thailand's NIS

Understanding the barriers to innovation that currently exist in Thailand enables making specific policy recommendations that should be considered to improve the NIS. In response to these impediments, conflicts in resource allocation must be minimized for more efficient use; incentives for domestic innovation must be created by attracting foreign-based R&D institutions to relocate and encouraging large domestic firms R&D that have the capital resources required for innovation; strengthening the linkages between university and industry should be done to affect university R&D; and trust and credibility within stakeholder partnerships must be created for these links to form. An effectively organized government sector can accomplish these through well-designed

policy. Thailand's government should address these problems using the recommendations provided here.

Reconcile the S&T Track and the Creative Economy Track

To gain the most innovation benefits, the current Creative Economy innovation track should be reconciled with Thailand's science and technology efforts and policies for pursuing innovation. By reconciling these two tracks, resources dedicated to innovation in Thailand will not conflict or overlap. To do so requires developing links between innovation policy and programs and creative industries. Niche markets exist for Thailand in terms of fashion, food, and culture, especially in the context of the growing tourist industry. In areas where advanced technology can assist the development of these industries, innovation policy and the innovation system should be present to provide that boost. It goes without saying that in the high-tech fields associated with the Creative Economy such as media and software design; innovation policy should be supportive and allow needed resources to flow. Within Thailand's NIS, these two innovation tracks should be complimentary and not competitive. By complimenting one another and efficiently allocating resources, larger benefits of innovation can be available.

Stimulate Private Sector Innovation

To overcome the innovation barriers posed by the branch plant structure and the predominant firm size in Thailand, the government must attract foreign-based MNCs' R&D institutions to Thailand. It must also encourage R&D in its large domestic firms that have the capital and resources required for innovation. It must do both of these to the

extent possible. Additionally, a privately-managed fund for technological upgrading in firms should be created. These three steps together can encourage domestic innovation.

How should foreign R&D institutions be attracted to Thailand? The BOI has a Regional Operating Headquarters (ROH) tax credit program, as discussed in Chapter 5 above. It needs to complement this scheme with an additional Regional R&D Headquarters ("RRDH") tax credit program. The RRHD would offer a further reduction in the corporate tax rate for companies that locate not only their Regional Operating Headquarters, but also their R&D facilities, to Thailand. The ROH tax rate provided by the BOI currently stands at 10%, well below the standard 30% corporate tax rate. For those firms that locate their ROHs and their RRDHs to Thailand, perhaps the rate could be revised downward to 5%, for example.

The Thai government should couple this approach with further investment in university and public sector R&D labs and facilities. Thailand should focus on niche areas – what it does well or where opportunities exist and promote innovation within target industries. A key lesson learned from the case studies of Finland, Korea, and Singapore was that major government-led investment in R&D is critical to successful NIS development. Thailand must continue with, and enhance, its plans to upgrade science parks and industrial estates. Centers of Excellence at universities need to be ready for action. These investments will go further in drawing foreign MNCs' R&D institutions to Thailand by creating the innovation infrastructure these MNCs need. MNCs used to be drawn to Thailand by its low-cost opportunities alone. Now, Thailand needs to draw

MNCs by its low-cost opportunities along with its state-of-the-art facilities and industrial clusters to provide them the best return on their investment.

How should domestic firms' R&D be stimulated? It is important to remember that not all industries in Thailand are foreign owned. Though most firms in Thailand are relatively small in size there are some, significant, large domestic firms in the country. These are the other private sector organizations necessary for Thai innovation which must be targeted by the NIS. These firms include, for example, Boonrawd Brewery,[63] Charoen Pokphand Group (CP),[64] Petroleum Authority of Thailand Plc. (PTT), and Siam Cement. Why are these large firms targeted for R&D and innovation support rather than directly supporting R&D in SMEs? Thailand's SMEs are so numerous and, overall, so small that supporting their innovation through direct government subsidy would end up spreading resources out so much as to be ineffective. These SMEs would have to start up internal R&D efforts from scratch and would need years to attain only marginal innovation results. Thailand would realize better return on its investment by offering a measure of support to complement the ongoing activities of larger firms that are operating in strategic fields.

These large domestic firms are now expanding their markets and operations in the Southeast Asian region and in wider Asia. Their competitive success will depend on their ability to innovate. These firms compose a select group in Thailand that are in a position to compete internationally and to innovate near the global technology frontier. Tax breaks

[63] Boonrawd Brewery is the first and largest Brewery of Thailand. Its products include beer, soda water, drinking water, and various energy drinks and beverage. The company serves customers throughout Thailand as well as in nearly 50 countries worldwide, including Europe and North America.
[64] Charoen Pokphand Group (CP) is a Thailand-based global conglomerate with operations and investments in agribusiness and food, retail and distribution, and telecommunications industries.

and supportive investments directed at these types of firms, in a similar fashion as those for foreign R&D institutions described above, provide the best return on public investment.

Large domestic firms indicate areas in which Thailand holds some comparative advantages, such as agriculture, automobiles, electronics and ICT, energy, and food and beverages. As shown in Table 5.1-5.3 (see p. 80-81) and Figure 5.2 (see p. 91), these sectors are the top producers and exporters, with the most value added, and the most investment in R&D. Thailand's innovation policy must identify and target areas where the country holds a comparative advantage. It cannot afford not to play to its strengths.

Moreover, these advantages should be viewed in the context of how they can meet (1) the country's future needs, and (2) regional and global opportunities that are available for exploitation. CP, one of the country's largest food and agricultural firms, provides an excellent example as it diversifies into aquaculture operations in Thailand. Aquaculture can be seen as a prime area for R&D and innovation as concerns over local, regional, and global food supplies are rising and world fish stocks are falling. These types of innovative efforts in areas of critical need should be viewed by government as strategic opportunity and supported appropriately. Other areas exist in which firms have strengths and local, regional, or global needs are emerging, such as energy, next generation vehicles, sustainable tourism, and management of water supply and water quality. These areas require the kind of innovation that comes from science and technological advancement. Government can play a matchmaking role to help make and support strategic connections in fields of future critical need.

Encouraging R&D in firms as described above can encourage domestic innovation even further because of the external effects of innovation. As larger firms undertake a new strategic phase of R&D, it can spill over and pull the relatively few mid-size SMEs in Thailand into their own phase of innovative activity in support of the larger firms. Indeed, Dr. Surin Pitsuwan, the director-general of ASEAN, has recently recommended that Thailand actively facilitate large firm-to-small firm innovation spillovers by using state funds to establish mentoring relationships for Thailand's SMEs.[65] These two approaches complement one another in helping to maximize the external benefits of innovation for Thai firms. However, a question may arise here as to whether large firms would be willing to bear the burden of SME innovation mentoring. Making large firm R&D assistance conditional on SME mentoring may be met with resistance. In this situation, it may be best to let the market allocate the gains of innovation spillovers. SMEs can still benefit indirectly from large firms R&D because of the public goods aspects of innovation.

Some innovation occurs in small start-ups as well. These start-ups are sometimes spun off from university research or other industrial concerns. To support relatively small innovation activities that often need small amounts of funding or resources, at least a few steps can be taken. Business incubators can be created in strategic locations such as within or nearby universities or other research institutes or labs. Similarly, entry into larger innovation hubs such as the Thailand Science Park can be facilitated for start-ups

[65] The Nation on Sunday. (2012, April 8). Small Thai firms should eye opportunities around the region, Surin says. *The Nation.*

by reducing their rent or other through concessions. Finally, small seed fund grants can, of course, be made available to start-ups with few or no strings attached.

As mentioned above, there are only two organizations in Thailand's private sector for encouraging innovation among firms, the Technology Promotion Agency (TPA) and the Kenan Institute Asia (KI Asia). These organizations play a relatively minor role in the system. NIS policymakers could enhance the role of these private sector organizations, or help to create a new private sector organization, by implementing a levy-grant program for firms' technological development, similar to the ones in Korea and Singapore. The system requires qualified firms to contribute some percentage of their wage bills to a general fund. Firms can then apply to receive a grant from the fund to sponsor technological skill training and other innovation-related development activities for employees. In Thailand, NIS policymakers should serve as monitors and consultants to the program, but the private sector firms themselves should be in charge of managing the fund. TPA or KI Asia can serve as fund manager, or an entirely new organization created by private sector firms themselves could perform this role. This program enhances private innovators by providing incentives for innovation-related activities and also giving some ownership of innovation management to firms themselves. By managing the fund, the relationship between private firms and the larger NIS can be deepened. By serving as consultant, NIS policymakers can better understand the innovation needs of firms. A pilot program could be tested before full implementation.

Incentivize Universities' Participation in the System

The reward system for universities, their staffs, and their students in Thailand should be reconfigured to help this institution become better integrated into the NIS. Enabling better linkages between industry and universities helps to achieve this. When industry and universities have a collaborative relationship, students learn about real-world issues in business and industry. Students can also have hands-on learning by participating in joint projects between universities and industry. These experiences create higher quality STI workforces that are ready to be hired. Seagate has created these types of linkages with universities, as discussed in Chapter 5.

Promoting private sector innovation by taking the steps described above creates the demand for STI human and knowledge resources. Thailand's academic sector must be prepared when this innovation pull takes effect. Several approaches can be taken. Scholarships and other educational subsidies should be targeted at the country's best and brightest science, technology, engineering and mathematics (STEM) students. Commercializable outputs of R&D should be incorporated into university professors' promotion schemes, as appropriate. Collaboration between private firms, R&D institutions, and universities for encouraging innovation should be facilitated by all means necessary.

Sakunsriprasert (2009) showed that trust and commitment among innovation actors in Thailand is important for successful collaboration. The structure of innovation grants can incentivize repeated interaction between industry and university for innovation projects. This can help to create trust and credibility. Funding agencies including TRF

and the NIA can do this by increasing the amount of funding to a pair of industry-university collaborators that remains stable over time. Table 6.10 below illustrates this approach.

Table 6.10 Incentivizing Repeated Interaction

Innovation Partners	Time Period	Payoff
A and B	t	x
A and B	t+1	0.5x
A and B	t+2	1.5x
A and B	t+3	2.5x
A and B	t+n	(n-0.5)x

The table shows that in the first year of a collaborative innovation project, innovator A and innovator B receive the payoff/award x to assist their work, for example, an innovation grant worth US$100,000 (x = 100,000). The table shows that by year five the same partners receive US$450,000 [(5 – 0.5)100,000]. With this policy, innovator A and innovator B are incentivized to maintain their relationship instead of just a one-time collaboration. This creates the opportunity for trust and credibility to form and a stronger innovation linkage develops. This is one option but another form could work in reverse. Start-up funds can be supplied to kick-start the process with lower funds for maintenance provided over time.

Industry-university linkages can also be enabled by reducing the risks of collaboration through risk management. Project partners can leave the partnership or the results of the project may not turn out as planned. Managing risks such as these help partners in an innovation project to commit to each other. Funding agencies can require

some amount of an innovation grant to be placed in an escrow fund. This policy provides insurance for innovation project risks. The fund can compensate the other partners in case one of them leaves the partnership. It can also compensate investors in case an innovation project does not produce the required results. With this policy, funds in escrow serve as a form of "innovation insurance." To mitigate the moral hazard aspects of innovation insurance, however, funding agencies must have a rigorous ex-ante review and ongoing monitoring process to ensure the feasibility of the projected outcome.

Rationalize the Public Sector

Rationalizing the government bureaucracy components of the NIS can also help enable linkages and improve the functioning of the NIS. There are several agencies involved with innovation in Thailand. Overlapping and redundant activities in the various agencies need to be streamlined. Bureaucratic boundaries and responsibilities have to be better defined. Government initiatives and points of contact for the private sector must be clear and well-managed, otherwise private actors will be less encouraged to engage with the NIS, as occurred in the Finland case.

The NRCT is well positioned to help rationalize the system and provide linkage by providing critical information. It performs this role to a great extent now, but can do still more. As mentioned by NRCT's Secretary General above, the NRCT is a central repository of R&D activities which received government funding since 1950. In this way, NRCT serves as a rich "database" or "clearinghouse" of research results which can be drawn upon for innovation and commercialization purposes. NRCT has formulated the 2008-2012 Master Plan to support the development, management and public access to the

National Research Database System (NRDB). The NRDB aims to create a national pool of innovation knowledge by linking, exchanging, and sharing research data with other institutes and agencies, including the National Science and Technology Development Agency (NSTDA), Ministry of Science and Technology (MOST), Ministry of Labour (MOL), Ministry of Social and Human Security Development (MSO), Kasetsart University (KU), and Chulalongkorn University (CU). NRCT is also involved in implementing internationally-accepted standards for R&D and other critical innovation activities and benchmarks.

Most importantly, an independent agency with an independent budget and a long term view to direct resources to the national innovation effort is needed. This should not be a newly created agency however, as there are already a number of agencies involved in Thailand's NIS. Instead, the National Science Technology and Innovation Policy Office (STI) should be reconfigured with independent budget control so that it can make more strategic choices about the direction of Thailand's NIS.

CHAPTER 7

SUMMARY AND CONCLUSIONS

From linear innovation processes to innovation systems, the National Innovation System (NIS) approach is a recent paradigm for organizing innovation in national economies. This systems approach represents a more holistic view of innovation processes and has the potential to improve innovation outputs and outcomes for firms, industrial sectors, and nations.

This study developed a framework for assessing the status and performance of a country's NIS by investigating the theoretical concept of the National Innovation System (NIS) and the experience with NIS in innovation-leading countries including adoption, implementation, and evaluation. Together this approach provides an understanding of the fundamental components of the NIS, the relationship among them, and the system as a whole. These components were used to develop a framework for assessing the status and performance of the NIS in a given country.

The framework calls for an understanding of, first, what the NIS is, i.e. its theoretical conceptualization and its basic system components; second, why the NIS approach is adopted, i.e. the rationale for incorporating the approach in encouraging innovation; third, its implementation in terms of the organizational structures and functions in place; and fourth, potential methods by which the performance of the NIS can be evaluated. Understanding the questions, the theories behind them, and real-world experiences provides guidance for policymakers in acquiring relevant data to create their own indicators for NIS assessment.

The NIS assessment framework was applied to a case study of a developing country, Thailand. Background information on Thailand's economic and science and technology policy development was presented, and the details of Thailand's NIS were then described. Examining the evidence from the Thailand case using the assessment framework identified aspects of the system where things have gone "right" and also areas of on-going challenges. Moreover, it provides a better understanding of both the functioning of the NIS and the barriers to innovation in the country. These barriers concern resource allocation, the nature of industry in Thailand, the integration of R&D into the innovation system, and the organization of the public sector component.

It is important that the barriers to innovation in Thailand be removed. Policy recommendations to improve the functioning of the NIS and overcome barriers include: (1) minimizing the conflicts in resource allocation for more efficient use; (2) creating incentives for domestic innovation by attracting foreign-based R&D institutions to relocate, encouraging large domestic firms R&D that have the capital resources required for innovation, and building internal capacity to encourage domestic firms to develop R&D components to allow them to compete more favorably in evolving global economy; (3) strengthening the linkages between university and industry affect university R&D; and (4) creating trust and credibility within stakeholder partnerships for these links to form. An effectively organized government sector can accomplish these objectives through well-designed policy.

Most importantly, a new strategic direction for innovation policy and a truly "country-specific" framework for assessing Thailand's NIS in the future can be

developed. This framework allows Thai NIS policymakers to determine their own indicators that are "made to measure" their specific system. Besides assessing the components that make up the NIS by focusing on the questions mentioned above, the country-specific assessment framework emphasizes: (1) the rationale and goals for NIS, (2) the necessary instruments for NIS, (3) the functioning of NIS components, and (4) measures of NIS success. This country-specific assessment framework is presented in Table 7.1 below. This, in turn, allows policymakers to better identify opportunities and target available resources to areas with the greatest potential return.

The policy recommendations just mentioned become the assessment framework for the future. The emphasis should now be on assessing whether the recommended steps are being taken, and evaluating their effects on achieving global competitiveness and economic growth and development. This assessment is done by asking, first, whether the rationale for the policy is logical and its objectives are clear, second, whether the necessary instruments for innovation are contained in the NIS, third, whether the components are functioning properly, and fourth, whether indicators of success are suitable.

Each question itself suggests appropriate measures for judging success, however the needs for policy and the actions government should take regarding NIS will change over time. Therefore we need to have a way to monitor and evaluate NIS status and performance and make necessary adjustments as needed. This country-specific assessment framework serves this role, as a feedback mechanism for Thailand's

innovation system. The four questions within it are the key questions to continue to ask and answer into the future.

Table 7.1 Country-Specific Assessment Framework for Thailand's NIS

Question	Criteria
Is the rationale for Thailand's NIS policy logical and are its objectives clear?	Continuing to build S&T capacity and infrastructure; increasing and enhancing R&D and innovation in Thailand; combining STI with strategic comparative advantages to facilitate global competitiveness and sustainable growth.
Are the necessary instruments to make innovation happen contained in Thailand's NIS?	Incentives and support to attract foreign R&D; incentives and support to stimulate domestic firm R&D and technological upgrading; reconfigured university reward system to facilitate R&D collaboration with industry; clearly defined public sector roles, responsibilities, and initiatives; independent budget control and long-term outlook for STI as lead NIS agency.
Are Thailand's NIS components functioning properly?	Firms: Conducting R&D and innovation; universities: increasing R&D and innovation and providing STI HRs; firms and universities: collaborating for mutually beneficial R&D; government: facilitating to other NIS actors, providing strategic, long-term STI direction.
Are suitable indicators used to measure the success of Thailand's NIS?	Public and private R&D expenditure; quantity and quality of STI HRs (including relocated foreign MNCs' R&D personnel); quantity and quality of (joint industry-university) patents; quantity and quality of (joint industry-university, joint international partner) STE publications and citations; opinion of domestic NIS experts; development of "Thai brand"; creation of new businesses; enhancement of global competitiveness; enhancement of human development.

The NIS is a fundamental component of the nation's overall economic development strategy. In the case of Thailand, innovation will affect the country's competitive position both globally and regionally. Referring back to the flying geese

analogy, Thailand's economic development depends on keeping up with innovation leaders in the region, like Singapore and Korea, who are flying ahead at a fast pace. Falling behind these leaders means Thailand's economic development will suffer. By closing the gap with the leading geese, however, Thailand stands to move to higher tiers of industrial and technological capability and more sophisticated stages of economic growth. At this point in time, focusing on regional innovation leaders in an increasingly competitive Southeast Asia makes sense for Thailand.

From this big-picture view, the NIS becomes an important means to an important end. This is the reason that outcomes of innovation, such as the creation of new businesses, the competitiveness of the economy in an international context, and the social development of the nation must also be measured when assessing NIS status. Enhancing these outcomes moves Thailand forward through subsequent stages of economic development. Enhancing these outcomes is the goal of the NIS and justifies its inclusion within a broader economic development strategy.

Thailand's economy can become more innovative by incorporating this study's policy recommendations for the NIS, keeping innovation outcomes and regional innovation leaders in sight, and addressing the questions of the country-specific framework above. Innovation is the key. As Thailand's economy becomes more innovative it will also become more competitive in the evolving global economy. In this process, further development of the economy will naturally occur. This is the reason for developing the NIS in the first place and the nation's global competitiveness and

development performance are the most important benchmarks against which it should be assessed.

Developing country policymakers can look to the experiences of innovation-leading countries including innovation systems adopted, how they were implemented, and how they are evaluated. This approach provides a framework for developing a comprehensive NIS. Ultimately however, they must determine a way forward for NIS development that is most appropriate for the unique context in their own country's economy. While "best practices" implemented elsewhere can offer useful guidance, "one size fits all" solutions are unlikely. Likewise, measures for evaluating NIS performance from international analyses can provide helpful insights, but the most applicable standards for evaluating a country's NIS, whether quantitative or qualitative, will most likely be domestically determined based upon concurrent conditions, resource availability and competitive advantage. A failure to develop a well-formulated and comprehensive innovation strategy will make it increasingly difficult for developing countries to compete in a rapidly changing global economy.

APPENDICES

Appendix A

Thailand's Knowledge Assessment Methodology Entry

Variable	Score
Economic Performance	
Annual GDP growth (%), 2005-2009	3.40
GDP per capita (in/nal current $ PPP), 2009	4.47
GDP (current US$ bill), 2009	7.78
Human development index, 2010	7.29
Multidimensional poverty index, 2008	8.49
Gender inequality index, 2008	4.63
Seats in parliament held by women (as % of total), 2009	3.38
Composite risk rating, 07/2010-06/2011	4.84
Economic Regime	
Gr. capital formation as % of GDP, 2005-2009	7.54
Trade as % of GDP, 2009	8.44
Tariff & nontariff barriers, 2011	3.99
Soundness of banks (1-7), 2010	7.94
Exports of goods and services as % of GDP, 2009	8.87
Interest rate spread, 2009	7.29
Intensity of local competition (1-7), 2010	7.33
Domestic credit to private sector as % of GDP, 2009	8.38
Cost to register a business as % of GNI per capita, 2011	5.89
Days to start a business, 2011	3.05
Cost to enforce a contract (% of debt), 2011	9.57
Governance	
Regulatory quality, 2009	5.96
Rule of law, 2009	5.41
Government effectiveness, 2009	5.75
Voice and accountability, 2009	3.70
Political stability, 2009	1.58
Control of corruption, 2009	5.00
Press freedom (1-100), 2010	3.68
Innovation System	
FDI outflows as % of GDP, 2004-2008	4.92
FDI inflows as % of GDP, 2004-0208	5.14
Royalty and license fees payments (US$ mil.), 2009	8.80
Royalty and license fees payments (US$/pop.), 2009	7.12

Variable	Score
Royalty and license fees receipts (US$ mil.), 2009	7.38
Royalty and license fees receipts (US$/pop.), 2009	5.95
Royalty payments and receipts(US$ mil.), 2009	8.48
Royalty payments and receipts(US$/pop.) 2009	6.80
Science and engineering enrollment ratio (%), 2009	n/a
Science enrollment ratio (%), 2009	n/a
Researchers in R&D, 2009	6.30
Researchers in R&D/mil. People, 2009	3.42
Total expenditure for R&D as % of GDP, 2008	2.38
Manuf. trade as % of GDP, 2009	9.28
University-company research collaboration (1-7), 2010	7.10
S&E journal articles, 2007	7.24
S&E journal articles/mil. people, 2007	5.17
Availability of venture capital (1-7), 2010	7.02
Patents granted by USPTO, avg. 2005-2009	7.53
Patents granted by USPTO/mil. people, avg. 2005-2009	5.89
High-tech exports as % of manuf. exports, 2009	8.93
Private sector spending on R&D (1-7), 2010	6.56
Firm-level technology absorption (1-7), 2010	5.50
Value chain presence (1-7), 2010	7.48
Capital goods gross imports(% of GDP), avg. 2005-2009	9.48
Capital goods gross exports (% of GDP), 2005-2009	9.48
S&E articles with foreign coauthorship (%), 2008	3.68
Avg. number of citations per S&E article, 2008	7.29
Intellectual property protection (1-7), 2010	4.05
Education	
Adult literacy rate (% age 15 and above), 2007	5.00
Average years of schooling, 2010	3.15
Average years of schooling, female, 2010	2.99
Gross secondary enrollment rate, 2009	3.45
Gross tertiary enrollment rate, 2009	6.10
Life expectancy at birth, 2009	3.52
Internet access in schools (1-7), 2010	6.95
Public spending on education as % of GDP, 2009	4.59
4th grade achievement in math (TIMSS), 2007	n/a
4th grade achievement in science (TIMSS), 2007	n/a
8th grade achievement in math (TIMSS), 2007	4.13
8th grade achievement in science (TIMSS), 2007	5.87

Variable	Score
Quality of science and math education (1-7), 2010	5.95
Quality of management schools (1-7), 2010	6.11
15-year-olds' math literacy (PISA), 2009	2.46
15-year-olds' science literacy (PISA), 2009	2.62
School enrollment, secondary, female (% gross), 2009	3.31
School enrollment, tertiary, female (% gross), 2009	5.70
No schooling, total, 2010	3.15
No schooling, female, 2010	3.70
Secondary school completion ,total (% of pop. 15+), 2010	2.36
Secondary school completion ,female (% of pop. 15+), 2010	2.28
Tertiary school completion ,total (% of pop. 15+), 2010	7.72
Tertiary school completion ,female (% of pop. 15+), 2010	7.72
Labor	
Unemployment rate, total (% of labor force), 2005-2009	9.91
Unemployment rate, male (% of male labor force), 2005-2009	9.82
Unemployment rate, female (% of female labor force), 2005-2009	10.00
Employment in industry (%), 2008	3.37
Employment in services (%), 2008	0.71
Prof. and Tech. workers as % of labor force, 2008	n/a
Extent of staff training (1-7), 2010	5.88
Brain drain (1-7), 2010	7.18
Cooperation in labor-employer relations (1-7), 2010	7.94
Flexibility of wage determination (1-7), 2010	3.89
Pay and productivity (1-7), 2010	8.32
Reliance on professional management (1-7), 2010	5.95
Local availability of specialized research and training services (1-7), 2010	5.27
Difficulty of hiring index, 2010	5.39
Rigidity of hours index, 2010	10.00
Difficulty of redundancy index, 2010	10.00
Redundancy costs (weeks of wages), 2010	3.81
Labor tax and contributions (%), 2011	8.58
Employment to population ratio, total, 15+ (%), 2005-2009	8.94
Employment to population ratio, male, 15+ (%), 2005-2009	8.52
Employment to population ratio, female, 15+ (%), 2005-2009	8.73
Employment to population ratio, total, ages 15-24 (%), 2005-2009	7.25
Employment to population ratio, male, ages 15-24 (%), 2005-2009	6.97
Employment to population ratio, female, ages 15-24 (%), 2005-2009	6.69
Employment to population ratio, total, 25+ (%), 2005-2009	8.73

Variable	Score
Employment to population ratio, male, 25+ (%), 2005-2009	7.68
Employment to population ratio, female, 25+ (%), 2005-2009	8.87
Share of unemployment with tertiary education , 2007	10.00
Share of unemployment with secondary education, 2007	4.22
Labor force participation rate, total, 15+, 2005-2009	8.45
Labor force participation rate, male, 15+, 2005-2009	7.54
Labor force participation rate, female, 15+, 2005-2009	8.38
Labor force participation rate, total, 15-24, 2005-2009	5.49
Labor force participation rate, male, 15-24, 2005-2009	5.14
Labor force participation rate, female, 15-24, 2005-2009	5.42
Labor force participation rate, total, 15-64, 2005-2009	8.24
Labor force participation rate, male, 15-64, 2005-2009	8.03
Labor force participation rate, female, 15-64, 2005-2009	7.96
Labor force participation rate, total, 65+, 2005-2009	6.48
Labor force participation rate, male, 65+, 2005-2009	5.77
Labor force participation rate, female, 65+, 2005-2009	7.25
Youth unemployment rate, total, 2005-2009	9.70
Youth unemployment rate, male, 2005-2009	9.69
Youth unemployment rate, female, 2005-2009	9.79
Adult unemployment rate, total, 2005-2009	9.90
Adult unemployment rate, male, 2005-2009	9.90
Adult unemployment rate, female, 2005-2009	10.00
Share of youth unemployment in total unemployment, total, 2005-2009	1.01
Share of youth unemployment in total unemployment, male, 2005-2009	1.34
Share of youth unemployment in total unemployment, female, 2005-2009	0.82
Long-term unemployment, total, 25+, 2005-2009	n/a
Long-term unemployment, male, 25+, 2005-2009	n/a
Long-term unemployment, female, 25+, 2005-2009	n/a
Labor force with tertiary education (% of total), 2007	n/a
Labor force with secondary education (% of total), 2007	n/a
Firms offering formal training (% of firms), 2009	n/a
Females in Labor Force (% of total labor force), 2009	7.11
ICT	
Total telephones per 1000 people, 2009	6.14
Main telephone lines per 1000 people, 2009	3.70
Mobile phones per 1000 people, 2009	8.00
Computers per 1000 people, 2008	6.23
Households with television (%), 2008	4.69

Variable	Score
Daily newspapers per 1,000 people, 2004	n/a
International internet bandwidth (bits per person), 2009	4.79
Internet users per 1000 people, 2009	4.28
Fixed broadband internet access tariff (US$ per month), 2009	7.71
Availability of e-government services (1-7), 2008	7.36
Government online service index (1-7), 2010	4.96
ICT expenditure as % of GDP, 2008	7.61

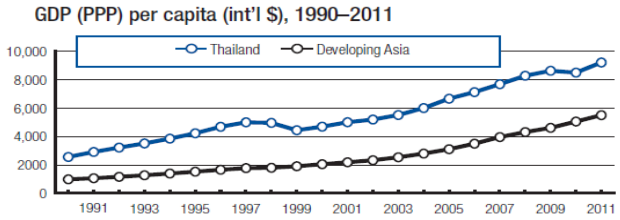
Source: Based on World Bank, 2012 (scores on 10-scale for 146 countries)

Appendix B

Thailand's Global Competitiveness Report Entry

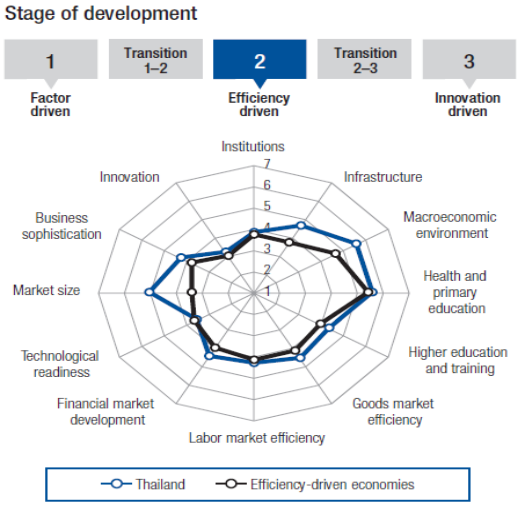
Key indicators, 2011

Population (millions)	70.7
GDP (US$ billions)	345.6
GDP per capita (US$)	5,394
GDP (PPP) as share (%) of world total	0.76



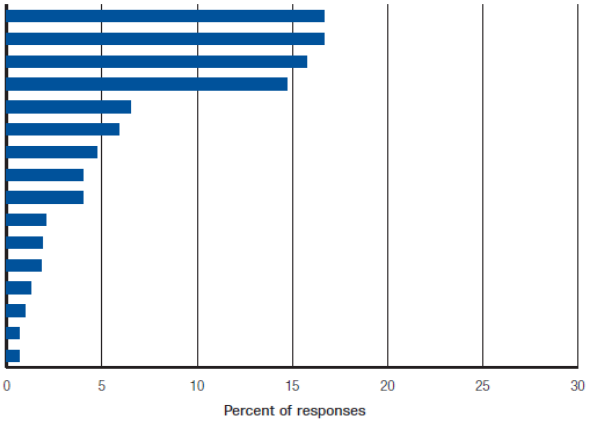
The Global Competitiveness Index

	Rank (out of 144)	Score (1–7)
GCI 2012–2013	**38**	**4.5**
GCI 2011–2012 (out of 142)	39	4.5
GCI 2010–2011 (out of 139)	38	4.5
Basic requirements (40.0%)	**45**	**4.9**
Institutions	77	3.8
Infrastructure	46	4.6
Macroeconomic environment	27	5.5
Health and primary education	78	5.6
Efficiency enhancers (50.0%)	**47**	**4.4**
Higher education and training	60	4.3
Goods market efficiency	37	4.6
Labor market efficiency	76	4.3
Financial market development	43	4.5
Technological readiness	84	3.6
Market size	22	5.0
Innovation and sophistication factors (10.0%)	**55**	**3.7**
Business sophistication	46	4.3
Innovation	68	3.2



The most problematic factors for doing business

Government instability/coups	18.6
Corruption	16.7
Policy instability	15.8
Inefficient government bureaucracy	14.7
Inadequately educated workforce	6.5
Insufficient capacity to innovate	5.9
Inflation	4.7
Inadequate supply of infrastructure	4.0
Poor work ethic in national labor force	4.0
Access to financing	2.0
Tax regulations	1.9
Tax rates	1.8
Restrictive labor regulations	1.2
Crime and theft	1.0
Foreign currency regulations	0.6
Poor public health	0.6



Note: From the list of factors above, respondents were asked to select the five most problematic for doing business in their country and to rank them between 1 (most problematic) and 5. The bars in the figure show the responses weighted according to their rankings.

The Global Competitiveness Index in detail

	INDICATOR	VALUE	RANK/144
	1st pillar: Institutions		
1.01	Property rights	3.7	103
1.02	Intellectual property protection	3.1	101
1.03	Diversion of public funds	3.0	82
1.04	Public trust in politicians	2.2	107
1.05	Irregular payments and bribes	3.7	80
1.06	Judicial independence	4.0	59
1.07	Favoritism in decisions of government officials	2.8	86
1.08	Wastefulness of government spending	3.2	70
1.09	Burden of government regulation	3.4	75
1.10	Efficiency of legal framework in settling disputes	3.8	65
1.11	Efficiency of legal framework in challenging regs.	3.6	73
1.12	Transparency of government policymaking	4.0	89
1.13	Gov't services for improved business performance	3.8	58
1.14	Business costs of terrorism	4.8	115
1.15	Business costs of crime and violence	4.8	77
1.16	Organized crime	5.2	76
1.17	Reliability of police services	3.6	101
1.18	Ethical behavior of firms	3.9	68
1.19	Strength of auditing and reporting standards	4.9	53
1.20	Efficacy of corporate boards	4.5	68
1.21	Protection of minority shareholders' interests	4.4	53
1.22	Strength of investor protection, 0–10 (best)*	7.7	**13**
	2nd pillar: Infrastructure		
2.01	Quality of overall infrastructure	4.9	49
2.02	Quality of roads	5.0	39
2.03	Quality of railroad infrastructure	2.6	65
2.04	Quality of port infrastructure	4.6	56
2.05	Quality of air transport infrastructure	5.7	**33**
2.06	Available airline seat kms/week, millions*	2,286.1	**17**
2.07	Quality of electricity supply	5.5	44
2.08	Mobile telephone subscriptions/100 pop.*	113.2	57
2.09	Fixed telephone lines/100 pop.*	9.7	95
	3rd pillar: Macroeconomic environment		
3.01	Government budget balance, % GDP*	-1.9	52
3.02	Gross national savings, % GDP*	30.0	**25**
3.03	Inflation, annual % change*	3.8	53
3.04	General government debt, % GDP*	41.7	77
3.05	Country credit rating, 0–100 (best)*	63.2	45
	4th pillar: Health and primary education		
4.01	Business impact of malaria	5.9	84
4.02	Malaria cases/100,000 pop.*	260.7	103
4.03	Business impact of tuberculosis	5.3	73
4.04	Tuberculosis cases/100,000 pop.*	137.0	103
4.05	Business impact of HIV/AIDS	4.6	103
4.06	HIV prevalence, % adult pop.*	1.3	114
4.07	Infant mortality, deaths/1,000 live births*	11.2	57
4.08	Life expectancy, years*	73.9	62
4.09	Quality of primary education	3.5	82
4.10	Primary education enrollment, net %*	89.7	97
	5th pillar: Higher education and training		
5.01	Secondary education enrollment, gross %*	79.2	92
5.02	Tertiary education enrollment, gross %*	47.7	54
5.03	Quality of the educational system	3.5	78
5.04	Quality of math and science education	4.1	61
5.05	Quality of management schools	4.3	62
5.06	Internet access in schools	4.3	63
5.07	Availability of research and training services	4.2	66
5.08	Extent of staff training	4.2	49

	INDICATOR	VALUE	RANK/144
	6th pillar: Goods market efficiency		
6.01	Intensity of local competition	5.0	54
6.02	Extent of market dominance	3.6	79
6.03	Effectiveness of anti-monopoly policy	3.9	80
6.04	Extent and effect of taxation	3.6	55
6.05	Total tax rate, % profits*	37.5	68
6.06	No. procedures to start a business*	5	**29**
6.07	No. days to start a business*	29	99
6.08	Agricultural policy costs	3.3	116
6.09	Prevalence of trade barriers	4.3	71
6.10	Trade tariffs, % duty*	6.4	78
6.11	Prevalence of foreign ownership	4.8	65
6.12	Business impact of rules on FDI	5.3	**20**
6.13	Burden of customs procedures	3.8	86
6.14	Imports as a percentage of GDP*	80.7	**25**
6.15	Degree of customer orientation	5.4	**21**
6.16	Buyer sophistication	3.9	**37**
	7th pillar: Labor market efficiency		
7.01	Cooperation in labor-employer relations	4.7	41
7.02	Flexibility of wage determination	4.7	97
7.03	Hiring and firing practices	4.3	41
7.04	Redundancy costs, weeks of salary*	36	130
7.05	Pay and productivity	4.5	**27**
7.06	Reliance on professional management	4.2	71
7.07	Brain drain	4.1	**36**
7.08	Women in labor force, ratio to men*	0.82	62
	8th pillar: Financial market development		
8.01	Availability of financial services	5.1	40
8.02	Affordability of financial services	4.8	**35**
8.03	Financing through local equity market	4.4	**27**
8.04	Ease of access to loans	3.6	**28**
8.05	Venture capital availability	2.9	49
8.06	Soundness of banks	5.6	45
8.07	Regulation of securities exchanges	4.7	43
8.08	Legal rights index, 0–10 (best)*	5	89
	9th pillar: Technological readiness		
9.01	Availability of latest technologies	4.9	73
9.02	Firm-level technology absorption	5.0	54
9.03	FDI and technology transfer	4.9	47
9.04	Individuals using Internet, %*	23.7	94
9.05	Broadband Internet subscriptions/100 pop.*	5.4	73
9.06	Int'l Internet bandwidth, kb/s per user*	10.6	84
9.07	Mobile broadband subscriptions/100 pop.*	0.0	128
	10th pillar: Market size		
10.01	Domestic market size index, 1–7 (best)*	4.8	**23**
10.02	Foreign market size index, 1–7 (best)*	5.8	**16**
	11th pillar: Business sophistication		
11.01	Local supplier quantity	5.2	**25**
11.02	Local supplier quality	4.9	39
11.03	State of cluster development	4.2	**34**
11.04	Nature of competitive advantage	3.5	63
11.05	Value chain breadth	4.2	**33**
11.06	Control of international distribution	4.2	56
11.07	Production process sophistication	3.9	55
11.08	Extent of marketing	4.3	54
11.09	Willingness to delegate authority	3.7	68
	12th pillar: Innovation		
12.01	Capacity for innovation	3.0	79
12.02	Quality of scientific research institutions	3.7	60
12.03	Company spending on R&D	3.1	74
12.04	University-industry collaboration in R&D	4.0	46
12.05	Gov't procurement of advanced tech products	3.2	98
12.06	Availability of scientists and engineers	4.3	57
12.07	PCT patents, applications/million pop.*	0.6	72

Notes: Values are on a 1-to-7 scale unless otherwise annotated with an asterisk (*). For further details and explanation, please refer to the section "How to Read the Country/Economy Profiles" on page 83.

Source: WEF, 2012

Appendix C

Thailand NIS Government Officials Interviews: Questions and Schedule

Interview Questions

Since National Science, Technology and Innovation Act (2008), Thailand has engaged in a formal strategy to enhance the nation's competitiveness by encouraging economic innovation in firms. The strategy takes a systemic, coordinated approach by creating and connecting both public and private institutions to promote innovation. Specific measures include creating dedicated government agencies, upgrading the legal and regulatory landscape (FDI rules, IPR regime), making grants and loans, and encouraging industrial clusters, R&D parks, and similar collaborative ventures.

1. In your view, is the NIS approach being implemented effectively?
2. How can NIS be improved?
3. What is your agency's role in this system?
4. How would you evaluate the status and the overall performance of NIS?

Thailand NIS Government Official Interviewees

1. Mr. Alongkorn Ponlaboot
   Deputy Minister
   Ministry of Commerce (MOC)
   Interview date: April 27, 2011
2. Prof. Dr. Soottiporn Chittmittrapap
   Secretary General
   National Research Council of Thailand (NRCT)
   Interview date: September 22, 2011
3. Dr. Yada Mukdapitak
   Deputy Secretary General
   National Science Technology and Innovation Policy Office (STI)
   Interview date: April 7, 2011

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